# Energy Conservation Standards
# for Residential Furnaces
# Rulemaking Analysis Plan
# RIN: 1904-AC06

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

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**RULEMAKING ANALYSIS PLAN**
**FOR RESIDENTIAL FURNACES**

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## I. Overview of the Rulemaking Analysis Plan

The purpose of the rulemaking analysis plan (RAP) is to describe the detailed analytical approaches DOE anticipates using to evaluate potential amended energy conservation standards for residential furnaces. The RAP is intended to inform interested parties of the analytical methods, data sources, and key assumptions DOE plans to use in its NOPR analyses. The RAP is the starting point for developing energy conservation standards and is not a definitive statement on any issue to be determined in the rulemaking. DOE will analyze each product class of residential furnaces to determine whether amended energy conservation standards are

technologically feasible, economically justified, and would result in significant energy savings. DOE will maintain information about this rulemaking on its website at: http://www1.eere.energy.gov/buildings/appliance_standards/residential/furnaces_boilers.html.

## A. Authority

### 1. General

Title III of the Energy Policy and Conservation Act (EPCA) sets forth a variety of provisions designed to improve energy efficiency. Part A[1] of Title III (42 U.S.C. 6291-6309) establishes the Energy Conservation Program for Consumer Products Other Than Automobiles. The program covers consumer products and certain commercial equipment (referred to hereafter as "covered products"), including the residential furnaces that are subject to this rulemaking. (42 U.S.C. 6292 (a)(5)) EPCA prescribed the initial energy conservation standards for residential furnaces. (42 U.S.C. 6295(f)(1)-(2)) The statute further provides DOE with the authority to conduct rulemakings to determine whether to amend these standards. (42 U.S.C. 6295(f)(4))

EPCA provides criteria for prescribing amended standards for covered products. Any amended standard for a covered product must be designed to achieve the maximum improvement in energy efficiency that is technologically feasible and economically justified. (42 U.S.C. 6295(o)(2)(A)) Furthermore, EPCA precludes DOE from adopting any standard that would not result in significant conservation of energy. (42 U.S.C. 6295(o)(3)(B)) EPCA also provides that, in deciding whether a standard is economically justified, DOE must determine whether the

[1] This part was originally titled Part B. It was redesignated Part A in the United States Code for editorial reasons.

benefits of the standard exceed its burdens. (42 U.S.C. 6295(o)(2)(B)(i)) DOE must do so after receiving comments on the proposed standard and by considering, to the greatest extent practicable, the following seven factors:

1. the economic impact of the standard on manufacturers and consumers of the products subject to the standard;
2. the savings in operating costs throughout the estimated average life of the covered products in the type (or class) compared to any increase in the price, initial charges, or maintenance expenses for the covered products that are likely to result from the imposition of the standard;
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 impact of any lessening of competition, as determined in writing by the Attorney General, that is likely to result from the imposition of the standard;
6. the need for national energy and water conservation; and
7. other factors the Secretary considers relevant.

(42 U.S.C. 6295(o)(2)(B)(i)(I)–(VII))

2. Regional Standards

a. General

Section 306(a) of the Energy Independence and Security Act of 2007 (EISA 2007; Pub. L. 110-140) amended EPCA to allow DOE to consider the establishment of separate regional standards for furnaces. (42 U.S.C. 6295(o)(6)(A)) Specifically, EPCA allows for the establishment of a single more-restrictive regional standard in addition to the base national standard. (42 U.S.C. 6295(o)(6)(B)) EPCA stipulates that the regions must include only contiguous states (with the exception of Alaska and Hawaii, which can be included in regions that they are not contiguous with), and that each state may be placed in only one region (i.e., a state cannot be divided among two regions). (42 U.S.C. 6295(o)(6)(C))

EPCA mandates that a regional standard produce significant energy savings in comparison to a single national standard. Further, EPCA provides that DOE must determine that the additional standards are economically justified and consider the impact of the additional regional standards on consumers, manufacturers, and other market participants, including product distributors, dealers, contractors, and installers. (42 U.S.C. 6295(o)(6)(D)) For this rulemaking, DOE will consider the impacts of regional standards in addition to national standards. Section II.A.1 of this document gives an overview of DOE's proposed methodology for analyzing impacts of a regional standard for furnaces, and additional detail about DOE's proposed approach is provided throughout this document in the applicable sections and subsections.

b. Regional Standards Enforcement

EPCA requires that DOE initiate a rulemaking to allow for the enforcement of regional standards not later than 90 days after the issuance of a final rule that sets regional standards. EPCA also states that "not later than 15 months after the date of the issuance of a final rule that establishes a regional standard for a product, the Secretary shall promulgate a final rule covering enforcement of regional standards for the product." Further, EPCA states that "any rules regarding enforcement of a regional standard shall clearly specify which entities are legally responsible for compliance with the standards and for making any required information or labeling disclosures." (42 U.S.C. 6295(o)(6)(G)) At this time, DOE considers EPCA's enforcement requirements as separate from this furnaces standards rulemaking, and as such, DOE plans to address the enforcement requirements in a separate rulemaking. See section II.A.2 of this document for details about the enforcement of regional standards.

3. Standby and Off Mode Energy Consumption

Section 310(3) of EISA 2007 amended EPCA to require that any new or amended energy conservation standard adopted after July 1, 2010 address standby mode and off mode energy use pursuant to 42 U.S.C. 6295(o). (42 U.S.C. 6295(gg)) Specifically, when DOE adopts new or amended standards for certain covered products after July 1, 2010, the final rule must, if justified by the criteria for adoption of standards in section 325(o) of EPCA, incorporate standby mode and off mode energy use into a single standard if feasible, or otherwise adopt a separate standard for such energy use for that product. (42 U.S.C. 6295(gg)(3)) Because the final rule for this

rulemaking is scheduled for issuance after July 1, 2010, DOE plans to address the standby mode and off mode energy use in this rulemaking.

In a NOPR published on July 27, 2009 (Energy Conservation Program for Consumer Products: Test Procedures for Residential Furnaces and Boilers), DOE proposed modifications to the existing furnace test procedures to include the measurement of standby and off mode electrical use. 74 FR 36959. See DOE's residential furnaces and boilers test procedures webpage for more information.[2] For the furnaces energy conservation standards rulemaking that is the subject of today's RAP, DOE intends to develop an analysis to consider new standards for standby and off mode electrical consumption to meet the requirements of EPCA as outlined in the paragraph above. For more details about DOE's approach to considering standards for standby and off mode electrical consumption of residential furnaces, see section II.B.2 of this document.

B. Consensus Agreement

On January 15, 2010, the Air-Conditioning, Heating and Refrigeration Institute (AHRI), American Council for an Energy Efficient Economy (ACEEE), Alliance to Save Energy (ASE), Appliance Standards Awareness Project (ASAP), Natural Resources Defense Council (NRDC), and Northeast Energy Efficiency Partnerships (NEEP) submitted a joint comment to DOE recommending minimum energy conservation standards for residential central air conditioners, heat pumps, and furnaces. The original agreement was completed on October 13, 2009 and had

[2] Available at: http://www1.eere.energy.gov/buildings/appliance_standards/residential/furnace_boiler_tp_nopr_mtg.html.

15 signatories, including AHRI, ACEEE, ASE, NRDC, ASAP, NEEP, Northwest Power and Conservation Council (NPCC), California Energy Commission (CEC), Bard Manufacturing Company Inc., Carrier Residential and Light Commercial Systems, Goodman Global Inc., Lennox Residential, Mitsubishi Electric & Electronics USA, National Comfort Products, and Trane Residential. The recommended minimum energy conservation standards for furnaces are shown in Table I.1.

The consensus agreement recommends standards that divide the nation into three regions for residential central air conditioners and two regions for residential furnaces based on the population-weighted number of heating degree days (HDD) of each state. States with 5000 HDD or more are considered as part of the northern region, while states with less than 5000 HDD are considered part of the southern region. For residential central air conditioners, the consensus agreement establishes a third region – the "southwest" region – comprised of California, Arizona, New Mexico, and Nevada. For furnaces, the southwest region states are included in the southern region. The compliance date specified in the agreement is May 1, 2013 for non-weatherized furnaces and January 1, 2015 for weatherized furnaces.

**Table I.1 Consensus Agreement Proposed Minimum Energy Conservation Standards for Residential Furnaces**

| System Type | Proposed AFUE Requirement for States with ≥ 5000 HDD % | Proposed AFUE Requirement for States with < 5000 HDD* % |
|---|---|---|
| Non-weatherized Gas Furnaces | 90 | 80 |
| Non-weatherized Oil Furnaces | 83 | 83 |
| Gas-Packs (weatherized furnace) | 81 | 81 |

* These states include Arizona, California, New Mexico, and Nevada, which were separated into the "southwest" region for residential central air conditioners.

DOE invites comment from interested parties regarding the consensus agreement. In particular, DOE is interested in comments relating to the proposed AFUE requirements, the proposed regional divisions, and the proposed compliance dates for residential furnace standards. This is identified as issue 1 in section III of this document, "Issues for Which DOE Seeks Comment."

C. Combined Rulemaking Approach

DOE is currently pursuing or planning separate standards rulemakings for three interrelated products: (1) central air conditioners and heat pumps; (2) gas furnaces; and (3) furnace fans. DOE is required by a Court-ordered consent decree to publish a final rule addressing the energy conservation standards for residential central air conditioners and heat pumps by June 30, 2011. A final rule published by DOE in November 2007 amending the minimum energy conservation standards for gas furnaces was remanded by the Courts to DOE under the mandate that DOE publish a new final rule by May 1, 2011. EISA 2007 amended EPCA to require that DOE publish a final rule establishing energy conservation standards for "the electricity used for purposes of circulating air through duct work" (i.e., the electrical energy consumed by furnace fans) by January 1, 2013. (42 U.S.C. 6295(f)(4)(D))

Rather than analyze each set of products separately, DOE is considering combining the analyses to examine how the interaction between the three products impacts the cost to

consumers, the energy savings resulting from potential amended standards, and other factors DOE is required to consider. If DOE conducts such an analysis and the results indicate that a combined approach yields additional savings beyond what can be achieved by considering each product separately, DOE may decide to pursue a combined standards rulemaking that addresses all three products, or two of the three products (i.e., central air conditioners and heat pumps and residential furnaces), simultaneously. If such a combined rulemaking is pursued, DOE would be required to publish the combined final rule by May 1, 2011 to comply with the conditions of the remand agreement for residential furnaces. DOE is seeking comment from interested parties relating to a combined rulemaking regarding energy conservation standards for residential central air conditioners and heat pumps, residential furnaces, and furnace fans. This is identified as issue 2 in section III, "Issues for Which DOE Seeks Comment."

## II. Rulemaking Analyses Overview and Proposed Methodology

### A. Regional Analysis

#### 1. General Approach

As described in section II.A.2 of this document, EISA 2007 amended EPCA to give DOE the authority to consider setting a regional standard level in addition to the national base standard level for furnaces. (42 U.S.C. 6295(o)(6)(A)) As a result, DOE is planning to assess the impacts of a regional standard in this furnace rulemaking. DOE intends to address the potential impacts from regional standards on the relevant NOPR analyses, including the mark-ups to determine product price, the life-cycle cost (LCC), the manufacturer impact analysis (MIA), and the national impact analysis (NIA). DOE's proposed approach for addressing regional standards is

included in the methodology section corresponding to each individual analysis, below. For more information about DOE's approach to developing regional standards, see sections II.G, II.H, II.I, II.J, and II.L of this document, where DOE's approach is described in additional detail. For certain phases of the analysis, additional regional analysis is not required. For example, technologies for improving product efficiency generally do not vary by region, and thus, DOE is not performing any additional regional analysis for the technology assessment and screening analysis. Similarly, DOE will not examine the impacts of having two regions in the engineering analysis, since the technologies and manufacturer processes are the same under both a national and regional standard.

To evaluate regional standards for residential furnaces, DOE proposes to use the regions shown in Table II.1 below. The allocation of individual States to the regions is similar to the methodology DOE used in its evaluation of regional standards in the November 2007 final rule. The allocation used in the November 2007 final rule was approximately based on whether a State's annual heating degree-days (HDD) average is above or below 5,000 HDD. 72 FR 65136, 65146-65147 (November 19, 2007). This level roughly provides a threshold point at which space heating demands are significant enough to require longer operation of heating systems, which provides a basis for utilization of higher-efficiency systems.

DOE is considering two changes from the November 2007 final rule methodology to establish regions. The first is moving Nevada from the Northern region to the Southern region and the second is moving West Virginia from the Southern region to the Northern region. This

change reflects the climate characteristics of these two states – West Virginia has on average more than 5000 HDD and Nevada's major population areas have fewer than 5000 HDD. The considered changes would result in regional definitions that are the same as the regions defined in the consensus agreement. DOE is seeking comment from interested parties about the regions proposed in Table II.1. This is identified as issue 3 in section III of this RAP, "Issues on Which DOE Seeks Comment."

