

**TECHNICAL SUPPORT DOCUMENT**  
Impacts on the Nation of the  
Energy Independence and Security Act of 2007

**March 2009**

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# 1 INTRODUCTION

## 1.1 PURPOSE OF THE DOCUMENT

This document provides analysis supporting the technical amendment incorporating the Energy Independence and Security Act of 2007 (EISA 2007) (Pub. L. 110-140) requirements into the Code of Federal Regulations. In this report, the Department of Energy (DOE) estimates the energy, economic, and environmental impacts of the energy conservation standards prescribed in EISA 2007 for certain consumer products and commercial and industrial equipment.

Chapter 2 outlines the baseline efficiency levels as well as the new energy conservation standards for standards prescribed in EISA 2007. Chapters 3, 4, and 5 outline the methodology and results for the energy, economic, and emissions savings analyses.

## 1.2 OVERVIEW OF STANDARDS PRESCRIBED IN THE ENERGY SECURITY INDEPENDENCE ACT OF 2007

On December 19, 2007, Congress enacted EISA 2007, which amends the Energy Policy Conservation Act of 1975, Pub. L. 94-163 (42 U.S.C. 6291 *et seq.*) to establish energy conservation standards for certain consumer products and commercial and industrial equipment. In today's technical amendment, DOE placed the prescribed energy conservation standards and related definitions into 10 CFR Part 430 ("Energy Conservation Program for Consumer Products") or 10 CFR Part 431 ("Energy Efficiency Program for Certain Commercial and Industrial Equipment") depending on the nature or type of the product or equipment.

In accordance with Executive Order 12866, DOE estimated the impacts of standards on products and equipment prescribed by EISA 2007 (Table 1.1). In this report, DOE provides benefit analyses of the prescribed standards.

**Table 1.1 EISA 2007 Prescribed Energy Conservation Standards**

<b>Product</b>
Dishwashers
Residential Clothes Washers
Dehumidifiers
External Power Supplies, Class A
Incandescent Reflector Lamps
General Service Incandescent Lamps
Candelabra Base Incandescent Lamps

<b>Product</b>
Intermediate Base Incandescent Lamps
Metal Halide Lamp Fixtures
Electric Motors
Small commercial Package Air-Conditioning and Heating Equipment
Single Package Vertical Air-Conditioners and Heat Pumps
Walk-In Coolers and Walk-In Freezers
Residential Boilers

Although standards for residential boilers are in EISA 2007, the standards were not codified in today's technical amendment. Instead, the prescribed standards for residential boilers are included in the Furnace and Boiler Technical Amendment, published in the *Federal Register* on July 28, 2008 (73 FR 43611).

### **1.3 GENERAL APPROACH**

DOE analyzed four criteria to estimate the benefits of the prescribed standards:

- cumulative energy savings (Quads)
- increased total installed cost (\$2007)
- net present value (\$2007)
- emissions reductions (MMTCE)<sup>1</sup>

Where possible, DOE used available data from prior rulemaking analyses to provide benefit estimates. The benefit estimates consider the difference between typical baseline product models and product models that comply with the new EISA 2007 prescribed standard. Before EISA 2007, DOE completed or began the rulemaking process and conducted preliminary benefit analyses for some of the products that were prescribed standards.

When DOE did not already have data, DOE gathered data on shipments or installed equipment stock, baseline efficiency levels, and typical product usage to determine energy savings benefits of the prescribed standards. In most cases, DOE assumed the Federal minimum energy conservation standard as the baseline efficiency level.

To determine cost benefits of products with no previous analyses, DOE analyzed the approximate changes in retail price of products that comply with EISA 2007. DOE also considered the energy cost savings associated with consuming less energy. DOE determined the emissions

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<sup>1</sup> Million metric tons of carbon equivalent includes only energy consumption effects, unless otherwise noted. Source: 2007 Building Energy Databook, U.S. Department of Energy, Office of Planning, Budget Formulation and Analysis, Energy Efficiency and Renewable Energy. September 2007.

savings by estimating the reduction of carbon dioxide (CO<sub>2</sub>) from decreased energy consumption. Lastly, DOE discusses the monetary savings associated with a decrease of carbon emissions.

DOE analyzed all standards over a single time period, 2008–2038. The analysis started in 2008, the effective date of the earliest standard in EISA 2007 (class A external power supplies). DOE converted all cost data to 2007 dollars.

## 1.4 SOURCES FOR SAVINGS

Before EISA 2007, DOE completed or began the standards rulemaking process for residential boilers, dishwashers, dehumidifiers, and incandescent reflector lamps and was also working on the advance notice of proposed rulemaking for general service incandescent lamps, incandescent reflector lamps and general service fluorescent lamps. General service incandescent lamps were removed from this rulemaking after EISA 2007. Table 1.2 lists the products for which DOE had prior analysis when it began.

**Table 1.2 Products for Which DOE Has Prior Analysis**

<b>Product</b>	<b>Data Source</b>	<b>Rulemaking Stage</b>	<b>TSD Location</b>	<b>Date of Data Release</b>
Residential Boilers	Furnace and Boiler Rulemaking Technical Support Document (TSD)	Final rule	<a href="http://www.eere.energy.gov/buildings/appliance_standards/residential/fb_tsd_0907.html">www.eere.energy.gov/buildings/appliance_standards/residential/fb_tsd_0907.html</a>	September 2007
Residential Dishwashers	AHAM 1 Rulemaking TSD Draft Analysis – NIA Spreadsheet	Framework document	<a href="http://www.eere.energy.gov/buildings/appliance_standards/residential/home_appl_tsd.html">www.eere.energy.gov/buildings/appliance_standards/residential/home_appl_tsd.html</a>	November 2007
Dehumidifiers	AHAM 1 Rulemaking TSD Draft Analysis – NIA Spreadsheet	Framework document	<a href="http://www.eere.energy.gov/buildings/appliance_standards/residential/home_appl_tsd.html">www.eere.energy.gov/buildings/appliance_standards/residential/home_appl_tsd.html</a>	November 2007
Incandescent Reflector Lamps	Lighting Rulemaking TSD	Advanced notice of proposed rule	<a href="http://www.eere.energy.gov/buildings/appliance_standards/residential/incandescent_lamps_anopr.html">www.eere.energy.gov/buildings/appliance_standards/residential/incandescent_lamps_anopr.html</a>	March 2008

For some products, such as class-A external power supplies and walk-in coolers and freezers, DOE or another source conducted prior analyses that were not part of the rulemaking process. DOE did not start an applicable rulemaking before EISA 2007 for metal halide lamp fixtures,

commercial package air conditioning and heating equipment, or electric motors. For these products, DOE estimated the impacts of prescribed standards using the same general methodology as for a DOE rulemaking, but made assumptions based on other available data.

## **1.5 PRODUCTS NOT CONSIDERED IN THE ANALYSIS**

DOE did not analyze prescribed standards for residential clothes washers, mercury vapor lamp ballasts, some commercial package air conditioning and heating equipment, candelabra base incandescent lamps, and intermediate base incandescent lamps because DOE considers the impacts of standards to be minimal. This section briefly outlines DOE's reasoning.

### **1.5.1 Residential Clothes Washers**

The 2001 DOE Residential Clothes Washer Final Rule (66 FR 3314) established the existing clothes washer energy conservation standard using a Modified Energy Factor (MEF). DOE established standards for residential clothes washers as 1.04 MEF in 2004 and 1.26 in 2007 for "standard" sized clothes washers. EISA 2007 amended Section 325(g) of EPCA by prescribing a water factor standard, but did not change the energy conservation standard. Therefore, DOE believes there will be minimum benefits resulting from the energy conservation standards for residential clothes washers prescribed in EISA 2007.

### **1.5.2 Mercury Vapor Lamp Ballasts**

Section 135(c) of EPACT 2005 amended section 325 of EPCA by prohibiting the manufacture of new mercury vapor ballasts after January 1, 2008. Section 316(d) of EISA 2007 amends the same section of EPCA by defining mercury vapor lamps as "screw-based" and providing an exception for ballasts for non-screw-based and specialty application mercury vapor lamps. This exclusion of ballasts for specialty application and non screw-based mercury vapor lamps does not result in increased equipment costs, energy savings, or emissions reductions. The exclusions apply to unique applications for which mercury vapor lamps are the best available technology, including quality inspection, industrial processing (such as chip manufacturing), and scientific use (such as fluorescent microscopy and ultraviolet curing). These special application and non-screw-based mercury vapor lamp ballasts must bear the label, "For specialty applications only, not for general illumination," and will have minimal impact on the overall efficiency of mercury vapor lighting systems.

### **1.5.3 Commercial Package Air Conditioning and Heating Equipment**

Section 314(a) of EISA 2007 amended section 340 of EPCA by adding definitions for single packaged vertical air conditioners (SPVACs) and single packaged vertical heat pumps (SPVHPs). Section 314(b) of EISA 2007 amended section 342(a) of EPCA by providing energy conservation standards for SPVACs and SPVHPs manufactured on or after January 10, 2010. Table 1.3 summarizes the standards prescribed by EISA 2007.

