

**ENVIRONMENTAL ASSESSMENT FOR PROPOSED ENERGY  
CONSERVATION STANDARDS FOR RESIDENTIAL  
FURNACES AND BOILERS**

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## ABBREVIATIONS AND ACRONYMS

**AEO:** *Annual Energy Outlook*, DOE/EIA publication

**ANOPR:** Advance Notice of Proposed Rulemaking

**ASHRAE:** American Society of Heating, Refrigeration, and Air-Conditioning Engineers, Inc.

**BT:** DOE's Building Technologies program

**Btu:** British thermal unit

**CO<sub>2</sub>:** carbon dioxide

**DOE or Department:** Department of Energy

**EA:** Environmental Assessment

**EIA:** Energy Information Administration

**EJ:** exajoule ( $10^{18}$  joules)

**EPA:** Environmental Protection Agency

**EPCA:** Energy Policy and Conservation Act: Part B of Title III of the Energy Policy and Conservation Act, Public Law 94-163, as amended by the National Energy Conservation Policy Act, Public Law 95-619, the National Appliance Energy Conservation Act, Public Law 100-12, the National Appliance Energy Conservation Amendments of 1988, Public Law 100-357, and the Energy Policy Act of 1992, Public Law 102-486

**FR:** Federal Register

**GJ:** gigajoule ( $10^9$  joules)

**GW:** gigawatt ( $10^9$  watts)

**kt/a:** kilo (thousand) metric tons per annum (year)

**kWh:** kilowatt-hour (thousand watts per hour)

**LCC:** life-cycle cost

**Mt/a:** million metric tons per annum (year)

**MW:** megawatt (million watts)

**NAECA:** National Appliance Energy Conservation Act

**NEMS:** National Energy Modeling System

**NEPA:** National Environmental Policy Act of 1969

**NES:** National Energy Savings

**NO<sub>x</sub>:** nitrogen oxides

**PBP:** payback period

**quad:** quadrillion Btu ( $10^{15}$  Btus)

**RIA:** Regulatory Impact Analysis

**SO<sub>2</sub>:** sulfur dioxide

**t:** metric ton

**TSL:** Trial Standard Level

**TSD:** Technical Support Document

**U.S.C.:** United States Code

# ENVIRONMENTAL ASSESSMENT FOR RESIDENTIAL FURNACES AND BOILERS

## 1.0 INTRODUCTION

The U.S. Department of Energy (DOE or Department) prepared this residential furnace and boiler environmental assessment (EA) pursuant to the National Environmental Policy Act of 1969 (NEPA)(42 U.S.C. 4321 *et seq.*), the regulations of the Council on Environmental Quality (40 CFR parts 1500-1508), and the DOE's regulations for compliance with NEPA (10 CFR part 1021).

Title III of the Energy Policy and Conservation Act (EPCA) sets forth a variety of provisions designed to improve energy efficiency. Part B of title III (42 U.S.C 6291-6309) provides for the Energy Conservation Program for Consumer Products other than Automobiles. The program covers consumer products and certain commercial products (all of which are referred to hereafter as "covered products") including residential furnaces and boilers.

EPCA authorizes the Department to prescribe new or amended standards for residential furnaces and boilers. (42 U.S.C 6292(a)(f)) EPCA provides criteria for prescribing new or amended standards for covered products. As indicated above, any new or 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)). EPCA precludes the Department from adopting any standard that would not result in significant conservation of energy. (42 U.S.C 6295(o)(3))

On June 13, 2001, the Department published a *Framework Document for Residential Furnaces and Boilers Standards Rulemaking*<sup>1</sup> that described the procedural and analytical approaches available to evaluate energy conservation standards for residential furnaces and boilers. The Department held a Framework Workshop on July 17, 2001, to discuss the procedural and analytical approaches for use in this rulemaking, to inform and facilitate stakeholders' involvement in the rulemaking process, and to seek their comments on the Framework Document. On July 29, 2004, after considering the stakeholder comments about the technical analysis, DOE published in the Federal Register an Advance Notice of Proposed Rulemaking (ANOPR) to solicit public comments on its preliminary analyses concerning energy efficiency standards for residential furnaces and boilers. 69 FR 45419 DOE held a public meeting on September 29, 2004, to present the methodology and results of the ANOPR analyses, and to solicit oral comments from the stakeholders in attendance. Subsequently revised the analysis and prepared a NOPR, of which the Environmental Assessment is a part.