**Table II.1 Proposed Regions for Regional Analysis in the Current Furnace Rulemaking**

| Northern Region States | Southern Region States |
|---|---|
| Alaska | Alabama |
| Colorado | Arizona |
| Connecticut | Arkansas |
| Idaho | California |
| Illinois | Delaware |
| Indiana | Dist. of Columbia |
| Iowa | Florida |
| Kansas | Georgia |
| Maine | Hawaii |
| Massachusetts | Kentucky |
| Michigan | Louisiana |
| Minnesota | Maryland |
| Missouri | Mississippi |
| Montana | Nevada |
| Nebraska | New Mexico |
| New Hampshire | North Carolina |
| New Jersey | Oklahoma |
| New York | South Carolina |
| North Dakota | Tennessee |
| Ohio | Texas |
| Oregon | Virginia |
| Pennsylvania | |
| Rhode Island | |
| South Dakota | |
| Utah | |
| Vermont | |
| Washington | |
| West Virginia | |
| Wisconsin | |

| | |
|---|---|
| Wyoming | |

2. Regional Standards Enforcement

DOE has not yet determined the enforcement mechanism for regional standards; however, DOE believes that an effective enforcement plan will likely be composed of multiple enforcement mechanisms. Among mechanisms DOE is considering are:

1. appropriate modifications to appliance labels to indicate in which regions of the country specific products are allowed to be installed;
2. requirements that marketing literature for systems clearly indicate in which regions a product could be legally installed;
3. encouraging state and local entities to adopt these regional standards in building codes and to provide reference to the required minimum efficiencies in required mechanical or electrical permits;
4. encouraging states who have regional appliance standards to adopt and codify the appropriate regional standards enacted by DOE;
5. providing that installations that don't meet regional standards could result in installers being subject to fines for each occurrence;
6. requirements to certify compliance of installations through warranty registration or other registration means;
7. an informational program so that consumers are made aware of any regional standards, what to look for in purchasing products, and what implications there would be for improper installation; and

8. competitively driven enforcement where manufacturers/distributors/contractors report other manufacturers/distributors/contractors whose actions result in installations not in compliance with Federal standards.

Certain goals of any enforcement plan would be that it not unduly regulate interstate commerce or otherwise constrain where a product may be manufactured or through which states a product can be transported and that it not place undue financial burden on consumers, manufacturers, contractors, distributors, dealers or installers. While DOE believes that much of the liability for proper installation will inevitably lie with the installer, it also believes that manufacturers and distributors can play a role in enforcement through labeling and possibly providing data, such as ongoing statistics, regarding non-complying products sold for final installation in a given region.

For the NOPR, as part of its analysis of regional impacts on distributors, dealers, contractors, and installers, DOE will analyze California's Title 24 requirements and other extant state-level standards and consider the issues that have developed concerning their enforcement. DOE will also seek industry input on the viability of the above enforcement mechanisms, other mechanisms DOE should consider, and the extent to which these mechanisms would result in additional financial burdens to consumers, manufacturers, contractors, distributors, dealers, and installers. DOE will consider all comments related to enforcement of regional standards submitted before the issuance of an enforcement plan rulemaking. DOE specifically seeks data

on how, if at all, the enforcement options listed above would increase compliance or other costs. This is identified as issue 4 in section III of this RAP, "Issues on Which DOE Seeks Comment."

EPCA also gave DOE the authority to consider regional standards for residential central air conditioners and heat pumps. Chapter 17 of the residential central air conditioners preliminary TSD details doe's preliminary analysis on the potential impacts of regional standards on market participants other than manufacturers and consumers for residential air conditioners and heat pumps and residential furnaces. This chapter identifies the primary market participants, including distributors, contractors and general contractors, describes their basic business models and assesses how additional regional standards may impact those models. For more information on the regional standards analysis for both rulemakings, please see chapter 17 of the residential central air conditioner preliminary TSD, located on DOE's website at http://www1.eere.energy.gov/buildings/appliance_standards/residential/central_ac_hp.html

B. Test Procedures

1. Annual Fuel Utilization Efficiency

EPCA defines the energy-efficiency descriptor for residential furnaces as AFUE. (42 U.S. C. 6291(22)(A)) AFUE is determined using test procedures prescribed pursuant to EPCA and based on the assumptions that: (1) all weatherized warm air furnaces are located outdoors, and (2) warm air furnaces that are not weatherized are located indoors, with all combustion and ventilation air being admitted through grills or ducts from the outdoors that do not communicate with air in the conditioned space. (42 U.S.C. 6291(22)(A)-(B)) DOE's test procedures are

codified at 10 CFR part 430, Subpart B, App. N. The current test procedure for residential furnaces accounts for the fuel consumption in active mode, standby mode, and off mode, and the electrical consumption in active mode. The current test procedure does not capture the standby and off mode electrical energy consumption.

2. Standby and Off Mode Energy Consumption

a. EISA 2007 Requirements

Section 310(3) of EISA 2007 amended EPCA to require that when DOE adopts new or amended standards for certain covered products after July 1, 2010, the final rule must, if justified by the criteria for adoption of standards in section 325(o) of EPCA, incorporate standby mode and off mode energy use into a single standard if feasible, or otherwise adopt a separate standard for such energy use for that product. (42 U.S.C. 6295(gg)(3)) Because the final rule for this rulemaking is scheduled for issuance after July 1, 2010, DOE plans to address the standby mode and off mode energy use in this rulemaking.

b. Incorporation of Standby and Off Mode Electrical Energy Consumption into the DOE Test Procedure for Residential Furnaces

In active mode, standby mode and off mode, residential furnaces can consume both electricity and fossil fuel. As stated previously, DOE must account for standby mode and off mode consumption of both types of energy in the residential furnaces final rule. In a NOPR published on July 27, 2009 (Energy Conservation Program for Consumer Products: Test Procedures for Residential Furnaces and Boilers), DOE tentatively concluded that the existing test procedures for residential furnaces and boilers already fully account for and integrate

standby mode and off mode fossil fuel energy consumption for gas-fired and oil-fired furnaces. In addition, DOE proposed modifications to the existing furnace test procedures (10 CFR Part 430 Subpart B Appendix N) to include the measurement of standby and off mode electrical energy use of residential furnaces and boilers. 74 FR 36959 (July 27, 2009).

DOE stated in the July 2009 NOPR that its existing AFUE test procedure, together with clarifying definitions of ''active mode'' and ''standby mode,'' provides a complete accounting of fossil fuel energy consumption during the entire heating season, because the test procedure's on-cycle and off-cycle are essentially identical in meaning to EISA 2007's ''active mode'' and ''standby mode,'' respectively. 74 FR 36962. AFUE also accounts for the non-heating season fossil fuel energy consumption (e.g., pilot light non-heating energy consumption). Non-heating season directly relates to the EISA 2007 definition of ''off mode.'' Accordingly, DOE tentatively concluded in the July 2009 NOPR that the AFUE provides a full accounting of active, standby and off mode fossil fuel energy consumption pursuant to EISA 2007. 74 FR 36963.

To include the measurement of standby and off mode electrical energy use, DOE proposed in the July 2009 NOPR to incorporate into the existing DOE test procedures for residential furnaces and boilers the International Electrotechnical Commission's (IEC) Standard 62301, Household electrical appliances—Measurement of standby power (First Edition 2005–06), as well as language to clarify application of this standard. 74 FR 36970. DOE also proposed to add definitions of standby mode and off mode for furnaces in section 2.0 of the current DOE

test procedure. Id. These amendments, if finalized, would add new methods to determine annual energy consumption associated with standby mode and off mode electrical use.

DOE intends to use the test procedures and definitions outlined in the July 2009 NOPR in the furnace standards rulemaking to develop energy conservation standards for the standby mode and off mode energy consumption for residential furnaces pursuant to EPCA section 325(o).

c. Metric for Standby and Off Mode Electrical Power Consumption

As mentioned previously, section 325(gg)(3)(A)(2) of EPCA mandates that "any final rule establishing or revising a standard for a covered product, adopted after July 1, 2010, shall incorporate standby mode and off mode energy use into a single amended or new standard, pursuant to subsection (o), if feasible." If not feasible, the Secretary shall prescribe within the final rule a separate standard for standby mode and off mode energy consumption, if justified under subsection (o). (42 U.S.C. 6295(gg)(3)(B) For residential furnaces, EISA 2007 requires that DOE modify the existing efficiency metric (i.e., AFUE) to incorporate the standby and off mode electrical energy use into a single standard unless DOE determines it is not feasible.

DOE has determined that incorporating standby and off mode energy consumption into a single standard for residential furnaces based on an amended AFUE efficiency metric is technically feasible. Therefore, pursuant to EISA 2007, DOE will develop a new, integrated annual fuel utilization efficiency metric, $AFUE_I$. $AFUE_I$ will be a function of the active, standby, and off mode fossil fuel energy consumption and the standby and off mode electrical energy

consumption measurements attained using the DOE test procedure, and will serve as the efficiency descriptor for the energy conservation standards prescribed in this rulemaking. A detailed description of the integration of standby and off mode energy consumption into $AFUE_I$ will be described during the test procedure rulemaking process for residential furnaces and boilers, which is described on the DOE website: http://www1.eere.energy.gov/buildings/appliance_standards/residential/furnaces_boilers.html As part of the test procedure rulemaking, interested parties can submit comments on the methodology used by DOE to incorporate standby and off mode electrical energy consumption into $AFUE_I$.

d. Methodology for Investigating Standby and Off Mode Electrical Power Consumption

DOE will follow the DOE test procedure, as proposed, to measure the standby mode and off mode power consumption rates, $P_{SB}$ and $P_{OFF}$, respectively, for each furnace it tests. Specifically, to measure the standby mode electrical demand, $P_{SB}$, DOE will execute the IEC Standard 62301 as proposed in the July 2009 NOPR. Although the proposals in the July 2009 NOPR have provisions for those furnaces that have a seasonal off switch, DOE believes it is reasonable to assume that most consumers are unlikely to set their furnaces to the off mode. Hence, DOE is assuming that furnaces will be consuming electricity at their respective standby rates during all non-active mode hours, and, accordingly, $P_{OFF}$ should be assumed to be equivalent to $P_{SB}$. DOE requests comment on the validity of this assumption, which is identified as issue 5 in section III, "Issues on Which DOE Seeks Comment." As part of this activity, DOE intends to test over 40 furnace models. The units selected for testing will be common and widely

available, come from multiple manufacturers, span the range of commercially-available efficiencies, and include a variety of features, such as the control components associated with single-stage or modulating burners and permanent split capacitor blower motor or electronically commutated blower motor.

The $AFUE_I$ standards will be based on the test data, as well as data from the AHRI database and manufacturer specification sheets and any other pertinent data the DOE might receive. DOE seeks comment on all aspects of this approach to setting standards based on $AFUE_I$ to account for furnace standby and off mode energy consumption. This is identified as issue 6 in section III of this RAP, "Issues on Which DOE Seeks Comment."

C. Market and Technology Assessment

1. Scope of Coverage

EPCA defines a residential "furnace" as a product that (1) either utilizes only single-phase electric current, or utilizes single-phase electric current or DC current in conjunction with natural gas, propane, or home heating oil; (2) is designed to be the principal heating source for the living space of a residence; (3) is not contained within the same cabinet with a central air conditioner whose rated cooling capacity is above 65,000 Btu per hour; (4) is an electric central furnace, electric boiler, forced- air central furnace, gravity central furnace, or low pressure steam or hot water boiler; and (5) has a heat input rate of less than 300,000 Btu per hour for electric boilers and low pressure steam or hot water boilers and less than 225,000 Btu per hour for forced-air central furnaces, gravity central furnaces, and electric central furnaces. (42 U.S.C.

6291(23)) This definition covers several different types of products, including: (1) gas furnaces (non-weatherized and weatherized); (2) oil-fired furnaces (non-weatherized and weatherized); (3) mobile home furnaces (gas and oil-fired); (4) electric resistance furnaces; (5) hot water boilers (gas and oil-fired); (6) steam boilers (gas and oil-fired); and (7) combination space/water heating appliances (water-heater/fancoil combination units and boiler/tankless coil combination units).

DOE is excluding combination space/water heating appliances from consideration in this rulemaking, as was done in the November 2007 final rule. DOE excluded these products from the November 2007 final rule because an adequate test procedure did not exist that would allow DOE to set minimum standards for these products. 71 FR 59204, 59214 (October 6, 2006). DOE will not consider such products as part of this rulemaking because DOE has not adopted a test procedure for combination appliances.