**Table 1.3 EISA 2007 Prescribed Standard for Commercial Package Air Conditioning**

<b>Product</b>	<b>Cooling Capacity (Btu/h)</b>	<b>Category</b>	<b>Efficiency Level</b>
Small Commercial Packaged Air Conditioning and Heating Equipment (Air-Cooled, Three-Phase)	<65,000	AC HP	SEER = 13.0 SEER = 13.0 HSPF = 7.7
Single Package Vertical Air Conditioners and Single Package Vertical Heat Pumps (Single-Phase, Three-Phase)	<65,000	AC HP	EER=9.0 EER=9.0 COP=3.0
Single Package Vertical Air Conditioners and Single Package Vertical Heat Pumps	≥ 65,000 and < 135,000	AC HP	EER=8.9 EER=8.9 COP=3.0
Single Package Vertical Air Conditioners and Single Package Vertical Heat Pumps	≥ 135,000 and <240,000	AC HP	EER=8.6 EER=8.6 COP=2.9

SEER – seasonal energy efficiency ratio

HSPF – heating seasonal performance factor

EER – energy efficiency ratio

COP – coefficient of performance

According to the Air-Conditioning, Heating, and Refrigeration Institute (AHRI) *Directory of Certified Product Performance*,<sup>2</sup> all certified equipment has a cooling capacity less than 65,000 Btu/h as of June 2008. Consequently, DOE did not analyze the two equipment classes included in EISA 2007 with cooling capacities above 65,000 Btu/h.

DOE also used the analysis developed as part of the 2006 Technical Support Document for Commercial Heating, Air-Conditioning, and Water Heating Equipment.<sup>3</sup> The market data presented in the TSD demonstrates that the majority of SPVACs are rated above 9.0 EER, which is the minimum energy conservation standard level EISA 2007 set for such equipment. The majority of SPVHPs are rated at or above 9.0 EER, which is also the minimum energy conservation standard level EISA set for such equipment. The energy conservation standards for SPVACs and SPVHPs set forth in EISA 2007 can be met by at least 97 percent of the total market.<sup>4</sup> DOE believes the efficiency levels set forth in EISA 2007 more closely represent the current market efficiency levels for SPVACs and SPVHPs and are representative of the baseline equipment. Therefore, DOE believes there will be minimal benefits resulting from the energy

<sup>2</sup> Air-Conditioning, Heating, & Refrigeration Institute (AHRI). *Directory of Certified Product Performance, Single Package Vertical Systems*. (Last Accessed June 4, 2008).

<<http://www.ahridirectory.org/ahriDirectory/pages/spv/defaultSearch.aspx>>.

<sup>3</sup> Department of Energy. Technical Support Document (TSD): Energy Efficiency Program for Commercial and Industrial Equipment: Efficiency Standards for Commercial Heating, Air-Conditioning, and Water Heating Equipment, March 2, 2006. (Last Accessed June 4, 2008).

<[http://www.eere.energy.gov/buildings/appliance\\_standards/commercial/pdfs/ashrae\\_products/ashrae\\_products\\_draft\\_tsd\\_030206.pdf](http://www.eere.energy.gov/buildings/appliance_standards/commercial/pdfs/ashrae_products/ashrae_products_draft_tsd_030206.pdf)>. pp. 25-36.

<sup>4</sup> Id.

conservation standards set forth in EISA 2007 for SPVACs and SPVHPs and did not perform any additional analysis on these equipment classes.

DOE only analyzed the EISA 2007 prescribed standard for small commercial packaged air conditioning and heating equipment (air-cooled, three-phase) for this report.

#### **1.5.4 Candelabra Base Incandescent Lamps and Intermediate Base Incandescent Lamps**

Section 321(a) of EISA 2007 also amended section 325(i) of EPCA to set energy conservation standards for candelabra incandescent lamps and intermediate base incandescent lamps. A candelabra base incandescent lamp shall not exceed 60 rated watts and an intermediate base incandescent lamp shall not exceed 40 rated watts. Because nearly all candelabra and intermediate base incandescent lamps on the market already meet their respective standards, DOE expects minimal impact as a result of the amendment.



## 2 ENERGY CONSERVATION STANDARDS PRESCRIBED BY EISA 2007

### 2.1 INTRODUCTION

DOE's benefit analysis estimates the impacts of the standards prescribed by EISA 2007. For all rulemakings and its analysis in this report, DOE selected baseline units as reference points against which it measured changes resulting from energy conservation standards. To determine energy, economic, and environmental benefits, DOE compared each higher energy efficiency and lower energy efficiency design option with the baseline unit. This chapter outlines the baseline units DOE used for this report and the new EISA 2007 prescribed standards.

### 2.2 BASELINE EFFICIENCY LEVELS

The baseline unit represents the basic characteristics of equipment in that class. Typically, a baseline unit just meets the current required energy conservation standards and provides basic consumer utility. For most products, DOE selects baseline efficiency levels based on the current minimum standard. The assumed baseline efficiency levels used in this analysis are described below.

**Residential boilers.** The current minimum energy conservation standards for gas- and oil-fired residential boilers as measured by Annual Fuel Utilization Efficiency (AFUE)<sup>5</sup> became effective on January 1, 1992 and apply to gas- and oil-fired residential boilers manufactured before November 19, 2015. DOE developed the following standards, which also serve as the baseline efficiency level for gas- and oil-fired residential boilers (10 CFR Part 430.32(e)):

- Boilers (excluding gas steam) = 80% AFUE
- Gas steam boilers = 75% AFUE

**Dishwashers.** The current minimum energy conservation standards for dishwashers, as measured by the energy factor (EF) in cycles per kilowatt-hour (kWh), became effective on May 14, 1994. DOE developed the following standards, which also serve as the baseline efficiency level for compact and standard capacity dishwashers (10 CFR Part 430.32(f)):

- Compact = 0.62 EF
- Standard = 0.46 EF

**Incandescent Reflector Lamps.** EPACT 1992 established minimum energy conservation standards for incandescent reflector lamps as measured by minimum average lamp efficacy (lumens per watt (LPW)) that became effective on November 1, 1995. EISA 2007 extends the coverage of the EPACT 1992 standard to include certain ellipsoidal reflector (ER), bulged

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<sup>5</sup> AFUE, as determined in §430.22(n)(2) of 10CFR Part 430

reflector (BR), and blown parabolic reflector (BPAR) reflector lamps. For this report, DOE considered the efficacy of lamps at two lamp wattages and generalized the energy savings from these two levels. At 120W, DOE estimated the baseline efficacy to be 10.8 lm/W, and at 90W, DOE used 12.2 lm/W as the baseline.

- 90W Baseline = 12.2 lm/W
- 120W Baseline = 10.8 lm/W

**Dehumidifiers.** For dehumidifiers, each energy efficiency level is expressed as a minimum EF, which is a function of liters per kWh. EPACT 2005 established the current minimum energy conservation standards for dehumidifiers based on the unit’s capacity (in pints/day). Table 2.1 shows the product classes EPACT 2005 established, along with the standard levels set to take effect October 1, 2007. (EPACT 2005, section 135(c)(4); 42 U.S.C. 6295(cc); 70 FR 60407, 60414, (October 18, 2005); 10 CFR 430.32(v)). DOE used the October 1, 2007 levels as baseline efficiency levels.

**Table 2.1 EPACT 2005 Standards for Residential Dehumidifiers**

<b>Dehumidifier Capacity</b>	<b>EF (liters/kWh)</b>
25.00 pints/day or less	1.00
25.01–35.00 pints/day	1.20
35.01–54.00 pints/day	1.30
54.01–74.99 pints/day	1.50
75.00 pints/day or more	2.25

**Class A External Power Supplies.** There is no current energy conservation standard for class A external power supplies. DOE obtained the baseline efficiency for class A external power supplies using line-frequency designs for units with low and medium output power and low-efficiency switched-mode for units with high output power. Table 2.2 shows the characteristics of the baseline units in each of the three product classes DOE analyzed.

**Table 2.2 Class A External Power Supply Baseline Units**

	<b>Representative Unit Low Power</b>	<b>Representative Unit Medium Power</b>	<b>Representative Unit High Power</b>
<b>Output Power</b>	2.75 W	18 W	90 W
<b>Output Voltage</b>	5 V	12 V	19 V
<b>Baseline Design Characteristics</b>	Line-Frequency	Line-Frequency	Baseline Switched- Mode
<b>Baseline Efficiency</b>	30%	66%	78%
<b>Baseline No-Load</b>	2 W	2 W	2 W

<b>Power</b>			
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Despite the absence of Federal standards before the passage of EISA 2007, the class A power supplies DOE examined exhibit a wide range of efficiencies. DOE estimated that at the time EISA was enacted, only 30 percent and 15 percent of power supplies on the market were operating at the baseline efficiency for those units similar to the low and medium power representative units, respectively. The remaining units on the market operate at higher efficiency levels. The proportion of units operating at the baseline efficiency level was higher for devices with higher output power; DOE estimated that 60 percent of the power supplies characterized by the high power representative unit were operating at baseline efficiency. The remainder of the market was estimated to be distributed among five (or four, in the case of the high power representative unit) additional efficiency levels to form the base case (*i.e.*, before the standard) distribution of products (Table 2.3). DOE attributes this variation in efficiency to consumer demand for portability,<sup>6</sup> market-pull programs such as ENERGY STAR, and international and state standards, including those developed by the California Energy Commission (CEC).