## 2.0 PURPOSE AND NEED

In proposing the action described in the NOPR the Department is responding to the requirements of Title III of the Energy Policy and Conservation Act (EPCA), which sets forth a variety of provisions designed to achieve the goal of improving the energy efficiency of consumer products.

Consistent with the EPCA requirements described in section 1.0, DOE exercises its discretion in deciding the level for a minimum efficiency standard, not in deciding if there should be one. More stringent energy efficiency standards for residential furnaces and boilers will result in saving energy. The metric used to measure the efficiency of residential furnaces and boilers is the Annual Fuel Utilization Efficiency (AFUE). An increase in the AFUE indicates that the furnace or boiler is more efficient. Details on the technical analysis of increased efficiency levels are provided in the Residential Furnace and Boiler Technical Support Document (TSD) that accompanies DOE's NOPR for the proposed standards.<sup>2</sup>

## 3.0 ALTERNATIVES INCLUDING THE PROPOSED ACTION

The Department analyzed five alternative standards levels consisting of the four TSLs identified in the NOPR and a no-action alternative. As discussed above, DOE's proposed action is to adopt TSL 2. The five alternatives are discussed below.

### 3.1 No-Action Alternative

Under a no-action alternative, DOE would not publish new minimum energy efficiency standards for residential furnaces and boilers, and the efficiency standards would remain at current levels (Table EA.2). (42 U.S.C 6295(f)(1)) The current standards went into effect on January 1, 1992, with the exception of the standard for mobile home furnaces, for which the effective date was September 1, 1990. DOE also refers to the no-action alternative as a base case.

**Table EA.1 Current Energy Efficiency Standard Levels for Residential Furnaces and Boilers, Base Case**

<b>NWGF</b>	<b>WGF</b>	<b>MHF</b>	<b>OF</b>	<b>GB</b>	<b>OB</b>
<b>AFUE %</b>	<b>AFUE %</b>	<b>AFUE %</b>	<b>AFUE %</b>	<b>AFUE %</b>	<b>AFUE %</b>
78	78	75	78	80	80

Product Class List:

NWGF = Non-Weatherized Gas Furnace

WGF = Weatherized Gas Furnace

MHF = Mobile Home Gas Furnace

OF = Oil-fired Furnace

GB = Gas Boiler

OB = Oil-fired Boiler

The no-action alternative is contrary to the requirement to amend the statutory energy efficiency standards to achieve the maximum improvement in energy efficiency for residential furnaces and boilers that it determines is technologically feasible and economically justified. 42 U.S.C 6295(o)(2)(A) Notwithstanding, DOE addresses the no-action alternative in the TSD, including the Residential Furnaces and Boilers Regulatory Impact Analysis (RIA), as well as other non-regulatory policy cases and voluntary incentive programs.

### 3.2 Proposed Action

The DOE’s proposed action is to adopt TSL 2 (see Table EA.2). Doe selected this level on the basis of national energy savings, reduced average life-cycle costs (LCC) to consumers, a net national benefit (i.e., monetary savings to the Nation exceed increased equipment costs to the Nation), and air-borne emissions reductions.

In analyzing improvements in the efficiency of residential furnaces and boilers, DOE defined five trial standard levels (TSLs). Each TSL consists of a combination of different AFUE levels applied to six different product classes. Of the five TSLs, DOE proposes to adopt TSL 2. Table EA.1 summarizes the proposed standard levels.