DOE also is not considering amending standards for any residential boiler product classes. Standards for residential boilers were recently amended by section 303(3) of EISA 2007 and incorporated into EPCA. (42 U.S.C. 6295(f)(3)) As a result of the EISA 2007 standards for residential boilers, DOE issued a technical amendment final rule that codified those standards in the code of federal regulations (CFR) at 10 CFR part 430.32(e)(2)(ii). 73 FR 43611, July 28, 2008. DOE considers the recently revised standards set by EISA 2007 as addressing the requirements of the remand for residential boilers, and thus is only considering residential furnaces in this rulemaking.

For residential furnaces, DOE is maintaining the same scope of coverage as the November 2007 rulemaking, which includes four product classes of furnaces (non-weatherized gas, weatherized gas, mobile home gas, and oil-fired non-weatherized). DOE is not considering amended standards for mobile home oil-fired furnaces and weatherized oil-fired furnaces because there are very few shipments of these products. DOE initially made this determination for the November 2007 final rule, and the market for mobile home oil furnaces and oil-fired weatherized furnaces has not changed. 71 FR 59204, 59214 (October 6, 2006).

2. Product Classes

DOE intends to separate residential furnaces into distinct product classes for this rulemaking. EPCA specifies the criteria for product class separation, as described in section II.A.1, which include: (1) the type of energy consumed; (2) capacity; or (3) other performance-related features, considering the utility to the consumer and other factors deemed appropriate by the Secretary that would justify the establishment of a separate energy conservation standard. (42 U.S.C. 6295(q))

Because the current residential furnaces market is not significantly different as compared to the market that existed for the November 2007 residential furnaces rulemaking in terms of the types of products available, DOE plans to continue the use of the product classes established for residential furnaces, which were developed during the previous rulemaking (i.e., those established for the November 2007 furnaces and boilers final rule). The November 2007 final

rule divided products by fuel type (gas versus oil-fired) and by efficiency related features, such as whether they were weatherized (i.e., intended for outdoor installation) or non-weatherized (i.e., intended for indoor installation). The November 2007 final rule also considered gas-fired mobile home furnaces as a separate product class due to the unique constraints (related to size and venting) that are placed on those products. Therefore, the product classes that DOE plans to consider in this rulemaking are: non-weatherized gas furnaces, weatherized gas furnaces, gas-fired mobile home furnaces, and non-weatherized oil-fired furnaces. DOE is seeking comment on its planned product classes for this rulemaking. This is identified as issue 7 in section III of this RAP, "Issues on Which DOE Seeks Comment." The current energy conservation standards for these products are codified at 10 CFR 430.32(e)(1)(i), and are also listed in Table II.3 of this RAP.

3. Market Assessment

As part of the market assessment, DOE will qualitatively and quantitatively characterize the structure of the furnaces market. DOE will identify and characterize the manufacturers of furnaces, estimate market shares and trends in the market, and address regulatory and non-regulatory initiatives impacting the market that are intended to improve the energy efficiency or reduce the energy consumption of residential furnaces.

The market assessment phase allows DOE to gather data that will assist in identifying important issues later in the rulemaking, such as potential small business impacts, competitive disruptions, and other factors that may arise from enacting standards. For example, DOE will use

historical product shipments and prices as an indicator of future shipments and prices. Market structure data will be particularly useful for assessing competitive impacts as part of the manufacturer impact analysis. This phase also allows DOE to start identifying technologies commonly used for improving efficiency by reviewing product literature, industry publications, and company websites.

DOE understands that there are considerable data available on manufacturers, market shares, and other information. Such data are essential to the development of technologically feasible, economically justified energy conservation standards. Interested parties are encouraged to submit any available, applicable data to DOE. DOE expects that feedback from interested parties, such as the Air Conditioning, Heating and Refrigeration Institute (AHRI, which is the trade association for manufacturers of furnaces), manufacturers, utilities, organizations promoting appliance energy efficiency, and other interested parties will play an important role in providing market information, including information on manufacturers, market shares, and trends in the market.

4. Technology Assessment

Typically, DOE uses information about existing and past technology options and prototype designs as input for identifying the technologies manufacturers could use to meet or exceed energy conservation standards. Based on the technologies considered in the previous rulemaking for residential furnaces and in consultation with interested parties, DOE intends to develop a complete list of technologies that should be considered in the analysis. Initially, this

list will include all those technologies considered to be technologically feasible and will serve to establish the maximum technologically feasible (max-tech) design. DOE intends to consider only technologies that will improve the AFUE as measured by DOE's test procedure for residential furnaces in 10 CFR part 430, Subpart B, App. N, because these technologies would be the technologies manufacturers would most likely implement as a result of amended energy conservation standards. DOE will develop a list of technologies based on both technologies considered for the November 2007 final rule and feedback from interested parties. DOE is seeking comment on the technologies that should be considered for improving the energy-efficiency of residential furnaces. This is identified as issue 8 in section III of this RAP, "Issues on Which DOE Seeks Comment."

D. Screening Analysis

The purpose of the screening analysis is to screen out technologies that will not be considered further in the analysis. These "screened out" technologies will not be considered as possible methods of improving the efficiency of residential furnaces. Following development of the initial list of technologies (during the market and technology assessment), DOE will review and evaluate each technology based on the following four criteria, as specified by 10 CFR part 430, subpart C, appendix A, 4(a)(4) and 5(b):

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

2. Practicability to manufacture, install, and service. If mass production and reliable installation and servicing of a technology in commercial products could be achieved on the scale necessary to serve the relevant market at the time the standard comes into effect, then DOE will consider that technology practicable to manufacture, install, and service.
3. Adverse impacts on product or equipment utility to consumers or availability. If DOE determines a technology would have a significant adverse impact on the utility of the product to significant subgroups of consumers, or would result in the unavailability of any covered product type with performance characteristics (including reliability), features, sizes, capacities, and volumes that are substantially the same as products generally available in the United States at the time, it will not consider this technology further.
4. Adverse Impacts on Health or Safety. If DOE determines that a technology will have significant adverse impacts on health or safety, it will not consider this technology further.

DOE's reasoning for eliminating any technologies from consideration during the screening analysis will be documented and published as part of the NOPR, and will be available for review and comment by interested parties.

## E. Engineering Analysis

### 1. Overview and Approach

The engineering analysis estimates the cost-efficiency relationship, which is the cost of products at various levels of increased energy efficiency above the baseline efficiency (i.e., the minimum efficiency required by energy conservation standards). This relationship shows the changes in manufacturing costs that result from achieving increased efficiency and serves as the basis for the subsequent cost-benefit calculations in terms of individual consumers, manufacturers, and the Nation. In determining the cost-efficiency relationship, DOE will estimate the increase in manufacturer cost associated with the efficiencies available on the market and technologies that manufacturers could use to increase the efficiency of the covered products above the baseline efficiency (i.e., the minimum efficiency allowed by energy conservation standards).

Residential furnace manufacturers structure their product lines around efficiency (this is particularly true for non-weatherized gas furnaces where manufacturers typically offer lower efficiency non-condensing products as well as high efficiency condensing products) and sell significant volumes of higher-efficiency products (i.e., condensing furnaces) to certain areas. Because of these market characteristics, it possible to determine the cost-efficiency relationship for residential furnaces largely by examining actual products in the marketplace instead of estimating the cost and performance of individual design options using theoretical models.

In the past, DOE has identified the following three methodologies to generate the manufacturing costs needed for the engineering analysis: (1) the design-option approach, which provides the incremental costs of adding to a baseline model design options that will improve its efficiency; (2) the efficiency-level approach, which provides the relative costs of achieving increases in energy efficiency levels, without regard to the particular design options used to achieve such increases; and (3) the cost-assessment (or reverse-engineering) approach, which allows for "bottom-up" manufacturing cost assessments for achieving various levels of increased efficiency, based on detailed data as to costs for parts and material, labor, shipping/packaging, and investment for models that operate at particular efficiency levels.

DOE plans to conduct the engineering analysis for the residential furnaces NOPR by using a combination of the efficiency level approach and the cost assessment approach. The efficiency level approach will be used to identify the incremental improvements in efficiency that are achievable for each product, and the cost-assessment approach will be used to develop the manufacturing cost at each efficiency level. DOE will identify the most common residential furnace efficiencies during the market assessment and will determine the corresponding distinguishing technology features associated with those efficiency levels. After identifying the most common products that represent a cross section of the market, DOE plans to gather additional information through the reverse-engineering of existing products, product information from manufacturer catalogs, and discussions with residential furnace manufacturers.

Subsequently, DOE will generate a bill of materials (BOM) by disassembling multiple manufacturers' products that span a range of efficiency levels for each of the four product classes. The BOMs will describe the product in detail, including all manufacturing steps required to make and/or assemble each part. DOE will use the BOMs to develop a cost model that will convert the BOMs and efficiency levels into manufacturer production costs (MPCs). By applying derived manufacturer markups to the MPCs, DOE will calculate the manufacturer selling prices (MSPs) and construct industry cost-efficiency curves. DOE's proposed approach for the engineering analysis is described in further detail in the sections that follow.

2. Representative Furnace Characteristics

For this analysis, DOE plans to examine furnaces that have characteristics that are representative of most furnaces currently available on the market. In the analysis for the November 2007 final rule, DOE identified several characteristics common to baseline furnaces. DOE began its investigation with the representative characteristics identified in the 2007 rulemaking. However, DOE's preliminary research has shown that a few product characteristics have changed. Common furnace characteristics for each product class are shown in Table II.2. DOE seeks comment from interested parties about the most commonly incorporated characteristics of residential furnaces. This is identified as issue 9 in section III of this RAP, "Issues on Which DOE Seeks Comment."

**Table II.2 Characteristics of Representative Residential Furnaces**

| Product Class | Input Capacity Btu/h | Configuration | Heat Exchanger Type | Ignition | Draft |
|---|---|---|---|---|---|

| | | | | | |
|---|---|---|---|---|---|
| Non-Weatherized Gas Furnaces | 75,000 | Upflow | Clamshell/Tubular | Hot Surface | Induced |
| Weatherized Gas Furnaces | 75,000 | Horizontal | Clamshell/Tubular | Hot Surface | Induced |
| Mobile Home Gas Furnaces | 80,000 | Downflow | Clamshell/Tubular | Hot Surface | Natural |
| Non-Weatherized Oil Furnaces | 105,000 | Upflow | Drum | Intermittent Ignition | Forced |

3. Baseline Units

DOE will select a baseline model as a reference point for each product class, against which it can estimate changes manufacturers will likely implement to improve efficiency performance as the result of more stringent energy conservation standards. The baseline model in each product class represents the typical characteristics of minimally efficient products in that class. DOE will use the baseline models in the engineering analysis, and the LCC and payback period (PBP) analyses. To determine energy savings and changes in MSP, DOE will compare each higher-efficiency level against the baseline efficiency in each product class. DOE will select a baseline model for each product class that just meets current energy conservation standards for that class.

The energy conservation standards for residential furnaces are codified at 10 CFR 430.32(e)(1)(i), which sets forth the existing standard levels for residential furnaces (see Table II.3). DOE will consider the current Federal standard levels to represent the baseline efficiency in each product class (i.e., the levels shown in Table II.3). The minimum standard levels are specified in terms of AFUE.

DOE seeks comment on what is the industries' typical baseline design for residential furnaces that are currently on the market in each product class. This is identified as issue 10 in section III of this RAP, "Issues on Which DOE Seeks Comment."

**Table II.3 Existing Residential Furnace Standards**

| **Product Class** | **Minimum AFUE Rating %** |
|---|---|
| Furnaces (excluding the other furnace classes listed) | 78 |
| Mobile Home Furnaces | 75 |
| Weatherized Small Furnaces (input capacity < 45,000 Btu/h) | 78 |
| Non-weatherized Small Furnaces (input capacity < 45,000 Btu/h) | 78 |

4. Max-Tech Efficiency Level

The "max-tech" efficiency levels are the maximum technologically feasible efficiency levels possible for each product class. As required by 325(o) of EPCA, DOE will determine the max-tech efficiency level for each residential furnace product class. (42 U.S.C. 6295(o)) DOE has tentatively identified the max-tech efficiency levels as being the highest efficiencies on the market at the representative capacities. Table II.4 shows the max-tech efficiency levels for the representative capacities in each product class that DOE plans to consider in the NOPR analysis. DOE is seeking comment from interested parties on these efficiency levels. In particular, DOE is seeking any data or information regarding prototype designs that may be capable of allowing

furnaces to achieve AFUE values above those identified in Table II.4. This is identified as issue 11 in section III of this RAP, "Issues on Which DOE Seeks Comment."