**Table 2.3 Base Case Efficiency Distribution for Class A External Power Supplies**

	<b>Representative Unit Low Power (%)</b>	<b>Representative Unit Medium Power (%)</b>	<b>Representative Unit High Power (%)</b>
<b>Baseline Line-Frequency</b>	30	15	Not Applicable
<b>Baseline Switched Mode</b>	30	45	60
<b>CEC Tier 1</b>	15	15	15
<b>CEC Tier 2</b>	12	6	9
<b>&gt; CEC Tier 2</b>	10	18	5
<b>Market Best</b>	3	1	11

**General Service Incandescent Lamps.** Although DOE completed draft analysis on general service incandescent lamps before EISA 2007, the Act preceded the DOE rulemaking. This report’s data on general service incandescent lamps is from manufacturer interviews, product catalogs, and a literature review conducted before EISA 2007. For this analysis, DOE assumed the residential incandescent lamp market only contains 75W and 60W lamps. These two lamp types have the largest market share. DOE assumed a baseline market of 70 percent incandescent lamps (both 60W and 75W) and 30 percent compact fluorescent lamps.

**Metal Halide Lamp Fixtures.** The baseline efficiency levels for metal halide lamp fixtures are from manufacturer catalogs for ballasts operating the most common metal halide lamps used in the market. DOE identified these lamps from data provided by the National Electrical

<sup>6</sup> The size of power electronic components is limited by the component’s ability to dissipate heat generated during operation. More efficient components generate less heat for a given output power, requiring less surface area for dissipation and permitting smaller power supply sizes.

Manufacturers Association's (NEMA) for the Energy Conservation Program for Commercial and Industrial Equipment: High-Intensity Discharge (HID) Lamps Rulemaking. For this report, DOE assumed a baseline metal halide ballast efficiency of 78 percent for medium-base magnetic probe-start ballasts, 77 percent for medium-base pulse-start ballasts, 88 percent for mogul-base magnetic probe start ballasts, 85 percent for mogul-base magnetic pulse-start ballasts, 87 percent for mogul-base electronic pulse-start ballasts, and 75 percent for ceramic metal halide ballasts.

**Table 2.4 Baseline Efficiency Levels for Metal Halide Lamp Fixtures**

<b>Ballast Type</b>	<b>Ballast Efficiency (%)</b>
Medium-Base Magnetic Probe Start	78
Medium-Base Pulse Start	77
Mogul-Base Magnetic Probe Start	88
Mogul-Base Magnetic Pulse Start	85
Mogul-Base Electronic Pulse Start	87
Ceramic Metal Halide	75

**Electric Motors.** The Energy Policy Act of 1992 (EPACT 1992) established nominal efficiency levels for electric motors. For this report, the baseline efficiency levels are the current energy conservation standard set by EPACT 1992. DOE considered only the product classes (as defined by horsepower) displayed in Table 2.5 due to limited shipment data. Because there is no energy conservation standard for motors with 500 horsepower, DOE assumed a baseline efficiency equal to that of 200 horsepower motors. The complete listing of motor horsepower and nominal full load efficiency established by EPACT 1992 can be found in 10 CFR Part 431.25.

**Table 2.5 Baseline Efficiency Levels for Electric Motors**

<b>Motor Horsepower</b>	<b>Nominal Full Load Efficiency Open Motors (four poles), (%)</b>
1	82.5
5	87.5
20	91.0
50	93.0
100	94.1
200	95.0
500*	95.0

\* DOE assumed the baseline efficiency for 500 hp motors to be the same as for 200 hp motors.

**Commercial air conditioning and heating equipment.** Table 2.6 presents the baseline efficiency level DOE assumed for commercial air conditioning and heating equipment.

**Table 2.6 Baseline Efficiency Levels for Commercial Air Conditioning and Heating Equipment**

<b>Product</b>	<b>Cooling Capacity (Btu/h)</b>	<b>Category</b>	<b>Efficiency Level</b>
Small Commercial Packaged Air Conditioning and Heating Equipment (Air-Cooled, Three-Phase) Split System	<65,000	AC HP	SEER = 10 SEER = 10 HSPF = 6.8
Small Commercial Packaged Air Conditioning and Heating Equipment (Air-Cooled, Three-Phase) Single Package	<65,000	AC HP	SEER = 9.7 SEER = 9.7 HSPF = 6.6

**Walk-in coolers and walk-in freezers.** Because there are no Federal energy conservation standards for walk-in coolers and walk-in freezers, DOE took the baseline energy use from *Energy Savings Potential for Commercial Refrigeration Equipment* by Arthur D. Little, 1996.

**Table 2.7 Baseline Efficiency Levels for Walk-In Coolers and Walk-In Freezers**

<b>Product</b>	<b>Average Energy Consumption (kWh/year)</b>
Walk-In Coolers	16,200
Walk-In Freezers	21,400
Walk-In Freezer/Cooler Combination Units	30,200

## 2.3 EISA 2007 STANDARDS

This section outlines standards prescribed by EISA 2007.

### 2.3.1 Residential Boilers

Section 303 of EISA 2007 amended section 325(f) of EPCA to adopt energy conservation standards for residential boilers manufactured after September 1, 2012 (Table 2.8).

**Table 2.8 EISA 2007 Prescribed Standards for Residential Boilers**

<b>Boiler Type</b>	<b>AFUE (%)</b>	<b>Design Requirements</b>
Gas Hot Water	82	No constant burning pilot, automatic means for adjusting water temperature
Gas Steam	80	No constant burning pilot
Oil Hot Water	84	Automatic means for adjusting temperature
Oil Steam	82	None
Electric Hot Water	None	Automatic means for adjusting temperature
Electric Steam	None	None

### 2.3.2 Dishwasher

Section 311(a) of EISA 2007 amended section 325(g) of EPCA to adopt energy conservation standards and water conservation standards for residential dishwashers manufactured on or after January 1, 2010 (Table 2.9).

**Table 2.9 EISA 2007 Prescribed Standards for Residential Dishwashers**

<b>Product Size</b>	<b>Maximum Energy Use (kwh/year)</b>	<b>Maximum Water Consumption (gallons per cycle)</b>
Standard Size	355	6.5
Compact Size	260	4.5

DOE did not analyze compact dishwashers in this report because they represent such a small fraction of the current market. In 2005, compact dishwashers comprised approximately 1 percent of the total U.S. dishwasher market.<sup>7</sup>

<sup>7</sup> ENERGY STAR® Criteria for Dishwashers Revision Meeting Notes, U.S. Department of Energy Headquarters, July 13, 2005. Available at:

### 2.3.3 Incandescent Reflector Lamps

Section 322(b) of EISA 2007 amended section 325(i) of EPCA by extending coverage of incandescent reflector lamps to include certain ellipsoidal reflector (ER), bulged reflector (BR), and blown parabolic reflector (BPAR) reflector lamps; added definitions for these lamps; and established energy conservation standards for lamps manufactured on and after January 1, 2008. For this analysis, DOE considered the benefits of the previously exempted ER, BR, and BPAR lamps complying with the incandescent reflector lamp standard established by EPACT 1992 (Table 2.10).

**Table 2.10 EPACT 1992 Prescribed Standards for Incandescent Reflector Lamps**

<b>Nominal Lamp Wattage</b>	<b>Minimum Average Lamp Efficacy (LPW)</b>
40-50	10.5
51-66	11.0
67-85	12.5
86-115	14.0
116-155	14.5
156-205	15.0

### 2.3.4 Dehumidifiers

Section 311(a) of EISA 2007 amended EPCA to add a new section 325(cc)(2) setting energy conservation standards using energy factor levels for dehumidifiers manufactured on or after October 1, 2012 (Table 2.11).

**Table 2.11 EISA 2007 Prescribed Standards for Dehumidifiers**

<b>Product Capacity (pints/day)</b>	<b>Minimum Energy Factor (liters/kWh)</b>
Up to 35.00*	1.35
35.01 – 45.00	1.50
45.01 – 54.00	1.60
54.01 – 75.00	1.70
75.00 or more	2.50

\* DOE analyzed 0–25.00 pints/day and 25.01–35.00 pints/day separately in the rulemaking. Values provided are for

[http://www.energystar.gov/ia/partners/prod\\_development/revisions/downloads/dishwashers/DW\\_CriteriaMeeting\\_MeetingNotes\\_0705.pdf](http://www.energystar.gov/ia/partners/prod_development/revisions/downloads/dishwashers/DW_CriteriaMeeting_MeetingNotes_0705.pdf) (last accessed Dec. 9, 2008).

25.01–35.00 pints/day class, which is most representative.