**Table EA.2 Proposed Standard Levels for Residential Furnaces and Boilers**

<b>NWGF</b>	<b>WGF</b>	<b>MHF</b>	<b>OF</b>	<b>GB</b>	<b>OB</b>
AFUE %	AFUE %	AFUE %	AFUE %	AFUE %	AFUE %
80	83	80	82	84	83

Product Class List:

NWGF = Non-Weatherized Gas Furnace

WGF = Weatherized Gas Furnace

MHF = Mobile Home Gas Furnace

OF = Oil-fired Furnace

GB = Gas Boiler

OB = Oil-fired Boiler

### 3.3 Alternative Standards

This EA also examines four other TSLs besides those from DOE’s proposed action (TSL 2) and the no action alternative. Each TSL is an alternative action, and is compared with the no-action alternative. The no-action alternative, also referred to as the base case, represents a situation where no new amended standards are proposed. The TSL 1 is less stringent than DOE’s proposed action (TSL 2), while TSLs 3 and 4 are more stringent than TSL 2. Each TSL has a unique combination of AFUE efficiency levels for each product class. The TSLs, including DOE’s proposed action, are shown in Table EA.3.

**Table EA.3 Trial Standard Levels for Residential Furnaces and Boilers**

Trial Standard Levels	NWGF	WGF	MHF	OF	GB	OB
	AFUE %	AFUE %	AFUE %	AFUE %	AFUE %	AFUE %
TSL 1	80	80	80	80	82	83
TSL 2	80	83	80	82	84	83
TSL 3	81	83	81	82	84	83
TSL 4	90	83	90	84	84	84
TSL 5	96	83	90	85	99	95

Product Class List:

NWGF = Non-Weatherized Gas Furnace

WGF = Weatherized Gas Furnace

MHF = Mobile Home Gas Furnace

OF = Oil-fired Furnace

GB = Gas Boiler

OB = Oil-fired Boiler

## 4.0 DESCRIPTION OF THE AFFECTED ENVIRONMENT

### 4.1 Geography

The residential furnaces and boilers standards that DOE has proposed would apply to all 50 states and United States territories.

### 4.2 Air Resources

To analyze the effect of proposed efficiency standards on air resources, DOE used a variant of the DOE Energy Information Administration's (DOE/EIA) National Energy Modeling System (NEMS), called NEMS-BT (BT is DOE's Building Technologies Program)<sup>a</sup>. The environmental analysis is similar to the utility sector analysis described in Chapter 13 of the Residential Furnace and Boiler TSD.<sup>2</sup> Outputs of the environmental analysis are in a format similar to the results of the DOE/EIA's *Annual Energy Outlook 2005 (AEO2005)*.<sup>3</sup>

For each trial standard level, DOE calculated total power sector emissions based on output from NEMS-BT. Household emissions are also calculated, although exogenous to

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<sup>a</sup> The 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 DOE/EIA assumptions, DOE refers to it as NEMS-BT. NEMS-BT was previously called NEMS-BRS.

NEMS-BT. The EA considers two pollutants, nitrogen oxides (NO<sub>x</sub>) and sulfur dioxide (SO<sub>2</sub>), and one emission, carbon dioxide (CO<sub>2</sub>). An air pollutant is any substance in the air that can cause harm to humans or the environment. Pollutants may be natural or man-made and may take the form of solid particles, liquid droplets, or gases. The Clean Air Act Amendments of 1990 list 188 toxic air pollutants that the U.S. Environmental Protection Agency (EPA) is required to control. The EPA has set national air quality standards for six common pollutants (also referred to as "criteria" pollutants), two of which are SO<sub>2</sub> and NO<sub>x</sub>. Also, the Clean Air Act Amendments of 1990 gave authority to EPA to control acidification and require operators of electric power plants to reduce emissions of SO<sub>2</sub> and NO<sub>x</sub>. In addressing SO<sub>2</sub> emissions, the Clean Air Act Amendments of 1990 set an SO<sub>2</sub> emissions cap on all power generation, but permitted flexibility among generators through the use of emissions allowances and tradable permits. Moreover, SO<sub>2</sub> trading implies that physical emissions effects of a standard will be zero because emissions will always be at, or near, the ceiling. Consequently, there is no physical SO<sub>2</sub> environmental benefit from electricity conservation as long as there is enforcement of the emissions ceiling.