**Table II.4 Max-tech Efficiency Levels**

| **Product Class** | **Max-tech AFUE %** |
|---|---|
| Non-weatherized Gas | 97.5 |
| Weatherized Gas | 81 |
| Mobile Home Gas | 95.5 |
| Non-weatherized Oil-fired | 97 |

5. Efficiency Levels for Analysis

For each residential furnace product class, DOE intends to analyze both the baseline and max-tech efficiency level, as well as several efficiency levels between those levels. DOE will choose efficiency levels between the baseline and max tech levels for each product class that are the most commonly available efficiencies on the market as determined in the market assessment. The efficiency levels DOE plans to analyze for each product class are shown in Table II.5 through Table II.8. DOE requests comment about the proposed efficiency levels for analysis for each product class. Specifically, DOE seeks information about any additional efficiencies or technologies that should be analyzed that may not be captured in the efficiency levels DOE is proposing. Additionally, DOE is requesting comments about whether any of the efficiencies proposed for the analysis will capture the same or very similar technologies, and thus be repetitive of one another, in which case DOE may not need to analyze both efficiency levels. This is identified as issue 12 in section III of this RAP, "Issues on Which DOE Seeks Comment."

**Table II.5 Efficiency Levels for Analysis for Non-weatherized Gas Furnaces**

| Efficiency Level | AFUE<br>% |
|---|---|
| 0 – Baseline | 78 |
| 1 | 80 |
| 2 | 90 |
| 3 | 92 |
| 4 | 93 |
| 5 | 95 |
| 6 – Max-tech | 97.7 |

**Table II.6 Efficiency Levels for Analysis for Weatherized Gas Furnaces**

| Efficiency Level | AFUE<br>% |
|---|---|
| 0 – Baseline | 78 |
| 1 | 79 |
| 2 | 80 |
| 3 – Max-tech | 81 |

**Table II.7 Efficiency Levels for Analysis for Mobile Home Furnaces**

| Efficiency Level | AFUE<br>% |
|---|---|
| 0 – Baseline | 75 |
| 1 | 80 |
| 2 | 90 |
| 3 | 92 |
| 4 | 93 |
| 5 – Max-tech | 95.5 |

**Table II.8 Efficiency Levels for Analysis for Non-weatherized Oil-fired Furnaces**

| Efficiency Level | AFUE<br>% |
|---|---|
| 0 – Baseline | 78 |
| 1 | 80 |
| 2 | 83 |
| 3 | 84 |
| 4 | 85 |
| 5 – Max-tech | 97 |

6. Teardown Analysis

The term "teardown analysis" describes DOE's process of estimating the manufacturer production costs of products through reverse-engineering (i.e., physically disassembling the products and examining existing product designs). The availability of a large number of residential furnaces across a wide range of efficiencies will allow DOE to consider the technologies most commonly used by manufacturers to improve the energy-efficiency of their products. The teardown analysis approach allows DOE to accurately estimate the manufacturers' cost of production. DOE will purchase and disassemble furnaces across a range of efficiencies in each product class, and characterize each furnace component according to its weight, dimensions, material, quantity, and the manufacturing processes used to fabricate and assemble it. The result of each teardown will be a detailed BOM that DOE will use as an input to the cost model.

A supplementary method to the "physical teardown" is a "virtual teardown," which uses published manufacturer catalogs and supplementary component data to estimate the physical differences between a product that was physically disassembled and a similar product that was not. DOE may perform "virtual teardowns" of products that differ from a physical teardown unit in ways that are easily identifiable and quantifiable in manufacturer literature.

For the teardown analysis DOE plans to include 43 "physical teardowns" and may include additional "virtual teardowns," as needed to supplement the analysis of residential furnaces.

a. Selection of Units

In the process of selecting units for teardowns, DOE intends to identify and select representative units across the entire range of efficiencies that are currently available to consumers. To the extent possible, all major efficiency levels and technologies will be captured in the selection of models for teardown analysis. Each product class will be considered separately.

Teardown units must be representative of the product class, and as such the input capacities of the teardown units will be chosen as close as possible to the representative input capacity and characteristics for each respective product class (see section II.E.2). DOE will also require that teardown units are manufactured in considerable volume, are commonly available, and have the most popular features.

In addition to the criteria specified in the paragraph above, DOE also adopted more specific criteria to guide the selection process. In order to understand incremental manufacturing costs in improving efficiency, products chosen for teardowns should be from the same manufacturer and product series to the extent possible. This minimizes the cost effects of non-efficiency-related design differences between models. The manufacturers that are chosen will have large market shares of the particular product class. An exception to this criterion may be made for the highest efficiency product (or max-tech product) in each product class because it will be chosen for teardown analysis irrespective of manufacturer. DOE will also attempt to

minimize the differences in non-efficiency-related features across the range of efficiency levels for products in the same product class. The selections will minimize the occurrence of non-efficiency-related premium features, which could over-inflate the incremental manufacturing cost of achieving higher-efficiency levels.

Because the large majority of residential furnace shipments fall into the non-weatherized gas product class, DOE will focus heavily on non-weatherized gas-fired furnaces. As a result, DOE plans to select units for teardown that will include approximately 25 non-weatherized gas-fired furnaces, 4 weatherized gas-fired furnaces, 6 mobile home gas-fired furnaces, and 8 non-weatherized oil-fired furnaces. The models for teardown that DOE plans to select are described in more detail below. DOE invites comment from interested parties about the teardown selection criteria. This is identified as issue 13 in section III of this RAP, "Issues on Which DOE Seeks Comment."

i. Non-Weatherized Gas Furnaces

As mentioned above, non-weatherized gas-fired furnaces represent the vast majority of the furnace market. Therefore, DOE's teardown analysis will include 25 models that are representative of the efficiency levels and technology options available for these types of furnaces on the market. Residential furnace manufacturers typically offer products in two distinct efficiency ranges: non-condensing (i.e., efficiencies between 78-percent and 82-percent AFUE) which make up approximately 57 percent of the market, based on the distribution of models in the AHRI residential furnace directory, and condensing (i.e., at or above 90-percent AFUE)

which make up approximately 43 percent of the residential furnace market, based on the distribution of models in the August 2009 AHRI residential furnace directory. Whenever possible, DOE will select the least efficient and the most efficient units in the given efficiency range. DOE plans to select seven units for teardown analysis in the non-condensing range (at or near 80-percent AFUE) and 18 in the condensing range (ranging from 90-percent to 97.7-percent AFUE).

Some manufacturers produce products with very basic design and construction differences that do not appear to have a significant impact on the overall efficiency of the furnaces. To examine the potential effects of common design differences (such as tubular versus clamshell heat exchangers) on MPC at different efficiencies, DOE will select products from different manufacturers that contain different design approaches. This will allow DOE to develop the manufacturing production costs for both design approaches. DOE can then use a market-share weighted-average cost of the designs to develop an overall industry cost-efficiency relationship.

ii. Weatherized Gas Furnaces

According to the certified ratings in the August 2009 AHRI directory, manufacturers of weatherized gas-fired furnaces offer products between 78-percent and 81-percent AFUE. DOE plans to select four representative units to analyze across the entire range of available efficiencies. The selected units will span the full efficiency range available at the representative input capacity for this product class.

Manufacturers typically sell weatherized furnaces as "packaged" units, meaning the unit includes both a furnace and an air conditioner together in a single package. Contractors typically install packaged units outside of a residence. The weatherized gas furnace units that DOE will select for the teardown analysis are paired with air conditioners at a three-ton capacity, which is the representative cooling capacity for residential central air conditioners.

iii. Mobile Home Gas Furnaces

Mobile home gas-fired furnace manufacturers offer products at the representative input capacity at several efficiency levels spanning a range from 80-percent to 95.5-percent AFUE. DOE intends to select six units for the teardown analysis across the range of efficiencies.

iv. Non-weatherized Oil-fired Furnaces

Manufacturers of non-weatherized oil-fired furnaces typically offer products between 78-percent and 97-percent AFUE. At or near the representative input capacity, available AFUEs range from 78.8 percent to 97 percent. DOE plans to perform a teardown analysis on eight units, spanning the available efficiency range.

b. Scaling to Other Input Capacities

DOE recognizes that there is a large variation in the input capacity rating of residential furnaces beyond the representative input capacity, which causes large variations in manufacturer production costs. To account for this variation, DOE plans to analyze additional common input

capacities (as determined by the market assessment) for the largest class of residential furnaces, non-weatherized gas furnaces. DOE will perform teardowns of several non-weatherized gas furnaces above and below the representative input capacity to gather the necessary data to accurately scale the results from the representative input capacity to other input capacities. Performing teardowns of models outside of the representative capacity will allow DOE to accurately model certain characteristics that are not identifiable in manufacturer literature. DOE plans to analyze models at input capacities of 50,000 Btu/h and 125,000 Btu/h in addition to the models at the representative input capacity. DOE seeks comment on the appropriateness of the additional input capacities that will be analyzed. This is identified as issue 14 in section III of this RAP, "Issues on Which DOE Seeks Comment."

c. Cost Model

The end result of each teardown will be a structured BOM. DOE will develop structured BOMs for each of the physical and virtual teardowns. The BOMs will incorporate all materials, components, and fasteners classified as either raw materials or purchased parts and assemblies, and characterize the materials and components by weight, manufacturing processes used, dimensions, material, and quantity. DOE will create a Microsoft Excel spreadsheet (i.e., the Cost Model) that converts the materials and components in the BOMs into dollar values based on the price of materials, labor rates associated with manufacturing and assembling, and the cost of overhead and depreciation. Thus, this spreadsheet will model the cost for a manufacturer to produce a residential furnace. To convert the information in the BOMs to dollar values for the NOPR analysis, DOE will collect information on labor rates, tooling costs, raw material prices,

and other factors. For purchased parts, the cost model will estimate the purchase price based on volume-variable price quotations and detailed discussions with manufacturers and component suppliers. For fabricated parts, the prices of raw metal materials (e.g., tube, sheet metal) will be estimated based on 5-year average prices. The cost of transforming the intermediate materials into finished parts will be estimated based on industry pricing at the time of the analysis.

7. Manufacturer Selling Price

DOE plans to apply a non-production cost multiplier (i.e., a manufacturer markup) to the full MPC to account for corporate non-production costs and profit. The resulting manufacturer selling price (MSP) is the price at which the manufacturer can recover all production and non-production costs and earn a profit. To meet new or amended energy conservation standards, manufacturers often introduce design changes to their product lines that result in increased manufacturer production costs. Depending on the competitive environment for these particular products, some or all of the increased production costs may be passed from manufacturers to retailers and eventually to customers in the form of higher purchase prices. As production costs increase, manufacturers typically incur additional overhead.

For the residential furnaces NOPR, DOE plans to estimate the manufacturer markup from publicly available financial information (e.g., Securities and Exchange Commission (SEC) 10-K reports). Then, DOE intends to apply the calculated manufacturer markup to the MPC to derive the MSP.

In the analysis for the November 2007 final rule, DOE used a manufacturer markup of 1.26, which resulted from a combination of DOE's analysis of SEC 10-K reports and an effort to be consistent with the central air conditioner rulemaking (for more information see chapter 5 of the November 2007 final rule TSD). DOE invites comment from interested parties about whether the manufacturer markup used in the previous analysis is still applicable for this analysis. This is identified as issue 15 in section III of this NOPM, "Issues on Which DOE Seeks Comment."

## F. Markups to Determine Product Price

The LCC and PBP analyses require among their inputs: (1) the price consumers pay for baseline products, and (2) the incremental prices consumers would pay to purchase more efficient products that meet a given energy conservation standard. DOE uses distribution chain markups to convert the manufacturer selling price from the engineering analysis to consumer prices.

### 1. Description of Market Participants and Distribution Channels

Before developing markups, DOE must first define all market participants and identify distribution channels. Generally, the furnace distribution chain includes six market participants: (1) distributors; (2) dealers; (3) general contractors; (4) mechanical contractors; (5) installers; and (6) builders. Based on comments regarding the similarities of market participants, DOE will consider three distinct categories of market participants: "distributors," "mechanical contractors," and "general contractors." The category of "mechanical contractors" includes dealers and installers. The category of "general contractors" also includes builders.

Distributors receive shipments from manufacturers and resell the products at a markup to contractors. No other participant in the channel carries significant inventory, so distributors absorb imbalances between manufacturer supply and consumer demand.

Most contractors compete at the local level and the majority of them are small businesses. Many contractors carry products made by more than one manufacturer. Contractors interface with the end-user: installing new furnace systems to their specifications as well as inspecting, servicing, or repairing the existing system. In the residential furnace market, contractors sell products as part of an installation package and do not list retail product prices separately from installation cost. Furthermore, differences in local markets, weather conditions, and many other factors can affect the price contractors charge for furnaces.