### 2.3.5 Class A External Power Supplies

Section 301 of EISA 2007 amended sections 321 and 325(u) of EPCA by adding definitions and establishing energy conservation standards for class A external power supplies manufactured on or after July 1, 2008. The EISA 2007 standard for class A external power supplies, presented in Table 2.12, is equal to the Tier 2 level of California Energy Commission (CEC) appliance efficiency standards. As Table 2.3 shows, DOE estimates that 25 percent of class A external power supplies already complied with this level and would not be affected by the EISA 2007 standard.

**Table 2.12 EISA 2007 Prescribed Standards for Class A External Power Supplies**

<b>Active Mode</b>	
<b>Nameplate Output</b>	<b>Required Efficiency (decimal equivalent of a percentage)</b>
Less than 1 watt	0.5 times the nameplate output
From 1 watt to no more than 51 watts	The sum of 0.09 times the natural logarithm or the nameplate output and 0.5
Greater than 51 watts	0.85
<b>No-Load Mode</b>	
Nameplate Output	maximum consumption
No more than 250 watts	0.5 watts

### 2.3.6 General Service Incandescent Lamps

Section 321(a) of EISA 2007 amended sections 321 and 325 of EPCA to add definitions and set energy conservation standards for general service incandescent lamps for certain rated lumen ranges and effective dates. Prescribed standards for general service lamps are shown in Table 2.13.

**Table 2.13 EISA 2007 Prescribed Standards for General Service Incandescent Lamps**

<b>Rated Lumen Ranges</b>	<b>Maximum Rated Wattage</b>	<b>Minimum Rated Lifetime (hrs)</b>	<b>Effective Date</b>
1,490 - 2,600	72	1,000	1/1/2012
1,050 - 1,489	53	1,000	1/1/2013
750 - 1,049	43	1,000	1/1/2014
310 - 749	29	1,000	1/1/2014

EISA 2007 also required the Secretary of the Department of Energy to complete a general service incandescent lamp rulemaking when the savings are greater than or equal to 45 lumens per watt by January 1, 2020. Currently, there is no 45 lumen per watt lamp available. For this



analysis, DOE assumed that all incandescent lamps would be obsolete by 2020 and only compact fluorescent lamps would be sold.

### **2.3.7 Metal Halide Lamps**

Section 324(e) of EISA 2007 amends sections 321 and 325 of EPCA to add definitions and set energy conservation standards for metal halide lamp fixtures. EISA 2007 prescribed that metal halide lamp fixtures manufactured on or after January 1, 2009, and designed to be operated with lamps rated greater than or equal to 150 watts but less than or equal to 500 watts, shall contain (a) a pulse-start metal halide ballast with a minimum ballast efficiency of 88 percent; (b) a magnetic probe-start ballast with a minimum ballast efficiency of 94 percent; (c) a nonpulse-start electronic ballast with either a minimum ballast efficiency of 92 percent for wattages greater than 250 watts; or (d) a minimum ballast efficiency of 90 percent for wattages less than or equal to 250 watts.

DOE modeled the metal halide ballast market as composed of six different product classes: (1) medium-base magnetic probe-start metal halide, (2) medium-base pulse-start metal halide, (3) mogul-base magnetic probe-start metal halide, (4) mogul-base magnetic pulse start metal halide, (5) mogul-base electronic pulse-start metal halide, and (6) ceramic metal halide. DOE assumed that medium-base magnetic probe-start lamp technology would become obsolete as a result of the EISA 2007 metal halide ballast efficiency standards, and would be replaced by medium-base electronic pulse start technology. DOE also assumed that mogul-base magnetic probe-start ballasts would be replaced by EISA 2007-compliant magnetic probe-start ballasts, and mogul-base magnetic and electronic pulse start ballasts would be replaced by EISA 2007-compliant electronic pulse-start ballasts. EISA 2007 has limited impact on the energy consumption of medium-base magnetic and electronic pulse-start ballasts and ceramic metal halide ballasts because most of these product classes are outside EISA 2007 coverage (*i.e.*, 150–500 W).

### **2.3.8 Electric Motors**

Section 313 of EISA 2007 amended sections 340 and 342 of EPCA to add definitions and set energy conservation standards for general purpose electric motors (subtype I), fire pump motors, general purpose electric motors (subtype II), and NEMA design B general purpose electric motors. EISA 2007 requires that general purpose electric motors (subtype I) with a power rating of 1 horsepower or greater, but not greater than 200 horsepower, manufactured alone or as a component of another piece of equipment on or after December 19, 2010, shall meet the nominal full load efficiency levels specified in Table 12-12 of NEMA's MG-1 (2006), "Motors and Generators." In addition, EISA 2007 requires that fire pump motors; general purpose electric motors (subtype II) with a power rating of 1 horsepower or greater, but not greater than 200 horsepower; and NEMA design B general purpose electric motors with a power rating of more than 200 horsepower, but not greater than 500 horsepower manufactured alone or as a component of another piece of equipment on or after December 19, 2010, shall meet the full load efficiency levels specified in NEMA MG-1 (2006) Table 12-11.

Because the shipment data for electric motors was minimal, DOE used the standards in Table

2.14 to estimate the benefits of the EISA 2007 prescribed standards.

**Table 2.14 EISA 2007 Prescribed Standard for Electric Motors Used in This Analysis**

<b>Motor Horsepower</b>	<b>Nominal Full Load Efficiency Open Motors (four poles)</b>
1	85.5
5	89.5
20	93.0
50	94.5
100	95.4
200	95.8
500	96.2

**2.3.9 Commercial Package Air Conditioning**

Section 314 of EISA 2007 amends sections 340 and 342(a) of EPCA to add definitions of new classes of commercial package air conditioning and heating equipment and to establish energy conservation standards for commercial package air-conditioning and heating equipment. Small commercial package air-conditioning and heating equipment (other than single package vertical air conditioners) manufactured on or after June 16, 2008, shall meet specific minimum energy efficiency levels, depending on category and on the product capacity (Btu per hour) specified in EISA 2007. DOE used the standards in Table 2.15 to estimate the benefits of the EISA 2007 prescribed standards.

**Table 2.15 EISA 2007 Prescribed Standard for Commercial Package Air Conditioning Considered in This Report**

<b>Product</b>	<b>Cooling Capacity (Btu/h)</b>	<b>Category</b>	<b>Efficiency Level</b>
Small Commercial Packaged Air Conditioning and Heating Equipment, (Air-Cooled, Three-Phase)	<65,000	AC HP	SEER = 13.0 SEER = 13.0 HSPF = 7.7

**2.3.10 Walk-In Coolers and Walk-In Freezers**

Section 312(b) of EISA 2007 amended sections 340, 342, and 343 of EPCA to add definitions, energy conservation standards, and test procedures for measuring the thermal resistance (R value) of the panels, doors, floors, door closures, motors, and lighting used in walk-in coolers and walk-in freezers manufactured on or after January 1, 2009. The energy conservation standards for these products are discussed in section 431.306 of the Code of Federal Regulations.

### 3 ENERGY SAVINGS ESTIMATES

#### 3.1 INTRODUCTION

The following chapter explains the general methodology used to estimate the energy savings of the EISA 2007 prescribed standards. For the products for which DOE has not conducted a rulemaking analysis, DOE followed a similar methodology, although DOE made some assumptions based on the available data. Table 1.2 shows the DOE rulemakings considered in this analysis and their corresponding data sources.

#### 3.2 ENERGY SAVINGS ESTIMATES

To determine energy saving benefits for consumers, DOE must determine the annual energy use, shipment data, equipment stock, national energy consumption, and site-to-source conversion factors.

DOE calculates annual national energy savings (NES) as the difference between two projections: a base case (without new standards) and a standards case (with new standards) (Equation 1). Positive values from this equation correspond to energy savings (*i.e.*, national energy consumption with standards is less than national energy consumption in the base case).

**Equation 1:**  $NES_y = AEC_{BASE} - AEC_{STD}$

where

$AEC =$	annual national energy consumption each year in quadrillion British thermal units (Btus) – or quads, summed over vintages of the product stock, $STOCK_V$ ,
$NES =$	annual national energy savings (quads),
$STOCK_V =$	stock of product (millions of units) of vintage $V$ surviving in the year for which DOE calculated annual energy consumption (vintages range from 5 to approximately 28 years, depending on the retirement function of the product),
$UEC_V =$	annual energy consumption per product in either kilowatt-hours (kWh) or million Btus (MMBtu) (electricity and gas consumption are converted from site energy to source energy (quads) by applying a time-dependent conversion factor),
$V =$	year in which the product was purchased as a new unit, and
$y =$	year in the forecast ( <i>i.e.</i> , 2012 to 2042).

Cumulative energy savings are the sum over the forecast period, extending from the assumed effective date of the energy conservation standard, *i.e.*, 2008, to 2038, of the annual national energy savings (Equation 2).

**Equation 2:**  $NES_{cum} = \Sigma NES_y$

DOE calculated the national annual energy consumption by multiplying the number or stock of the given product by its unit energy consumption (Equation 3):

**Equation 3:**  $AEC = \Sigma STOCK_v \times UEC_v$

The following subsections describe the general approach DOE used to develop the four inputs to calculate the energy savings estimates.