Most residential furnaces pass through the following distribution channel: the original equipment manufacturer (OEM) assembles the system and sells it to a distributor; the distributor sells the unit to a contractor; the contractor sells the unit to the final end-user and performs the installation. After installation, the contractor performs all service on the system, including inspection, maintenance, and repair.

2. Markup Estimation Using Financial Statements and Regression Analysis

DOE will determine typical markups in the distribution chain using publicly-available corporate and industry data. DOE will rely on Economic Census data from the United States

Census Bureau[3] and input from industry trade associations such as the Heating, Air-Conditioning, and Refrigeration Distributors International (HARDI) to define how furnaces are marked up from the manufacturer to the consumer.

Along the distribution chain, companies mark up the price of products to cover their business costs and profit margin. In financial statements, gross margin is the effective markup on a company's cost of goods sold (CGS). It includes all corporate overhead costs; sales, general and administration costs; research and development, interest expenses; depreciation and taxes; and profits. For sales of a product to contribute positively to company cash flow, its markup must be greater than the corporate gross margin less the company's operating profit margin.

To estimate markups, DOE categorizes expenses into two categories: labor-scaling costs (LSC), which are fixed labor and occupancy expenses that increase in proportion to the amount of labor required to produce or sell the product; and non-labor-scaling costs (NLSC), which are variable operating costs that do not scale with labor and vary in proportion to CGS. Together, LSC and NLSC represent the gross margin.

DOE develops baseline and incremental markups to transform the manufacturer selling price into a consumer product price. DOE uses the baseline markups, which cover all of a distributor or contractor's costs, to determine the sales price of baseline models. DOE considers

[3] U.S. Census Bureau. Plumbing, Heating, and Air-Conditioning Contractors: 2002. Report EC02-231-238220.

baseline models to be products sold without new energy conservation standards. DOE calculates the baseline markup ($MU_{BASE}$) using the following equation:

$$MU_{BASE} = \frac{CGS + GM}{CGS} = \frac{CGS + (LSC + NLSC)}{CGS}$$

Where:

$MU_{BASE}$ = Baseline markup, $CGS$ =Cost of goods sold, $GM$ =Gross margin, $LSC$ =Labor-scaling costs, and $NLSC$ =Non-labor-scaling costs.

Incremental markups are coefficients that relate the change in the manufacturer sales price of higher-efficiency models to the change in the final sales price. Incremental markups cover only those costs that scale with a change in the manufacturer's sales price (i.e., NLSC). DOE considers higher-efficiency models to be products sold under market conditions with new or amended standards. It calculates the incremental markup ($MU_{INCR}$) using the following equation:

$$MU_{INCR} = \frac{CGS + NLSC}{CGS}$$

Where:

$MU_{INCR}$ = Incremental markup, $CGS$ =Cost of goods sold, and $NLSC$ =Non-labor-scaling costs.

Because detailed financial data is not available for general and mechanical contractors, DOE relies on an alternative method of markup estimation. Using U.S. Economic Census data on

the value of construction, cost of materials, payroll costs, and cost of subcontracted work, DOE calculates the baseline markup for contractors using the following equation:

$$MU_{BASE} = \frac{V_{CONSTRUCT}}{Pay + MatCost + SubCost}$$

Where:

$MU_{BASE}$ = Baseline contractor markup, $V_{CONSTRUCT}$ = Value of construction, $Pay$ = Payroll, $MatCost$ = Cost of materials, and $SubCost$ = Cost of subcontracted work.

DOE estimates the incremental contractor markup using regression analysis of per firm revenue on per firm cost of goods sold and payroll, estimating the coefficients for the equation:

$$R_i = \alpha CGS_i + \beta Pay_i$$

Where:

$R_i$ = Revenue of firm i, $CGS_i$ = Cost of goods sold of firm i, and, $Pay_i$ = Payroll of firm i.

The coefficient $\alpha$ is an estimate of the incremental builder markup.

The overall markups will include an average multiplier to account for any sales tax applied at the last stage of the distribution channel. The State Tax Clearinghouse[4] is an Internet source that DOE intends to use to calculate applicable sales taxes.

[4] Sales Tax Clearinghouse, Inc., State sales tax rates along with combined average city and county rates. Available at: http://thestc.com/STrates.stm.

3. Potential Impacts of Regional Efficiency Standards in the Distribution Channels

Market participants in the residential furnace distribution chain are often represented by the same trade associations as those in the central air conditioning and heat pump distribution chain. For the current central air conditioner and heat pump standards rulemaking, DOE conducted limited interviews with distributors and contractors, and sought comment regarding the potential impacts of regional standards as they relate to these products. Commenters noted that distributors and contractors of central air conditioner and heat pumps also service furnaces and face very similar issues with respect to regional standards.

The distributors were concerned that possible disparities between the regional boundaries for standards and existing distribution boundaries may prove problematic. Distributors stated that regional standards may be defined based on geographic boundaries composed of state lines, which are usually different than the boundaries of markets for heating and cooling products. Additionally, distributors were concerned about the possible impact of regional standards on the efficiency of the distribution chain, and ultimately, their ability to control costs. National and regional distributors stated that they would face decreases in their economies of scale, which currently affect products that can be stocked and sold nationwide. They stated that if certain products could not be sold throughout the entire country, then the cost of those products in the regions where they could be sold would be driven up. They added that distributors that service areas that overlap borders between regions would be particularly affected, as their costs would increase due to the more complex and diverse inventories.

Based on the above interviews and its own preliminary market assessment, DOE believes there are two main ways in which regional standards could impact furnace distributors and contractors. First, because some distributors close to borders of regions may sell products in more than one region, complying with standards that differ across regions may cause these distributors to carry a different mix of inventory to fill orders in each region. The inventory management costs could increase or the overall investment in inventory could increase. Second, EISA 2007 allows for regional standards to be enforced at the installation level, in addition to the existing enforcement of national efficiency standards at the manufacturer level. As a consequence, there likely would be new compliance costs for distributors and contractors, involving at a minimum additional record-keeping and reporting.

Based on its current assessment of the market, DOE believes that any additional costs that regional standards may impose on furnace distributors and contractors would be reflected by a change in the markups used by these entities. In its analysis of regional standards, DOE plans to estimate changes in markups based on an assessment of (1) the inventory that would likely be carried in various geographic areas (South, North, and border areas), and (2) the potential costs of enforcement requirements.

DOE seeks further comment regarding the potential impact of regional standards on furnace distributors, contractors, and other installers, such as individual homeowners. DOE also seeks comment on how, if at all, impacts of regional standards on furnace distributors and contractors will be different than those in the central air conditioner and heat pump market. In

addition, DOE is seeking market data that will assist in the identification and analysis of the impacts of regional standards on furnace distributors and contractors. This is identified as issue 16 in section III of this RAP, "Issues on Which DOE Seeks Comment."

## G. Energy Use Analysis

### 1. Overview of Energy Use Analysis

The purpose of the energy use analysis is to determine the annual energy consumption of residential furnaces in representative U.S. homes and to assess the energy-savings potential of increased product efficiencies. DOE will estimate the annual energy consumption of residential furnaces at specified energy efficiency levels across a range of climate zones. The annual energy consumption includes use of natural gas or oil for heat production as well as use of electricity for the blower and auxiliary components. The annual energy consumption of residential furnaces will be used in subsequent analyses, including the LCC, PBP, and National Impact Analyses.

In its rulemaking for residential furnaces that ended in 2007, DOE used data from the Energy Information Administration's (EIA) Residential Energy Consumption Survey (RECS)[5] to determine the energy consumption of households using the covered products. Specifically, DOE used the 2005 version of the RECS, which was the most current survey available at that time. DOE will use data from the 2005 RECS for the current rulemaking as well, because it is still the most recent available survey. The 2005 RECS is based on a sample of 4,382 households statistically selected to represent 111 million housing units in the United States. RECS data are

[5] See http://www.eia.doe.gov/emeu/.

available for the four Census regions, the nine Census divisions, and the four most populous States: California, Florida, New York, and Texas.

RECS survey data provide information on the age of the products, as well as associated energy use in residential housing units in the United States. The survey includes information on the physical characteristics of housing units, demographic characteristics of households, heating and cooling products used, fuels used, energy consumption and expenditures, and other data on residential characteristics.

From RECS, DOE will develop household samples for each product class. Details on how DOE will use RECS to determine the annual energy consumption of residential furnaces are provided below. DOE plans to use the household samples not only to establish each product's annual energy consumption, but also as the basis for conducting the LCC and PBP analysis (see section 8).

2. Estimating Annual Energy Consumption of Furnaces

As indicated above, DOE intends to use the RECS data to estimate the annual energy consumption of residential furnaces used in existing homes. Furnace energy efficiencies in existing homes will be based primarily on data from the 2005 RECS as well. To estimate the annual energy consumption of furnaces meeting higher efficiency levels, DOE will calculate the house heating load based on the RECS estimates of the annual energy consumption of the furnace for each household. For each household with a furnace, RECS estimates the product's

annual energy consumption from the household's utility bills using conditional demand analysis. DOE will estimate the house heating load by reference to the existing furnace's characteristics, specifically its capacity and efficiency (AFUE), as well as by the heat generated from the electrical components. The AFUE will be determined using the furnace vintage[6] from RECS and data on the market share of condensing furnaces published by AHRI.[7]

DOE will then use the house heating load to calculate the burner operating hours, which is needed to calculate the fuel consumption and electricity consumption using the current version of the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) test procedure SPC 103-2007 section C. To calculate blower electricity consumption, DOE plans to take into account field data on static pressures of duct systems as well as airflow curves for furnace blowers from manufacturer literature.

To account for the effect of annual weather variations, the 2005 RECS household energy consumption values will be adjusted based on 30-year average heating degree-day (HDD) data for the specific Census Division or the large State location. In addition, DOE will make adjustments to the house heating load based on information indicating that housing units in the year in which compliance with the amended standards is expected to be required will have a somewhat different heating load than the housing units in the RECS 2005. The adjustment considers projected improvements in building thermal efficiency (due to improvement in home insulation and other thermal efficiency practices) and increases in house floor area between 2005

[6] The term "vintage" refers to the year of installation of the product in question.
[7] Air Conditioning, Heating & Refrigeration Institute Industry Statistics is the reference source for the shipped efficiency data by vintage year. Available at**:** http://www.ahrinet.org/Content/EquipmentStatistics_118.aspx.

and the effective date of the standards. DOE will apply this adjustment to both the replacement and new construction market using data from EIA's AEO 2010 residential sector forecast as well as data from RECS 2005 and American Housing Survey (AHS 2009).

DOE seeks stakeholder input on the planned approach of using RECS data for determining the energy consumption of residential furnaces in residential buildings. This is identified as issue 17 in section III of this RAP, "Issues on Which DOE Seeks Comment."

DOE also plans to consider the "rebound effect" in its determination of annual energy consumption. A rebound effect occurs when a product that is made more efficient is used more intensively, so that the expected energy savings from the efficiency improvement may not fully materialize. Based on limited research, the rebound effect for residential space heating appears to be highly variable, ranging from 10 to 30 percent (i.e., 70 to 90 percent of the expected energy savings from more efficient products will actually occur). DOE seeks comments on the rebound effect that may be associated with more efficient residential furnaces. This is identified as issue 18 in section III of this RAP, "Issues on Which DOE Seeks Comment."

## H. Life-Cycle Cost and Payback Period Analyses

### 1. Overview

Energy conservation standards affect products' operating expenses—usually decreasing them—and consumer prices for the products—usually increasing them. DOE analyzes the effect of amended standards on consumers by evaluating changes in the LCC of owning and operating

the product, as well as the payback period of higher-efficiency products. To evaluate changes in LCC, DOE used the manufacturer costs derived in the engineering analysis, along with the energy costs derived from the energy use characterization. The LCC and PBP analyses consider the same efficiency levels developed in the engineering analysis. Inputs to the LCC calculation include the installed cost of a product to the consumer (consumer purchase price plus installation cost), operating expenses (energy expenses and maintenance costs), the lifetime of the unit, and a discount rate.

Because the installed cost of a product typically increases while operating cost typically decreases in response to new standards, there is a time in the life of products having higher-than-baseline efficiency when the net operating-cost benefit (in dollars) since the time of purchase is equal to the incremental first cost of purchasing the higher-efficiency product. The length of time required for the appliance to reach this cost-equivalence point is known as the payback period.

DOE considers both LCC and PBP to determine the impacts of potential energy conservation standards on consumers of the covered products. However, because calculation of LCC uses a discount rate (that depends on consumers' cost of financing) and takes into account changing energy prices over time, it is considered by DOE to be a better indicator of the economic impacts of standards on consumers.

DOE will perform the LCC and PBP analyses using a spreadsheet model combined with Crystal Ball (a commercially available software add-on program to Microsoft Excel to conduct

stochastic analysis using Monte Carlo simulation and probability distributions) to account for uncertainty and variability among the input variables. Each Monte Carlo simulation will consist of 10,000 LCC and PBP calculations. The models will perform each calculation using input values that are either sampled from probability distributions and household samples or characterized with single point values. The analysis results will be a distribution of 10,000 data points showing the range of LCC savings and PBPs for a given efficiency level relative to the base case efficiency forecast. For any sensitivity analyses it conducts, DOE will account for correlations that may exist between inputs.

As discussed in section II.G.2, DOE intends to take into account the rebound effect associated with more efficient residential furnaces. The take-back in energy consumption associated with the rebound effect provides consumers with increased value (e.g., a cooler or warmer indoor environment). The net impact on consumers is thus the sum of the change in the cost of owning the space-conditioning products (i.e., life-cycle cost) and the increased value for the more comfortable indoor environment. DOE believes that, if it were able to monetize the increased value to consumers added by the rebound effect, this value would be similar in value to the foregone energy savings. Thus, for this standards rulemaking, DOE plans to assume that this value is equivalent to the monetary value of the energy savings that would have occurred without the rebound effect. Therefore, the economic impacts on consumers with or without the rebound effect, as measured in the LCC analysis, are the same.

DOE will conduct the LCC and PBP analysis using appropriate values for product life, product retail price, regional energy prices, and discount rates. The following sections discuss the methodologies DOE plans to use to develop several of the inputs to the LCC and PBP analysis, including: (1) energy prices; (2) discount rates; (3) maintenance, repair, and installation costs; and (4) product lifetime. The other inputs to the LCC and PBP analysis—namely, manufacturer costs, annual energy consumption, and markups for the determination of consumer retail prices—have been discussed previously.

2. Energy Prices

Energy prices are used to calculate the annual energy cost savings at different efficiency levels. DOE will derive average monthly energy prices using recent EIA data for each of the Census divisions and large States to establish appropriate energy prices for each sample household.

In contrast to the situation with residential air conditioner and heat pumps, for which the appliance's load primarily occurs during utility "on peak" periods during the summer, electricity consumption of furnaces is not concentrated during peak periods. Therefore, DOE does not see a compelling reason to use marginal electricity prices.

DOE will use projections of national average natural gas, LPG, electricity and fuel oil prices to residential consumers to estimate future energy prices. DOE will use the most recent

available edition of EIA's Annual Energy Outlook (AEO) as the default source of projections for future energy prices.

3. Consumer Discount Rates

The calculation of LCC requires the use of an appropriate discount rate to determine the present value of operating expenses during the product lifetime. The discount rate used in the LCC analysis represents the rate from an individual consumer's perspective.[8]

For consumers of residential furnaces, DOE plans to use the same approach that it relied on to develop discount rates for the November 2007 residential furnaces and boilers standards rulemaking (i.e., deriving the discount rates from estimates of the "finance cost" to purchase residential products). The finance cost can be interpreted as: (1) the financial cost of any debt incurred to purchase products (principally interest charges on debt), or (2) the opportunity cost of any equity used to purchase products (principally interest earnings on household equity). Much of the data DOE uses to determine the cost of debt and equity comes from the Federal Reserve Board's triennial Survey of Consumer Finances.[9] DOE seeks comment on the planned approach for estimating discount rates for consumers of residential furnaces. This is identified as issue 19 in section III of this RAP, "Issues on Which DOE Seeks Comment."

[8] The consumer discount rate is in contrast to the discount rates used in the national impact analysis, which are intended to represent the rate of return of capital in the U.S. economy as well as the societal rate of return on private consumption. Refer to section 10.3 for additional information.
[9] Available at: http://www.federalreserve.gov/pubs/oss/oss2/scfindex.html.

4. Installation Costs and Maintenance and Repair Costs

DOE will evaluate how installation costs and maintenance and repair costs change with increased efficiency for the residential furnaces covered in this rulemaking. DOE will estimate installation costs and maintenance and repair costs at each considered efficiency level using a variety of sources, including RS Means, manufacturer literature, and information from expert consultants. DOE will account for regional differences in labor costs. Installation costs will be calculated individually for each household based on RECS household characteristics. DOE seeks comment on appropriate methods and data sources for assessing changes in installation costs and maintenance and repair costs for more efficient residential furnaces. This is identified as issue 20 in section III of this RAP, "Issues on Which DOE Seeks Comment."

5. Product Lifetime

Product lifetime is the age at which a residential furnace is retired from service. In the prior standards rulemaking, DOE used information from various literature sources, such as Appliance Magazine, handbooks published by the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) and input from manufacturers and other stakeholders to determine a range for the lifetime of residential furnaces. For this rulemaking, DOE plans to use an approach that more accurately accounts for furnace lifetimes in the field. It is based on an analysis of lifetime in the field using a combination of shipments data, the stock of furnaces, and RECS data on the age of the furnaces in the homes. The data will allow DOE to estimate a survival function, which also provides an average and a median appliance lifetime. DOE seeks comments on the methodology to determine the lifetimes for residential furnaces, as

well as on lifetime differences among non-weatherized, weatherized and mobile home gas furnaces, and oil-fired furnaces. This is identified as issue 21 in section III of this RAP, "Issues on Which DOE Seeks Comment."

6. Energy Efficiency in the Base Case

To estimate the share of consumers that would be affected by a standard at a particular efficiency level, DOE's LCC and PBP analysis will consider the projected distribution (i.e., market shares) of product efficiencies that consumers will purchase in the first compliance year under the base case (i.e., the case without amended energy efficiency standards). The projection will use available data on recent market trends in furnace efficiency and will take into account the potential impacts of the ENERGY STAR program and other policies that may affect the demand for more efficient furnaces (such as consumer rebate programs or State tax credits to consumers that encourage the purchase of more efficient products, and manufacturer tax credits that encourage the production of more efficient products).

DOE plans to develop separate base case efficiency distributions for each Census division and large State. DOE seeks comments on the appropriate distribution of energy efficiencies for residential furnaces in the absence of amended energy conservation standards. This is identified as issue 22 in section III of this RAP, "Issues on Which DOE Seeks Comment."

## I. Shipments Analysis

Shipment forecasts are required to calculate the national impacts of standards and future manufacturer cash flows. DOE will develop shipment forecasts based on an analysis of key market drivers for residential furnaces.

### 1. Base-Case Forecast

To evaluate the impacts of standards, DOE will develop a base-case forecast against which to compare forecasts for higher efficiency levels. (The latter are also referred to as standards-case forecasts). DOE designs the base-case forecast to depict what would be anticipated to happen to energy consumption and costs over time if DOE does not adopt new energy conservation standards for the products covered under this rulemaking. In determining base-case shipments, DOE plans to calibrate its shipments model against historical shipments. DOE will also consider the distribution of efficiencies in the absence of new standards and how that mix might change over time.

For furnaces, DOE plans to develop base-case forecasts for each of the four Census Regions that, in turn, can be aggregated to produce regional or national forecasts. DOE plans to project shipments of residential furnaces by primarily accounting for sales to two market segments: (1) the replacement market and (2) new construction.

To forecast replacement shipments, DOE will develop the product's retirement function from the lifetime estimated in the LCC and PBP analyses and apply it to the existing furnaces in

the housing stock. The existing stock of furnaces will be tracked by vintage and will be developed from historical shipments data dating back to the late 1970s. To establish historical shipments by product class, DOE plans to rely on public sources including Appliance Magazine[10] and the AHRI's Industry Statistical Profile.[11] DOE also requests regional data from the industry so that the national shipments data can be disaggregated into the four Census Regions.

After the historical shipments data have been compiled, DOE plans to validate the existing product stock developed from the historical shipments data and the estimated lifetime with data on product saturations in the housing stock. Saturations at the Census Region level are provided by the Census Bureau's American Housing Survey (AHS).[12] The base case forecast assumes that consumers replace a furnace with the same type of product.

To forecast shipments to the new construction market, DOE plans to utilize estimates of forecasted new housing construction and saturation rates of various furnace types in new housing). DOE plans to rely on the latest available edition of EIA's AEO for forecasts of new residential construction. New housing saturation rates are provided by the U.S. Census Bureau's Characteristics of New Housing.[13] In projecting future new housing saturation rates of residential furnaces, DOE will consider expected trends in builder and consumer preferences, including competition from other space heating products (e.g., electric heat pumps, direct heating

[10] Available at: http://www.appliancemagazine.com/.
[11] Available at: http://www.ari.org/Content/EquipmentStatistics_118.aspx.
[12] See http://www.census.gov/hhes/www/housing/ahs/ahs.html.
[13] Available at: http://www.census.gov/const/www/charindex.html.

equipment and combination heating systems). Both EIA's residential construction forecasts and the Census Bureau's historical product saturation rates are broken down by Census Region (i.e., Northeast, Midwest, South, and West), thereby allowing DOE to estimate regional new construction shipments.

In addition to the new construction and replacement market segments, DOE plans to consider the market segment consisting of existing households that do not already own a furnace who would purchase it. In the case of furnaces, this would primarily refer to homes built without central heating in which a furnace is later installed. DOE plans to use this market segment to calibrate the base-case historical forecasts (i.e., backcasts) to historical shipments. In order to reduce the discrepancy between the backcasts and historical shipments, DOE plans to derive a historical rate of product adoption for the non-centrally-heated market. DOE plans to project future adoption rates by considering the historical trend as well as market saturation effects.

DOE seeks historical shipments data, including shipment-weighted AFUE, for each of the following product classes: (1) Non-weatherized gas furnaces; (2) Weatherized gas furnaces; (3) Oil-fired furnaces; (4) Mobile home gas furnaces. Within each product class, DOE also requests shipments data, including shipment-weighted AFUE, disaggregated regionally by Census Region.

2. Standards Impacts on Product Shipments (Standards-Case Forecast)

For each product class, DOE will develop standards-case forecasts that reflect the projected impacts of standards on product shipments. Standards-case forecasts take into account

the estimated increase in purchase price and the decrease in operating costs caused by standards. The magnitude of the difference between the standards-case and base-case shipment forecasts depends on the estimated purchase price increase, as well as the operating cost savings caused by the energy conservation standard, relative to household income. Because the purchase price tends to have a larger impact than operating cost on product purchase decisions, standards-case forecasts typically show a drop in product shipments relative to the base case.

DOE also plans to account for fuel and product switching that may result from standards requiring higher-efficiency furnaces. Because home builders are sensitive to first costs, a standard level that significantly increases the purchase price may induce some builders to switch to a different heating system. Such a standard level may also induce some home owners to replace their existing furnace with a different heating product, although in this case switching may incur additional costs to accommodate the different product. The decision to switch is also affected by the prices of the energy sources for competing products (i.e., the prices of natural gas and electricity). DOE's analysis will account for the key factors expected to influence fuel and product switching that may result from standards requiring higher-efficiency furnaces. DOE will take into consideration factors from the rulemaking on heat pumps that may influence fuel switching from furnaces, in particular the potential installed costs of heat pumps, which compete with furnaces in some markets.

As part of its preliminary manufacturer impact analysis, DOE seeks input from manufacturers on the potential impact of amended energy conservation standards on residential

furnace shipments, including impacts on shipments that may result from fuel switching. DOE also seeks input from other parties on the potential impact of standards on product shipments. This is identified as issue 23 in section III of this RAP, "Issues on Which DOE Seeks Comment."

## J. National Impact Analysis

The national impact analysis assesses the aggregate impacts at the national level of potential energy conservation standards for each of the considered products, as measured by the net present value (NPV) of total consumer economic impacts and the national energy savings (NES). DOE determines the NPV and NES for the efficiency levels considered for each of the product classes analyzed. To make the analysis more accessible and transparent to all interested parties, DOE prepares a MS Excel spreadsheet model to forecast NES and the national consumer economic costs and savings resulting from new standards. The spreadsheet model uses typical values as inputs (as opposed to probability distributions). To assess the effect of input uncertainty on NES and NPV results, DOE may conduct sensitivity analyses by running scenarios on specific input variables.

### 1. Inputs to NES and NPV Analyses

Analyzing impacts of amended energy conservation standards for residential furnaces requires a comparison of projected U.S. energy consumption with and without new or amended energy conservation standards. The forecasts contain projections of annual appliance shipments, the annual energy consumption of new appliances, and the purchase price of new appliances.

A key component of DOE's NIA analysis is the energy efficiencies forecasted over time for the base case (without new standards) and each of the standards cases. The forecasted efficiencies represent the annual shipment-weighted energy efficiency of the products under consideration over the forecast period (i.e., from the assumed compliance date of a new standard to 30 years after compliance is required).