### 3.2.1 Annual Energy Consumption Per Unit

In a rulemaking, DOE presents the per-unit annual energy consumption as a function of product efficiency. Because the per-unit annual energy consumption directly depends on efficiency, DOE used the base case and standards case in combination with the annual energy data to estimate the shipment-weighted average annual per-unit energy consumption under the base case and standards cases. The technical support document accompanying each DOE rulemaking describes this process in detail (Table 1.2).

For products that had no prior analysis, DOE determined the annual per-unit energy consumption using the same methodology used in the rulemakings. Table 3.1 and Table 3.2 show the sources DOE used to determine the unit efficiency and operating hours of the baseline and EISA 2007 standard levels.

**Table 3.1 Unit Efficiency Sources**

<b>Product/Equipment Type</b>	<b>Unit Efficiency Data Source</b>
General Service Incandescent Lamps	Lamp catalogs and product research
Class A External Power Supplies	Manufacturer interviews, DOE measurements, and ENERGY STAR qualified product list
Metal Halide Lamp Fixtures	Ballast product catalogs
Electric Motors	N/A. The standard is presented in horsepower efficiency.
Commercial Package Air Conditioning and Heating Equipment	Department of Energy. "Commercial Package Air Conditioning and Heating Equipment Screening Analysis." 2000.
Walk-In Coolers and Walk-In Freezers	Arthur D. Little. "Energy Savings Potential for Commercial Refrigeration Equipment." 1996.

**Table 3.2 Operating Hour Sources**

<b>Product/Equipment Type</b>	<b>Operating Hours Source</b>
General Service Incandescent Lamps	Energy Information Agency. "Residential Energy Consumption, Energy Information Agency." 2003.

	<p>Navigant Consulting, Inc. "U.S. Lighting Market Characterization: Volume 1: National Lighting Inventory and Energy Consumption Estimate." 2002. Washington, DC: U.S. Department of Energy.  <a href="http://www.netl.doe.gov/ssl/publications-ssltechreports.htm">http://www.netl.doe.gov/ssl/publications-ssltechreports.htm</a>.</p>
Class A External Power Supplies	<p>Porter, Moorefield, Ostendorp. "Final Field Research Report." October 2006. Ecos Consulting: Durango, CO.</p> <p>Rosen and Meier. "Energy Use of Consumer Electronics at the End of the 20th Century." 2000. Lawrence Berkeley National Laboratory: Berkeley, CA.</p> <p>Roth, Ponoum, and Goldstein. "US Residential Information Technology Energy Consumption in 2005 and 2010." May 2006. TIAX: Cambridge, MA.</p> <p>TIAX LLC. "Assessment of Analyses Performed for the California Energy Efficiency Regulations for Consumer Electronics Products. Prepared by TIAX for CEA." Feb 2006. TIAX LLC: Cambridge, MA.</p>
Metal Halide Lamp Fixtures	<p>Navigant Consulting, Inc. "U.S. Lighting Market Characterization: Volume 1: National Lighting Inventory and Energy Consumption Estimate." 2002. Washington, DC: U.S. Department of Energy.  <a href="http://www.netl.doe.gov/ssl/publications-ssltechreports.htm">http://www.netl.doe.gov/ssl/publications-ssltechreports.htm</a>.</p>
Electric Motors	<p>American Council for and Energy-Efficient Economy. "Impact of Proposed Increases to Motor Efficiency Performance Standards." October 2007.</p>
Commercial Package Air Conditioning and Heating Equipment	<p>Department of Energy. "Commercial Package Air Conditioning and Heating Equipment Screening Analysis." 2000.</p>
Walk-In Coolers and Walk-In Freezers	<p>Operating hours were assumed to be 24 hr/day.</p>

### 3.2.2 Shipments Equipment Stock

DOE forecasts shipments for the base case and all proposed standards cases in a rulemaking. Several factors, including total installed costs (purchase price plus installation costs), operating cost, household income, and equipment lifetime, all affect forecasted shipments. Of these factors, total installed cost was the primary driver in forecasting the impact of standards on shipments.

The increased total installed cost of more efficient equipment causes some customers to forego equipment purchases. Consequently, shipments forecasted under the standards cases can be lower than under the base case. An extensive description of the methodology for conducting and generating the shipments forecasts for each of the considered products can be found in the product’s technical support document in the shipments analysis chapter (Table 1.2).

For products that DOE has no prior analysis on, DOE estimated the shipment data using outside sources. Historical shipments were available for general service incandescent lamps and metal halide lamp fixtures. Based on that data, DOE made flat projections of future shipments. DOE estimates that metal halide ballast shipments are one-third of metal halide lamp shipments, assuming one lamp per ballast and that each ballast has a lifetime as long as a metal halide lamp.

DOE did not project future shipments for electric motors or walk-in coolers and walk-in freezers because the available shipment data was too limited. DOE assumed that the shipments and installed base for electric motors would not change significantly by 2038. DOE was able to project future shipments for class A external power supplies and commercial package air conditioning and heating equipment based on historical shipments.

**Table 3.3 Shipment and Equipment Stock Data Sources**

<b>Product/Equipment Type</b>	<b>Shipment Data Source</b>
General Service Incandescent Lamps	Obtained from National Electrical Manufacturers Association (NEMA), 2007.  Lamp catalogs
Class A External Power Supplies	Department of Energy. “Battery Chargers and External Power Supplies Draft Technical Report.” June 2008.
Metal Halide Lamp Fixtures	NEMA. “High-Intensity Discharge Lamp Survey.” Energy Conservation Program for Commercial and Industrial Equipment: High-Intensity Discharge (HID) Lamps Rulemaking, 2004.
Electric Motors	U.S. Census Bureau. Current Industry Reports 2003. MA335H. 2003.
Commercial Package Air Conditioning and Heating Equipment	Department of Energy. “Commercial Package Air Conditioning and Heating Equipment Screening Analysis.” 2000.
Walk-In Coolers and Walk-In Freezers	Arthur D. Little. “Energy Savings Potential for Commercial Refrigeration Equipment.” 1996.

The equipment stock of a product denotes the number of devices in use in commercial buildings, industries, and residential buildings, or a combination of these, depending on which segment is under investigation. The equipment stock in a given year is the number of products shipped from earlier years that survive in the given year. The models DOE uses for a rulemaking track the number of units shipped each year. DOE assumes that the products have an increasing probability of retiring as they age. The probability of survival as a function of years-since-purchase is the survival function. See the specific TSD product sections for further details on the survival functions that DOE used in its rulemaking analysis.

For products for which DOE had no prior analysis, stock estimates came from other studies, commercial stock estimates, sales data, and equipment lifetimes. DOE summed the sales data over the lifetime of a product to develop a stock estimate. Table 3.3 provides a list of sources for equipment stock; Table 3.4 provides a list of sources for lifetime.

**Table 3.4 Lifetime Sources**

<b>Product/Equipment Type</b>	<b>Lifetime Source</b>
General Service Incandescent Lamps	Lamp product catalogs  Energy Information Agency. "Residential Energy Consumption, Energy Information Agency." 2003.  Navigant Consulting, Inc. "U.S. Lighting Market Characterization: Volume 1: National Lighting Inventory and Energy Consumption Estimate." 2002. Washington, DC: U.S. Department of Energy. <a href="http://www.netl.doe.gov/ssl/publications-ssltechreports.htm">http://www.netl.doe.gov/ssl/publications-ssltechreports.htm</a> .
Class A External Power Supplies	Department of Energy. "Battery Chargers and External Power Supplies Draft Technical Report." June 2008.
Metal Halide Lamp Fixtures	Lamp product catalogs.  Venture. "Ballast Function." 2003. <a href="http://www1.eere.energy.gov/buildings/appliance_standards/commercial/pdfs/hid_lamps/venture_2003b.pdf">http://www1.eere.energy.gov/buildings/appliance_standards/commercial/pdfs/hid_lamps/venture_2003b.pdf</a>
Electric Motors	American Council for and Energy-Efficient Economy. "Impact of Proposed Increases to Motor Efficiency Performance Standards." October 2007.

Commercial Package Air Conditioning and Heating Equipment	Department of Energy. “Commercial Package Air Conditioning and Heating Equipment Screening Analysis.” 2000.
Walk-In Coolers and Walk-In Freezers	Arthur D. Little. “Energy Savings Potential for Commercial Refrigeration Equipment.” 1996.

For electric motors, DOE estimated that the survival function is approximately one half the lifetime. DOE assumed that products that comply with EISA 2007 would diffuse into the stock linearly over the lifetime of the device (Figure 3.1). This is similar to the assumption DOE made in the FY 2003 Priority Setting Summary Report and Action Proposed.<sup>8</sup>

### 3.2.3 National Annual Energy Consumption

For DOE rulemakings, the national annual energy consumption is the product of the annual energy consumption per unit and the number of units of each vintage (Equation 4). This approach accounts for differences in unit energy consumption from year to year.

**Equation 4:**  $AEC = \sum STOCK_v \times UEC_v$

Except for electric motors, DOE used the same methodology as above for products that had no prior analysis. Since the shipment data was minimal for electric motors, DOE calculated the annual energy savings from 2008–2038 assuming that products that comply with EISA 2007 diffuse into the stock linearly over the lifetime of the motor (see Figure 3-1) (Equation 5). The area under the shaded portion in the graph corresponds to the total actual savings and equals:

**Equation 5:**  $AEC(Motors) = (2038 - 2010) * AES - (1/2 Lifetime * AES)$

Where:

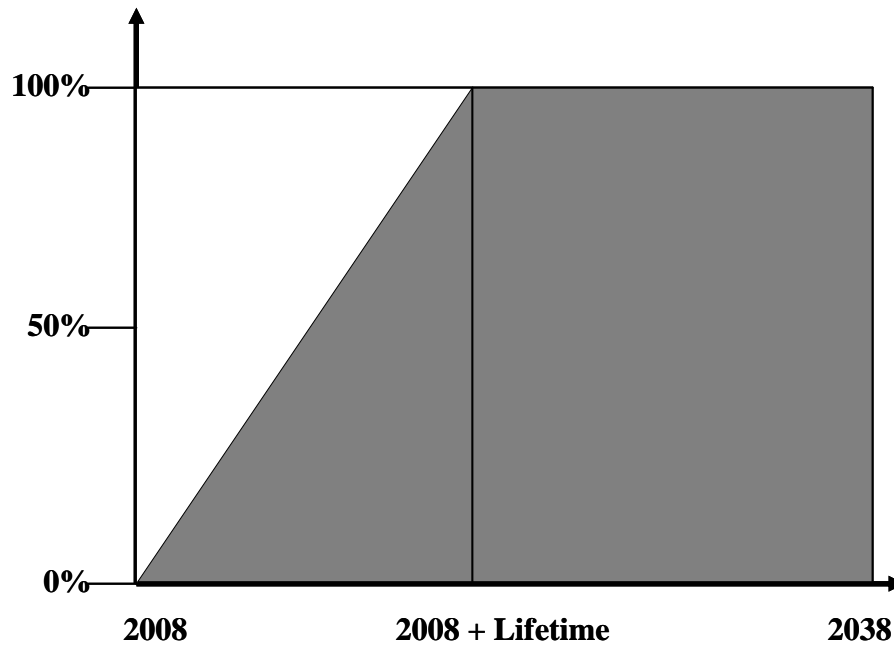
$AES =$  annual national energy savings and represents the energy saved by replacing the entire installed base with products that comply with EISA 2007, and

$Lifetime =$  average number of years the product functions as intended.

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<sup>8</sup> FY 2003 Priority Setting Summary Report and Action Proposed, Technical Support Document. Available at: [www.eere.energy.gov/buildings/appliance\\_standards/pdfs/fy03\\_priority\\_setting\\_app\\_a.pdf](http://www.eere.energy.gov/buildings/appliance_standards/pdfs/fy03_priority_setting_app_a.pdf) (last accessed Dec. 9, 2008).





**Figure 3.1 Product Penetration Model**

For electric motors, DOE calculated energy savings relative to typical new annual energy consumption estimates, *i.e.*, assuming that with the energy conservation standard the entire stock has the same efficiency level as the typical new product.

In determining national annual energy consumption, DOE initially calculated the annual energy consumption at the site, and then applied a conversion factor to calculate primary energy consumption.

### **3.2.4 Energy Site-to-Source Conversion Factors**

For DOE rulemakings, DOE initially calculates the annual energy consumption at the site (*e.g.*, for electricity, the energy in kWh consumed at the household or establishment). It then calculates primary (source) energy consumption from site energy consumption by applying a conversion factor to account for losses associated with the generation, transmission, and distribution of electricity and gas. The site-to-source conversion factor is the multiplicative factor used for converting site energy consumption into primary or source energy consumption, expressed in quads. DOE used annual site-to-source conversion factors in EIA's *Annual Energy Outlook*.<sup>9</sup> The factors used are marginal values, which represent the response of the system to an incremental decrease in consumption. Natural gas losses include pipeline leakage, pumping energy, and transportation fuel. The specific site-to-source conversion factors can be found in the

<sup>9</sup> For DOE rulemakings, the AEO version varies based on when the data was published.

TSD for the corresponding product. For products that had no prior rulemaking analysis, DOE estimated the site-to-source conversion for electricity as 10,851 Btu/kWh<sup>10</sup> and for natural gas as 1.10 Btu/Btu<sup>11</sup>.

### 3.3 ASSUMPTIONS

The energy savings estimates and calculations do not address several issues that could affect future energy consumption or savings estimates. For residential boilers, dishwashers, dehumidifiers, and incandescent reflector lamps, the assumptions are found in each rulemaking’s TSD. Table 3.5 lists assumptions for other products.

**Table 3.5 Energy Savings Calculation Assumptions**

Product/Equipment Type	Assumptions
General Service Incandescent Lamps	All energy standards come into effect in 2012 and then in 2020 (no staggering).  Impacts of other lumen packages apart from baseline 75W and baseline 60W packages are negligible.
Class A External Power Supplies	The assumptions for this analysis can be found in the Battery Chargers and External Power Supplies Draft Technical Report, June 2008.
Metal Halide Lamp Fixtures	DOE estimated the metal halide ballast shipments to be one-third of historical metal halide lamp shipments, assuming one lamp per ballast and that each ballast has a lifetime three times as long as a metal halide lamp. From the lamp/ballast shipments, DOE determined the inventory of metal halide lamps/ballasts for 2008–2038.

<sup>10</sup> 2007 Building Energy Databook. U.S. Department of Energy, Office of Planning, Budget Formulation and Analysis, Energy Efficiency and Renewable Energy. September 2007.

<sup>11</sup> Estimated from EIA’s *Annual Energy Outlook, 2007*.

Electric Motors	DOE assumed fixed shipments from 2008–2038 based on average shipments in 2003.  DOE calculated average efficiencies by averaging efficiency standard for the two extreme levels.  DOE assumed 60% of full load for operating hours.
Commercial Package Air Conditioning and Heating Equipment	The assumptions for this analysis can be found in the DOE 2000 Screening Analysis for Commercial package air conditioning and heating equipment.
Walk-In Coolers and Walk-In Freezers	DOE assumed constant shipments across the analysis period.  DOE assumed constant installed base across the analysis period.

### 3.4 ENERGY SAVINGS RESULTS

The following section provides the energy saving estimates for the products prescribed in EISA 2007. DOE estimates that the prescribed standards in EISA 2007 will save the Nation approximately 31 quads of energy from 2008–2038.

**Table 3.6 Cumulative Energy Savings, 2008–2038**

<b>Product</b>	<b>Cumulative Energy Savings (Quads)</b>
Residential Boilers	0.16
Residential Dishwashers	0.65
Incandescent Reflector Lamps	1.02
Dehumidifiers	0.17
Class A External Power Supplies	4.43
Metal Halide Lamp Fixtures	5.94
Electric Motors	0.14
General Service Incandescent Lamps	14.14
Small Commercial Package Air Conditioning and Heating Equipment	2.91
Walk-In Coolers and Walk-In Freezers	1.35
<b>Total</b>	<b>30.93</b>

## 4 NET PRESENT VALUE ANALYSIS

### 4.1 INTRODUCTION

The following chapter explains the general methodology DOE used to calculate the net present value of the EISA 2007 prescribed standards. For the products for which DOE has not conducted a rulemaking analysis, DOE followed a similar methodology, although DOE made some assumptions based on the available data. Table 1.2 shows the rulemakings considered in this analysis.

### 4.2 NET PRESENT VALUE ESTIMATES

The net present value (NPV) is the value in the present of a time series of costs and savings. NPV is described by the equation:

$$NPV = PVS - PVC$$

where:

*PVS* = present value of operating cost savings (including energy, water, repair, and maintenance costs), and

*PVC* = present value of increased total installed costs (including equipment and installation).

DOE determines the PVS and PVC using the following equations:

$$PVS = \sum OCS_y \times DF_y$$

$$PVC = \sum TIC_y \times DF_y$$

For DOE rulemakings, DOE calculates the total annual operating cost savings by multiplying the number or stock of the given product (by vintage) by its per-unit operating cost savings (also by vintage). DOE calculated the total annual installed cost increases by multiplying the number or stock of the given product (by vintage) by its per-unit total installed cost increase (also by vintage). DOE calculates the annual operating costs savings and total annual installed equipment cost increases using the following equations:

$$OCS_y = \sum STOCK_v \times UOCS_v$$

$$TIC_y = \sum STOCK_v \times UTIC_v$$

where:

$OCS$  = total annual operating cost savings each year summed over vintages of the product stock,  $STOCKV$ ,  
 $TIC$  = total annual installed cost increases each year summed over vintages of the product stock,  $STOCKV$ ,  
 $DF$  = discount factor in each year,  
 $STOCKV$  = stock of product (millions of units) of vintage  $V$  surviving in the year for which DOE calculated annual energy consumption,  
 $UOCSV$  = annual operating cost savings per unit,  
 $UTICV$  = annual total installed cost increase per unit,  
 $V$  = year in which the product was purchased as a new unit, and  
 $y$  = year in the forecast (*i.e.*, 2008 to 2038).