Section II.I.1 described how DOE plans to develop a base-case energy efficiency distribution (which yields a shipment-weighted average efficiency) for each of the furnace product classes for the first year of the forecast period. To forecast base-case efficiencies over the entire forecast period, DOE intends to extrapolate from the historical trends to the extent that is reasonable. DOE seeks comments on the appropriate assumptions to use regarding long-run changes in furnace energy efficiency independent of amended energy conservation standards. This is identified as issue 24 in section III of this RAP, "Issues on Which DOE Seeks Comment."

To develop shipment-weighted efficiencies for the various standards cases, DOE will utilize the efficiency market share data for each product class. Once DOE establishes the shipment-weighted efficiency for the assumed compliance date of the standard, it plans to estimate future shipment-weighted efficiencies using the same rate of forecasted efficiency growth as in the base-case efficiency trend.

To estimate the impact that standards may have in the year compliance becomes required, DOE has used "roll-up" and/or "shift" scenarios in its standards rulemakings. Under the "roll-up" scenario, DOE assumes: (1) product efficiencies in the base case that do not meet the standard level under consideration would "roll-up" to meet the new standard level; and (2) product efficiencies above the standard level under consideration would not be affected. Under the "shift" scenario, DOE retains the pattern of the base-case efficiency distribution but re-orients the distribution at and above the new minimum energy conservation standard. DOE will evaluate whether one of these approaches is more reasonable for furnaces, or whether it would be preferable to use both scenarios in its calculation of national impacts. DOE seeks comments on the use of the "roll-up" and "shift" efficiency scenarios to characterize the impact that potential standards will have on the product efficiency distributions. This is identified as issue 25 in section III of this RAP, "Issues on Which DOE Seeks Comment."

2. National Energy Savings

DOE will calculate national energy consumption for each year in the forecast period. DOE will calculate national energy consumption by fuel type for the base case and each standards case analyzed. DOE plans to perform this calculation through the use of a spreadsheet model that multiplies the stock of products (which is determined by the shipments forecasts) by unit energy savings, accounting for the stock of products affected by the energy conservation standards. In response to comments by stakeholders who asked for a simple, transparent model, DOE has developed National Impact Analysis (NIA) spreadsheet models to forecast energy savings from standards at different efficiency levels.

As previously discussed, DOE intends to take into account the rebound effect associated with more efficient residential furnaces. DOE will incorporate the rebound effect utilized in the energy use analysis into its calculation of national energy savings.

To estimate the primary energy savings resulting from fuel and/or electricity savings at building sites, DOE will develop site-to-source factors based on forecasts in AEO2009.

3. Net Present Value of Consumer Benefit

The inputs for determining net present value (NPV) of the total costs and benefits experienced by consumers of the considered appliances are: (1) total annual installed cost; (2) total annual savings in operating costs; (3) a discount factor; (4) present value of costs; and (5) present value of savings. DOE calculates net savings each year as the difference between the base case and each standards case in total savings in operating costs and total increases in installed costs. DOE calculates savings over the life of each product. DOE calculates NPV as the difference between the present value of operating cost savings and the present value of total installed costs.

DOE calculates increases in total installed costs as the product of the difference in total installed cost between the base case and a standards case. DOE expresses savings in operating costs as decreases associated with the lower energy consumption of products bought in the

standards case compared to the base case. Total savings in operating costs are the product of savings per unit and the number of units of each vintage that survive in a given year.

According to U.S. Office of Management and Budget (OMB) guidelines for Federal agencies, 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 (OMB, Circular A-4: Regulatory Analysis. 2003).[14] The discount rates for the determination of NPV are in contrast to the discount rates used in the LCC analysis, which are designed to reflect a consumer's perspective. The 7-percent real value is an estimate of the average before-tax rate of return to private capital in the U.S. economy. The 3-percent real value represents the "societal rate of time preference," which is the rate at which society discounts future consumption flows to their present value.

As noted above, DOE intends to take into account the rebound effect associated with more efficient residential furnaces in its determination of national energy savings. As previously discussed, because the rebound effect provides consumers with increased value (i.e., a more comfortable environment), DOE believes that, if it were able to monetize the increased value to consumers added by the rebound effect, this value would be similar in value to the foregone energy savings. For this standards rulemaking, DOE estimates that this value is equivalent to the monetary value of the energy savings that would have occurred without the rebound effect. Therefore, the economic impacts on consumers with or without the rebound effect, as measured in the NPV, are the same.

[14] Available at: http://www.whitehouse.gov/omb/memoranda/m03-21.html.

4. Other National Impacts

To evaluate potentially important indirect effects of energy conservation standards on energy users in general, DOE plans to analyze the impact on natural gas prices resulting from amended standards on furnaces, and the associated benefits for all natural gas consumers in all sectors of the economy. DOE plans to use a variant of the EIA's National Energy Modeling System (NEMS), called NEMS-BT (BT refers to DOE's Building Technologies Program), to estimate the annual changes in natural gas prices that would result from a decrease in natural gas demand due to furnace standards.[15] NEMS is a large, multi-sectoral, partial-equilibrium model of the U.S. energy sector that EIA has developed over several years, primarily for the purpose of preparing the AEO. NEMS produces a widely-recognized energy forecast for the United States through 2030 and is available in the public domain.

DOE will calculate the nominal savings in total natural gas expenditures in each year by multiplying the estimated annual change in the average end-user natural gas price by the annual total U.S. natural gas consumption associated with standards-case scenarios. DOE will then calculate the NPV of the savings in natural gas expenditures over the forecast period using 3- and 7-percent discount rates for each scenario.

[15] 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) and is available at: http://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.

Regarding impacts of furnace standards on electricity prices, DOE investigated the possibility of estimating the impact of specific standard levels on electricity prices in its rulemaking for general service fluorescent lamps and incadescent reflector lamps.[16] Whereas natural gas markets exhibit a fairly simple chain of agents from producers to consumers, the power industry is a complex mix of fuel suppliers, producers and distributors. While the distribution of electricity is regulated everywhere, its institutional structure varies, and upstream components are more complicated, with generation priced using different methods across the country. For these and other reasons, accurate modeling of the response of electricity prices to a decrease in residential-sector demand due to standards is problematic. Thus, DOE does not plan to estimate the value of potentially reduced electricity costs for all consumers associated with revised standards for residential furnaces. However, it acknowledges that there is likely to be some positive economic benefit from reduced electricity demand.

## K. Life-Cycle Cost Subgroup Analysis

The LCC consumer subgroup analysis evaluates economic impacts on selected groups of consumers who might be adversely affected by a change in the energy conservation standards for the considered products. DOE evaluates impacts on particular subgroups of consumers primarily by analyzing the LCC impacts and PBP for those particular consumers. For the furnace rulemaking, DOE intends to evaluate impacts of standards on low-income and senior-only households because the potential higher first cost of products that meet new standards may lead to negative impacts for these particular groups. DOE seeks input regarding which consumer

[16] U.S. Department of Energy-Office of Energy Efficiency and Renewable Energy, Energy Conservation Program: Energy Conservation Standards for General Service Fluorescent Lamps and Incandescent Reflector Lamps; Proposed Rule. Federal Register, 2009. 74(69): pp. 16920-16968.

subgroups it should consider in this rulemaking. This is identified as issue 26 in section III of this RAP, "Issues on Which DOE Seeks Comment."

In comparing potential impacts on the different consumer subgroups, DOE will evaluate variations in energy prices, energy use, and installation costs that might affect the impacts of a standard on the consumer subgroups. In evaluating variations in energy use, DOE will take into account how the climate associated with the consumer's geographic location impacts the energy consumption of the product.

## L. Manufacturer Impact Analysis

The purpose of the manufacturer impact analysis (MIA) is to identify and quantify the likely impacts of amended energy conservation standards on manufacturers of residential furnaces. During the NOPR stage of analysis, DOE will analyze and consider a wide range of quantitative and qualitative industry impacts that may occur due to amended energy conservation standards. DOE will identify and analyze these impacts through industry research, public comments, and interviews with manufacturers and other interested parties. Other sources of information will include reports published by industry groups, trade journals, the U.S. Census Bureau, and SEC 10-K filings.

Initially, DOE will conduct a profile of the furnace manufacturer industry by gathering pertinent qualitative and quantitative financial and market information, including industry cost structures, employment metrics, and competitive behavior. Next, DOE will conduct detailed

interviews with residential furnace manufacturers to gain insight into the potential impact of amended standards on sales, direct employment, capital assets, and industry competitiveness. DOE will use the information gathered in the industry profile to shape an interview guide that will be distributed to manufacturers prior to these interviews. The guide will facilitate the discussion of production costs; shipment projections; product mix; conversion costs; markups; assessment of the impact on competition, manufacturing capacity, and other relevant topics raised by stakeholders. Because standards may have differential impacts on groups of manufacturers with different cost structures or business models, DOE will also identify and characterize any such subgroups during interviews.

DOE is aware that amended standards may require additional investment, raise production costs, and affect revenue through higher prices and, possibly, lower shipments. To quantify these impacts on manufacturers, DOE will calculate standards-induced changes in industry and subgroup cash flows using the Government Regulatory Impact Model (GRIM). This will enable DOE to derive a base case and standards case industry net present value. The inputs to the GRIM will include financial information, manufacturing costs, shipment forecasts, and price forecasts developed in other analyses. Lastly, based on the information gathered during interviews and other research, DOE will assess impacts on competition, manufacturing capacity, employment, and regulatory burden.

DOE plans to evaluate any differential impacts regional standards may have on manufacturers within the framework of its normal MIA process, described above. DOE will

tailor its MIA interview guides to include questions exploring the quantitative and qualitative impacts of regional standards on manufacturers. Potential impacts could include additional compliance, inventory, or marketing costs associated with the promulgation of regional standards. Such impacts will be captured in DOE's GRIM analysis.

To the extent appropriate, DOE may evaluate subgroups of manufacturers that are differentially impacted by regional standards. One possible subgroup, for example, may be manufacturers that own their own distribution networks. DOE will include any differential financial impacts that it determines are appropriate in its GRIM analyses. DOE seeks further comment regarding the potential impact of regional standards on manufacturers of furnaces. In addition, DOE seeks market data that will assist in the identification and analysis of the impacts of regional standards on manufacturers. This is identified as issue 27 in section III of this RAP, "Issues on Which DOE Seeks Comment."

M. Utility Impact Analysis

To estimate the effects of energy conservation standards for residential furnaces on the utility industry, DOE plans to use NEMS-BT (see discussion in section J.4). The utility impact analysis is a comparison between the NEMS-BT model results for the base case (the most recent AEO reference case) and standards cases. The utility impact analysis reports the changes in installed capacity and generation that result from each standard level by plant type. DOE will

model the impacts from amended energy conservation standards using NEMS-BT to generate forecasts that deviate from the AEO reference case.[17]

N. Employment Impacts Analysis

The imposition of standards can affect employment both directly and indirectly. Direct employment impacts are changes in the number of employees at the plants that produce the covered product, along with the affiliated distribution and service companies, resulting from the standards. DOE will evaluate direct employment impacts in the manufacturer impact analysis.

Indirect employment impacts 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 the standards. DOE defines indirect employment impacts from standards as net jobs eliminated or created in the general economy as a result of increased spending driven by increased product prices and reduced spending on energy.

The indirect employment impacts will be investigated in the employment impact analysis using the Pacific Northwest National Laboratory's "Impact of Sector Energy Technologies" (ImSET) model. The ImSET model was developed for DOE's Office of Planning, Budget, and Analysis, and estimates the employment and income effects of energy-saving technologies in buildings, industry, and transportation. In comparison with simple economic multiplier approaches, ImSET allows for more complete and automated analysis of the economic impacts

[17] Several descriptions of NEMS-BT models from previous rulemakings, including residential furnaces and boilers, can be found on DOE's website at: http://www.eere.energy.gov/buildings/appliance_standards/residential/pdfs/fb_fr_tsd/chapter_13.pdf.

of energy conservation investments. DOE requests comments on its approach to assessing employment impacts of standards on the products covered under this rulemaking. This is identified as issue 28 in section III of this RAP, "Issues on Which DOE Seeks Comment."

## O. Environmental Impact Analysis

The intent of the environmental assessment is to fulfill requirements to properly quantify and consider the environmental effects of amended energy conservation standards for furnaces. The primary environmental effects of energy conservation standards for residential furnaces would be lower emissions resulting from reduced fossil fuel consumption at building sites. There may also be reduced power plant emissions resulting from reduced consumption of electricity. DOE will assess power plant emissions by using NEMS-BT to provide key inputs to its analysis. The portion of the environmental assessment that will be produced by NEMS-BT considers carbon dioxide ($CO_2$), nitrogen oxides ($NO_X$), and mercury (Hg). The environmental assessment also considers impacts on $SO_2$ emissions.

After a brief discussion of general methodology, this section will address each of the relevant emissions. This section then explains how DOE plans to monetize the benefits associated with emissions reductions.