DOE determined the  $PVC$  and  $PVS$  for each year, from the effective date of the standard to the year when units purchased in 2038 retire. DOE calculated costs and savings as the difference between a standards case and a base case (*i.e.*, without new standards).

DOE calculated a discount factor from the discount rate and the number of years between the “present” (*i.e.*, year to which the sum is being discounted) and the year in which the costs and savings occur. The NPV is the sum over time of the discounted net savings.

The NPV calculation uses the following inputs:

- total installed cost per unit
- annual operating cost savings per unit
- total annual installed cost increases
- total annual operating costs
- discount factor
- present value of costs
- present value of savings

The increase in the *total annual installed cost* is equal to the annual change in the per-unit total installed cost (difference between base case and standards case) multiplied by the shipments forecasted in the standards case. The *total annual operating cost savings* are equal to the change in the annual operating costs (difference between base case and standards case) per unit multiplied by the shipments forecasted in the standards case. The annual operating cost includes energy, water, repair, and maintenance costs.

#### **4.1.1 Total Installed Cost Per Unit**

DOE analyzed the per-unit total installed cost as a function of product efficiency. Because the per-unit total annual installed cost directly depends on efficiency, DOE used the base case and standards case, in combination with the total installed costs to estimate the shipment-weighted average annual per-unit total installed cost under the base case and standards cases. For the products that had no prior DOE analysis, DOE researched price data and estimated the increase in unit prices for products that comply with EISA 2007. Table 4.1 shows the sources DOE used for price data.

**Table 4.1 Equipment Price Sources**

<b>Product/Equipment Type</b>	<b>Price Sources</b>
General Service Incandescent Lamps	Lamp product catalogs ( <i>i.e.</i> , Grainger), online distributors, manufacturing interviews
Class A External Power Supplies	The assumptions for this analysis can be found in the Battery Chargers and External Power Supplies Draft Technical Report, June 2008.
Metal Halide Lamp Fixtures	State of Arkansas (AR) Procurement contracts for Osram Sylvania and Advance Transformer lighting products. <a href="http://www.state.ar.us/dfa/procurement/documents/ballastprice.xls">www.state.ar.us/dfa/procurement/documents/ballastprice.xls</a> . <a href="http://www.state.ar.us/dfa/procurement/documents/sp070399_consolidated_pricing.pdf">www.state.ar.us/dfa/procurement/documents/sp070399_consolidated_pricing.pdf</a> .  State of South Dakota (SD) Procurement documents for Advance Transformer lighting products. <a href="http://www.state.sd.us/boa/opm/Downloads/23809%20Electrical%20Supplies%20Price%20Lists/23809%20Voss%20Electric%20Price%20Lists.xls">www.state.sd.us/boa/opm/Downloads/23809%20Electrical%20Supplies%20Price%20Lists/23809%20Voss%20Electric%20Price%20Lists.xls</a>
Electric Motors	Motor Challenge Information Clearinghouse, <i>Motor Master+</i>
Commercial Package Air Conditioning and Heating Equipment	Department of Energy. “Commercial Package Air Conditioning and Heating Equipment Screening Analysis.” 2000.
Walk-In Coolers and Walk-In Freezers	Arthur D. Little. “Energy Savings Potential for Commercial Refrigeration Equipment.” 1996.

**4.1.2 Annual Operating Cost Savings Per Unit**

The per-unit annual operating cost includes energy, water, repair, and maintenance costs. DOE assumed no increase in maintenance and repair costs due to standards for all products. Therefore, DOE determined the per-unit annual operating cost savings based only on the energy cost savings due to a standard level. DOE determined the per-unit annual operating cost savings by taking the per-unit annual energy consumption savings developed for each product and multiplying it by the appropriate energy price. As described previously, DOE forecasted the per-unit annual energy consumption for the base case and each standards case for all products.

The energy prices used in the DOE rulemakings are presented in each corresponding TSD and follow EIA’s *Annual Energy Output*. For products for which there was no prior analysis, DOE forecasted energy prices based on EIA’s *Annual Energy Output 2008 – Early Released Edition*.

**4.1.3 Total Annual Installed Cost Increases**

The total annual installed cost increase for any given standards case is the product of the total installed cost increase per unit due to the standard and the number of units of each vintage. This approach accounts for differences in total installed cost from year to year.

#### **4.1.4 Total Annual Operating Cost Savings**

The total annual operating cost savings for any given standards case is the product of the annual operating cost savings per unit due to the standard and the number of units of each vintage. This approach accounts for differences in annual operating cost savings from year to year.

#### **4.1.5 Discount Factors**

For DOE rulemakings and most of the analyses in this report, DOE multiplies monetary values in future years by a discount factor (DF) to determine the present value (Equation 5):

$$DF(y) = \frac{1}{(1+r)^{(y-y_p)}}$$

where:

- $r$  = discount rate,
- $y$  = year of the monetary value, and
- $y_p$  = year in which the present value is being determined.

DOE estimated national impacts with both a 3-percent and a 7-percent real discount rate as the average real rate of return on private investment in the U.S. economy. It used these discount rates in accordance with the Office of Management and Budget (OMB)'s guidance to Federal agencies on the development of regulatory analysis (OMB Circular A-4, September 17, 2003), and section E, "Identifying and Measuring Benefits and Costs," therein.

#### **4.1.6 Present Value of Costs**

The present value of increased installed costs is the annual installed cost increase in each year (*i.e.*, the difference between the standards case and base case), discounted to the present, and summed for the time period over which DOE is considering the installation of equipment (*i.e.*, from the effective date of standards, 2008 to 2038).

The increase in total installed cost refers to both equipment costs and installation costs associated with the higher energy efficiency of equipment purchased in the standards case compared to the base case. DOE calculated annual increases in installed costs as the difference in total installed cost for new equipment purchased each year, multiplied by the shipments in the standards case.

#### **4.1.7 Present Value of Savings**

The present value of operating cost savings is the annual operating cost savings (*i.e.*, the difference between the base case and standards case) discounted to the present, and summed over the period from the effective date, 2008, to the time when the last unit installed in 2038 is retired from service.

Savings are decreases in operating costs (including electricity, repair, and maintenance costs) associated with the higher energy efficiency of equipment purchased in the standards case compared to the base case. Total annual operating cost savings are the savings per unit multiplied by the number of units of each vintage surviving in a particular year. DOE rulemakings consider that equipment consumes energy over its entire lifetime. For units purchased in 2038, the consumption includes energy consumed until the unit is retired from service.

### 4.3 ASSUMPTIONS

The value of energy savings estimates and calculations do not address several issues that could affect the estimates. For residential boilers, dishwashers, dehumidifiers, and incandescent reflector lamps, the assumptions are found in each rulemaking’s TSD. Table 4.2 lists additional assumptions for other products that may affect the energy savings results.

**Table 4.2 Net Present Value Calculation Assumptions**

<b>Product/Equipment Type</b>	<b>Assumptions</b>
General Service Incandescent Lamps	Equipment prices stay fixed (in 2007 dollars).
Class A External Power Supplies	The assumptions for this analysis can be found in the Battery Chargers and External Power Supplies Draft Technical Report, June 2008.
Metal Halide Lamp Fixtures	Equipment prices stay fixed (in 2007 dollars).
Electric Motors	DOE used price data from 450 hp motors because there was insufficient data for 500 hp motors.  Equipment prices stay fixed (in 2007 dollars).
Commercial Package Air Conditioning and Heating Equipment	The assumptions for this analysis can be found in the DOE 2000 Screening Analysis for Commercial Package Air Conditioning and Heating Equipment.
Walk-In Coolers and Walk-In Freezers	Equipment prices stay fixed (in 2007 dollars).



#### 4.4 NET PRESENT VALUE RESULTS

The following section provides the net present value results for the products prescribed in EISA 2007. The results are cumulative from 2008 to 2038 and are shown as primary energy savings. DOE estimates that the prescribed standards will save the Nation approximately \$48 billion-\$105 billion (\$2007) between 2008 and 2038.

**Table 4.3 Cumulative Net Present Value, 2008–2038**

<b>Product</b>	<b>Net Present Value (\$2007 Billion) (7% Discount Rate)</b>	<b>Net Present Value (\$2007 Billion) (3% Discount Rate)</b>
Residential Boilers	0.3	1.2*
Residential Dishwashers	1.4	4.1
Incandescent Reflector Lamps	1.4	2.5
Dehumidifiers	0.3	0.7
Class A External Power Supplies	7.0	14.7
Metal Halide Lamp Fixtures	9.6	16.0
Electric Motors	(0.6)	(1.0)
General Service Incandescent Lamps	27.5	64.2
Small Commercial Package Air Conditioning and Heating Equipment	(0.9)	(2.1)
Walk-In Coolers and Walk-In Freezers	2.1	4.7
<b>Total</b>	<b>48.0</b>	<b>104.9</b>

\*Data was not available to calculate the value of energy savings for the residential steam boiler product class.

## 5 EMISSIONS REDUCTION ANALYSIS

### 5.1 INTRODUCTION

DOE estimated the environmental emissions reductions of the energy conservation standards prescribed by EISA 2007. For a rulemaking, DOE assesses the impact on certain environmental indicators using a variant of the U.S. DOE/Energy Information Administration (EIA)'s National Energy Modeling System (NEMS)<sup>12</sup> known as NEMS-BT to provide key inputs to the analysis. The model is based on the latest version of the *AEO*. Results of the environmental assessment will be similar to those provided in the *Annual Energy Outlook*.

DOE only provides emissions reductions for carbon dioxide in this report, but recognizes that other pollutants are important to consider. The Clean Air Act requires the Environmental Protection Agency (EPA) to set National Ambient Air Quality Standards for the following six common air pollutants, also known as “criteria pollutants”: (1) ozone, (2) particulate matter (PM), (3) carbon monoxide (CO), (4) nitrogen dioxide (NO<sub>x</sub>), (5) sulfur dioxide (SO<sub>2</sub>), and (6) lead. EPA recently added mercury to this list. Four of the “criteria pollutants” (ozone, PM, CO, and lead) are not increased significantly by either electric utility power plants or fuel-fired appliances. Other pollutants are precursors to the formation of ozone and particulate matter. Electric utilities and fuel-fired appliances are also not significant sources of CO. Almost all carbon emissions from electric power plants come in the form of CO<sub>2</sub> as the combustion process is lean enough not to yield CO in significant amounts. For fuel-fired appliances, proper appliance maintenance, installation, and use can prevent dangerous levels of CO. Finally, the ban on the use of leaded gasoline has resulted in a dramatic decrease in lead emissions since the mid 1970s. Now industrial processes (but not electric utilities)—particularly primary and secondary lead smelters and battery manufacturers—are responsible for most lead emissions and all violations of the lead air quality standards.

The Clean Air Act Amendments of 1990 gave EPA authority to control acidification and require operators of electric power plants to reduce emissions of SO<sub>2</sub> and NO<sub>x</sub>. In addressing SO<sub>2</sub> emissions, the Clean Air Act Amendments of 1990 set an SO<sub>2</sub> emissions cap on all power generation, but permitted flexibility among generators through the use of emissions allowances and tradable permits. This SO<sub>2</sub> trading implies that physical emissions impacts of a standard are likely to be zero because emissions will always be at, or near, the allowable amount. Consequently, there is no direct SO<sub>2</sub> environmental benefit from electricity conservation, as long as there is enforcement of the emissions ceiling. To the extent reduced power generation demand

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<sup>12</sup> 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(2000), March 2000. 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 as NEMS-BT (BT is DOE's Building Technologies Program). NEMS-BT was previously called NEMS-BRS.

decreases the demand for and price of emissions allowance permits, there could be an environmentally related economic benefit from standards reducing SO<sub>2</sub> emissions allowance demand. DOE recognizes there will be a direct benefit of NO<sub>x</sub> emission savings; however, no data is available to calculate those estimates at this time.

## 5.2 EMISSIONS REDUCTIONS ESTIMATES

While DOE analyzed the energy savings and net present value for several products, the emissions reductions analysis occurs later in the rulemaking stage and for most products, was not completed in time for EISA 2007. However, the final rule for residential boilers contains emissions reductions analysis using NEMS-BT.<sup>13</sup> For the other products, because there was little available data on environmental emissions savings, DOE determined these savings from the primary energy savings estimates. DOE assumed there would be emissions reductions from decreased energy consumption.

### 5.1.1 Carbon Dioxide Emission Savings

Carbon dioxide is of interest because of its classification as a greenhouse gas and its impact on global climate change. Greenhouse gases — which trap the sun’s radiation inside the Earth’s atmosphere — either occur naturally in the atmosphere or result from human activities. Naturally occurring greenhouse gases include water vapor, CO<sub>2</sub>, methane (CH<sub>4</sub>), nitrous oxide, and ozone. Human activities, however, add to the levels of most of these naturally occurring gases. For example, CO<sub>2</sub> is emitted to the atmosphere when solid waste, fossil fuels (oil, natural gas, and coal), wood, and wood products are burned. During the past 20 years, about three-quarters of anthropogenic (*i.e.*, human-made) CO<sub>2</sub> emissions resulted from burning fossil fuels. Concentrations of CO<sub>2</sub> in the atmosphere are naturally regulated by numerous processes, collectively known as the “carbon cycle.” The movement of carbon between the atmosphere and the land and oceans is dominated by natural processes, such as plant photosynthesis. While these natural processes can absorb some of the anthropogenic CO<sub>2</sub> emissions produced each year, billions of metric tons are added to the atmosphere annually. The Earth’s positive imbalance between emissions and absorption results in the continuing growth of greenhouse gases in the atmosphere, thereby causing surface air temperatures and sub-surface ocean temperatures to rise.

For this report, DOE translated the energy savings estimates into carbon dioxide emissions savings using a 15.75 MMTCE/quad conversion factor<sup>14</sup>. This factor assumes primary energy savings from reduced building energy consumption and is an average conversion factor for fuel types.

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<sup>13</sup> US Department of Energy. Environmental Assessment for Today’s Energy Conservation Standards for Residential Furnaces and Boilers. September 2007.

<sup>14</sup> 2008 Building Energy Databook, U.S. Department of Energy, Office of Planning, Budget Formulation and Analysis, Energy Efficiency and Renewable Energy. Table 1.4.8 September 2007.

### 5.1.2 Monetization of Carbon Dioxide Emission Savings

DOE may consider a monetary benefit of CO<sub>2</sub> emission reductions associated with the prescribed standards in EISA 2007. During the preparation of its most recent review of the state of climate science, the Intergovernmental Panel on Climate Change (IPCC) identified various estimates of the present value of reducing CO<sub>2</sub> emissions by one ton over the life that these emissions would remain in the atmosphere. The estimates reviewed by the IPCC spanned a range of values. Without a consensus on any single estimate of the monetary value of CO<sub>2</sub> emissions, DOE used an estimate identified by the study cited in Summary for Policymakers prepared by Working Group II of the IPCC's Fourth Assessment Report to estimate the potential monetary value of the CO<sub>2</sub> reductions likely to result from the standards under consideration in this report.

DOE converted the estimated yearly reductions in CO<sub>2</sub> emissions into a range of monetary values based on an assumption of no benefit to an average benefit value reported by the IPCC. According to the IPCC, the mean social cost of carbon (SCC) reported in studies published in peer-reviewed journals was U.S. \$43 per ton of carbon. This translates into about \$12 per ton of carbon dioxide. The literature review (Tol 2005) from which this mean was derived indicated the values to be approximately 1995 values in 1995 dollars, which correspond to a range of \$0 to \$15 in 2007 dollars.<sup>15</sup> Additionally, DOE has applied an annual growth rate of 2.4 percent as suggested by the IPCC Working Group II, based on estimated increases in damages from future emissions.<sup>16</sup> As a result, DOE is using a range for the social cost of carbon of \$0–\$20 (\$2007) per ton of CO<sub>2</sub> emissions. Table 5.1 shows the resulting estimates of the potential range of benefits associated with reducing CO<sub>2</sub> emissions.

The estimate DOE used as the upper bound value was derived from an estimate of the mean value of worldwide climate impacts caused by CO<sub>2</sub> emissions. There are no estimated values for the U.S. benefits likely to result from CO<sub>2</sub> emission reductions. However, if such values were developed, DOE would likely use them in its analysis. DOE also expects that such values would be lower than comparable global values.

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<sup>15</sup> Tol, Richard S. J., 2005. The Marginal Damage Costs of Carbon Dioxide Emissions: An Assessment of the Uncertainties, *Energy Policy*, November. Vol. 33, Issue 16, p. 2064-2074.

<sup>16</sup> IPCC Fourth Assessment Report: Working Group II Report *Impacts, Adaptation and Vulnerability*. 2007. p. 822.

### 5.3 EMISSIONS REDUCTIONS RESULTS

The following section provides emission reduction estimates for the products prescribed by in EISA 2007. DOE estimates that the prescribed standards will save the Nation approximately 490 MMTCE of CO<sub>2</sub> emissions from 2008–2038.

**Table 5.1 Cumulative Carbon Dioxide Emissions Savings and Value of Emission Savings, 2008-2038**

<b>Product</b>	<b>Carbon Dioxide Emission Savings (MMTCE)</b>	<b>Value of Estimated CO<sub>2</sub> Emission Reductions Based on IPCC Range (\$2007 Billion)</b>
Residential Boilers	2.6	0–0.19
Residential Dishwashers	10.2	0–0.74
Incandescent Reflector Lamps	16.1	0–1.18
Dehumidifiers	2.7	0–0.20
Class A External Power Supplies	69.8	0–5.12
Metal Halide Lamp Fixtures	93.6	0–6.86
Electric Motors	2.3	0–0.17
General Service Incandescent Lamps	222.8	0–16.34
Small Commercial Package Air Conditioning and Heating Equipment	45.9	0–3.36
Walk-In Coolers and Walk-In Freezers	21.3	0–1.56
<b>Total</b>	<b>487.1</b>	<b>0–35.72</b>