### 1. Carbon Dioxide (Power Plant Emissions)

In the absence of any 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 national energy savings 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.

2. Sulfur Dioxide (Power Plant Emissions)

NEMS-BT reports emissions of $SO_2$ from power generation. However, DOE has preliminarily determined that $SO_2$ emissions from affected Electric Generating Units (EGUs) are subject to nationwide and regional emissions cap and trading programs that are likely to eliminate the standards' impact on $SO_2$ emissions. Title IV of the Clean Air Act sets an annual emissions cap on $SO_2$ for all affected EGUs. $SO_2$ emissions from 28 eastern States and the District of Columbia (DC) are also limited under the Clean Air Interstate Rule (CAIR). 70 FR 25162 (May 12, 2005)) CAIR creates an allowance-based trading program that will gradually replace the Title IV program in those States and DC. (The recent legal history surrounding CAIR is discussed below.) The attainment of the emissions caps is flexible among EGUs and is enforced through the use of emissions allowances and tradable permits. Under existing EPA regulations, any excess $SO_2$ emission 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 emission 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 plans to use to forecast emissions reductions currently indicates that no physical reductions in power sector emissions would occur for $SO_2$.

Even if there is no significant reduction in the overall emissions of $SO_2$ that results from the standard, there may still be some economic benefit from reduced demand for $SO_2$ emission allowances that is not fully reflected in the cost savings experienced by individual consumers. Electricity savings that decrease the overall demand for $SO_2$ emissions allowances could lower allowance prices and thereby result in some economic benefits for all electricity consumers, not just those that reduced their electricity use as a result of an efficiency standard. DOE does not plan to monetize this particular benefit because the effect on the $SO_2$ allowance price from any single energy conservation standard is likely to be small and highly uncertain.

3. Nitrogen Oxides (Power Plant Emissions)

NEMS-BT has an algorithm for estimating $NO_x$ emissions from power generation. The impact of these emissions, however, will be affected by the CAIR, which the Environmental Protection Agency (EPA) issued on May 12, 2005. CAIR will permanently cap emissions of $NO_x$ in 28 eastern states and the District of Columbia. 70 FR 25162 (May 12, 2005).

Much like $SO_2$ emissions, a cap on $NO_X$ emissions means that the amended standards may have little or no physical effect on these emissions in the 28 eastern States and the DC covered by CAIR. Although CAIR has been remanded to the EPA by the DC Circuit, it will

remain in effect until it is replaced by a rule consistent with the Court's July 11, 2008, opinion in North Carolina v. EPA. 531 F.3d 896 (DC Cir. 2008); see also North Carolina v. EPA, 550 F.3d 1176 (DC Cir. 2008). Because all States covered by CAIR opted to reduce $NO_X$ emissions through participation in cap-and-trade programs for electric generating units, emissions from these sources are capped across the CAIR region.

Standards may produce an environmental-related economic benefit in the form of lower prices for emissions allowance credits. As with $SO_2$ allowance prices, however, DOE does not plan to monetize this particular benefit because the effect on the $NO_X$ allowance price from any single energy conservation standard is likely small and highly uncertain.

DOE plans to use NEMS-BT to estimate the emissions reductions from possible standards in the 22 States where emissions are not capped.

4. Mercury (Power Plant Emissions)

Similar to emissions of $SO_2$ and $NO_X$, future emissions of Hg would have been subject to emissions caps. In May 2005, EPA issued the Clean Air Mercury Rule (CAMR). 70 FR 28606 (May 18, 2005). CAMR would have permanently capped emissions of mercury for new and existing coal-fired power plants in all States by 2010. However, on February 8, 2008, the DC Circuit issued its decision in New Jersey v. Environmental Protection Agency, in which the DC Circuit, among other actions, vacated the CAMR. 517 F.3d 574 (DC Cir. 2008). EPA has decided to develop emissions standards for power plants under the Clean Air Act (section 112), consistent with the DC Circuit's opinion on the CAMR. See

http://www.epa.gov/air/mercuryrule/pdfs/certpetition_withdrawal.pdf. Pending EPA's forthcoming revisions to the rule, DOE is excluding the CAMR from its Environmental Analysis. In the absence of CAMR, a DOE standard would likely reduce Hg emissions, and DOE plans to use NEMS-BT to estimate these emission reductions.

5. Particulate Matter (Power Plant Emissions)

DOE acknowledges that particulate matter (PM) impacts are of concern due to human exposures that can impact health. But impacts of PM emissions reduction are much more difficult to estimate than other emissions reductions due to the complex interactions between PM, other power plant emissions, meteorology, and atmospheric chemistry that impact human exposure to particulates. Human exposure to PM usually occurs at a significant distance from the power plants that are emitting particulates and particulate precursors. When power plant emissions travel this distance, they undergo highly complex atmospheric chemical reactions. Although the EPA does keep inventories of direct PM emissions of power plants, in its source attribution reviews, the EPA does not separate direct PM emissions from power plants from the sulfate particulates indirectly produced through complex atmospheric chemical reactions. The great majority of PM emissions from power plants are of these secondary particles (secondary sulfates). Thus, it is not useful to examine how the amended standard impacts direct PM emissions independent of indirect PM production and atmospheric dynamics. Therefore, DOE is not planning to assess the impact of these standards on particulate emissions. Further, even the cumulative impact of PM emissions from power plants and indirect emissions of pollutants from other sources is unlikely to be significant.

6. Site Emissions

The operation of the furnaces considered in this rulemaking requires use of fossil fuels and results in emissions of $CO_2$, $SO_2$, and $NO_X$ (but not Hg) at the sites where these appliances are used. NEMS–BT provides no means for estimating such emissions. DOE will calculate the effect of the proposed standards on the above site emissions based on emissions factors derived from the literature.

7. Monetization of Emissions Reduction Benefits

For those emissions for which real emission reductions are anticipated ($CO_2$, Hg, and $NO_X$ for 22 states), ranges of estimated economic values based on environmental damage studies of varying quality and applicability are available. DOE plans on reporting estimates of monetary benefits derived using these values and plans to consider these benefits in weighing the costs and benefits of each of the standard levels considered. In accordance with U.S. Office of Management and Budget (OMB) guidance, DOE will conduct two calculations of the monetary benefits of emissions reductions, one using a real discount rate of 3 percent and another using a real discount rate of 7 percent.[18]

In order to estimate the monetary value of benefits resulting from reduced emissions of $CO_2$ emissions, DOE intends to use the most current Social Cost of Carbon (SCC) values

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

developed and/or agreed to by interagency reviews. 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 were $5, $10, $20, $34 and $56 per metric ton, and the estimate of the potential domestic benefits was approximately $1 per metric ton. All of these unit values represent emissions that are valued in 2008$ for emissions that occur in 2007. For emissions (or emission reductions) that occur in later years, these values are escalated in real terms by 3 percent per year, then discounted to the present using real discount rates of 7 percent and 3 percent.

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 economic and other damages. Thus, these values are subject to change.

DOE also intends to estimate the potential monetary benefit of reduced NOx and Hg emissions resulting from the standard levels it considers. For NOx emissions, available estimates

suggest a very wide range of monetary values, ranging from $370 per ton to $3,800 per ton of NOx from stationary sources, measured in 2001$ (equivalent to a range of $442 to $4,540 per ton in 2008$). Refer to the OMB, 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," for additional information.

For Hg emissions reductions, DOE has previously determined that the impact of mercury emissions from power plants on humans is considered highly uncertain. However, DOE identified two estimates of the environmental damage of mercury based on two estimates of the adverse impact of childhood exposure to methyl mercury on intelligence quotient (IQ) for American children, and subsequent loss of lifetime economic productivity resulting from these IQ losses. The high-end estimate is based on an estimate of the current aggregate cost of the loss of IQ in American children that results from exposure to mercury of U.S. power plant origin ($1.3 billion per year in year 2000$), which works out to $33.3 million per ton emitted per year (2008$). Refer to L. Trasande *et al*., "Applying Cost Analyses to Drive Policy that Protects Children," 1076 Ann. N.Y. Acad. Sci. 911 (2006) for additional information. The low-end estimate is $0.66 million per ton emitted (in 2004$) or $0.745 million per ton in 2008$. DOE derived this estimate from a published evaluation of mercury control using different methods and assumptions from the first study but also based on the present value of the lifetime earnings of children exposed. See Ted Gayer and Robert Hahn, "Designing Environmental Policy: Lessons from the Regulation of Mercury Emissions," Regulatory Analysis 05–01, American Enterprise Institute-Brookings Joint Center for Regulatory Studies, Washington, DC (2004). A version of

this paper was published in the *Journal of Regulatory Economics* in 2006. The estimate was derived by back-calculating the annual benefits per ton from the net present value of benefits reported in the study.

P. Regulatory Impact Analysis

In the NOPR and final rule stages of this rulemaking, DOE will prepare a regulatory impact analysis, which addresses the potential for non-regulatory approaches to supplant or augment energy conservation standards to improve the efficiency of residential furnaces on the market. DOE recognizes that voluntary or other non-regulatory efforts by manufacturers, utilities, and other interested parties can result in substantial efficiency improvements. DOE intends to analyze the likely effects of non-regulatory initiatives on product energy use, consumer utility, and LCCs. DOE will attempt to base its assessment on the actual impacts of any such initiatives to date, but will also consider information presented regarding the impacts that any existing initiative might have in the future.

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

## III. Issues on Which DOE Seeks Comment

DOE is particularly interested in receiving comments and views of interested parties concerning the following issues:

1. The consensus agreement.
2. A combined rulemaking regarding energy conservation standards for residential central air conditioners and heat pumps, residential furnaces, and furnace fans.
3. DOE's proposed regional definitions for the analysis of regional standards.
4. The viability of the regional standard enforcement mechanisms presented in this document, other mechanisms DOE should consider, and the extent to which these mechanisms would result in additional financial burdens to consumers, manufacturers, contractors, distributors, dealers, and installers. DOE specifically seeks data on how, if at all, the enforcement options listed above would increase compliance or other costs.
5. The assumption that most consumers are unlikely to set their furnaces to the off mode.
6. DOE's approach to setting standards using integrated annual fuel utilization, $AFUE_I$ which account for furnace standby and off mode energy consumption.
7. DOE's planned product classes for this rulemaking.
8. Technologies that should be considered during the technology assessment and screening analysis that can be used to improve the energy-efficiency of residential furnaces.
9. The representative characteristics DOE has identified for each of the four product classes.
10. Typical characteristics of the baseline designs for residential furnaces that are currently on the market in each product class.

11. The max-tech efficiency levels identified for the analyses, including information regarding prototype designs that may be capable of allowing furnaces to achieve AFUE values above those identified in this document.
12. The proposed efficiency levels for analysis for each product class, including information about any additional efficiencies or technologies that should be analyzed that may not be captured in the efficiency levels proposed by DOE. Additionally, DOE is requesting comments about whether any of the efficiencies proposed for analysis will capture the same or very similar technologies, and thus be repetitive of one another, in which case DOE may not need to analyze both efficiency levels.
13. The criteria DOE plans to use to select units for teardown analysis.
14. The appropriateness of the additional input capacities being analyzed outside of the representative input capacity for non-weatherized gas furnaces (50 kBtu/h and 125 kBtu/h).
15. Whether the manufacturer markup used in the previous analysis (1.26) is still applicable for the current residential furnace market.
16. The potential impact of regional standards on furnace distributors and contractors, including how (if at all) impacts of regional standards on furnace distributors and contractors will be different than those in the central air conditioner and heat pump market. In addition, DOE is seeking market data that will assist in the identification and analysis of the impacts of regional standards on furnace distributors and contractors.

17. DOE's planned approach of using RECS data for determining the energy consumption of residential furnaces in residential buildings.
18. The rebound effect that may be associated with more efficient residential furnaces.
19. DOE's planned approach for estimating discount rates for consumers of residential furnaces.
20. The appropriate methods and data sources for assessing changes in installation costs and maintenance and repair costs for more efficient residential furnaces.
21. The methodology to determine the lifetimes for residential furnaces, as well as lifetime differences among non-weatherized, weatherized and mobile home gas furnaces, and oil-fired furnaces.
22. The appropriate distribution of energy efficiencies for residential furnaces in the absence of amended energy conservation standards.
23. The potential impacts of standards on product shipments, including impacts related to fuel switching.
24. The appropriate assumptions to use regarding long-term changes in furnace energy efficiency independent of amended energy conservation standards.
25. The use of the "roll-up" and "shift" efficiency scenarios to characterize the impact that potential standards will have on the product efficiency distributions.
26. Residential furnace consumer subgroups that should be considered in this rulemaking.

27. Market data or information that will assist in the identification and analysis of the impacts of regional standards on manufacturers.
28. DOE's planned approach for assessing employment impacts of standards that will result from this rulemaking.