#### **4.2.1 Assumptions**

The Department conducted the EA as a policy deviation from the Typical Meteorological Year (TMY) System Load Reference Case, a modified *AEO2005 Reference Case*, using the same basic set of assumptions in NEMS. The emissions characteristics of all electricity-generating plants are exactly as used in *AEO2005*. The TMY System Load Reference Case and alternative growth scenarios are as described in the utility impact analysis of the Residential Furnace and Boiler TSD (Chapter 13).<sup>2</sup> The Department derived the environmental impacts using the same higher decrement approach described in the utility impact analysis.

As in the utility impact analysis, the Department substituted the default NEMS system load with a system load that represents weather conditions for a TMY, which is here referred to as the TMY system load. As a result, the reference case used to judge the impacts from a proposed residential furnace and boiler standard is no longer an exact replication of the *AEO2005 Reference Case* and is therefore referred to as the TMY System Load Reference Case.

The EA also includes a sensitivity analysis for the proposed standard level, using the High and Low Economic Growth scenarios of NEMS-BT. As described in Chapter 13 of the TSD<sup>2</sup> these scenarios cover a range of macroeconomic growth assumptions.

All environmental impact results include a 15 percent rebound effect which is already accounted for in the national energy savings inputs.

## **4.2.2 Methods**

### **4.2.2.1 CO<sub>2</sub>**

The NEMS-BT tracks CO<sub>2</sub> emissions using a detailed CO<sub>2</sub> module that features broad coverage of all sectors and inclusion of interactive effects. Past experience with CO<sub>2</sub> emissions results from NEMS suggests that the estimated emissions reduction generated by NEMS are somewhat lower than estimates based on simple average factors. One of the reasons for this divergence is that NEMS tends to predict that energy conservation displaces more energy-efficient generating capacity in the later years of its forecast.

### **4.2.2.2 Power Sector NO<sub>x</sub>**

The Department evaluates emissions of two airborne pollutants, SO<sub>2</sub> and NO<sub>x</sub>. The NEMS-BT estimates NO<sub>x</sub> emissions from power generation by conforming to all current legislation regarding the power facility development, retrofitting, and dispatch, including potential installations of emissions-reducing equipment. On March 10, 2005, EPA issued the Clean Air Interstate Rule (CAIR). CAIR will permanently cap emissions of NO<sub>x</sub> across 28 eastern states and the District of Columbia. 70 FR 25162 (May 12, 2005). As with SO<sub>2</sub> emissions, a cap on NO<sub>x</sub> emissions would possibly result in no physical emissions effects from equipment efficiency standards in the affected states. When NO<sub>x</sub> emissions are subject to emissions caps, the Department's emissions reduction estimate corresponds to incremental changes in emissions allowance credits in cap-and-trade emissions markets rather than physical emissions reductions.

### **4.2.2.3 Power Sector SO<sub>2</sub>**

As explained above, accurate simulation of SO<sub>2</sub> trading tends to imply that physical emissions effects will be zero, as long as emissions are at the ceiling. Therefore, DOE does not report SO<sub>2</sub> results here.

### **4.2.2.4 Household Emissions**

While NEMS-BT contains provisions for estimating emissions of NO<sub>x</sub> and SO<sub>2</sub> from power generation, it does not estimate household emissions. Because households use natural gas, oil, and LPG, the residential sector also contributes to NO<sub>x</sub> and SO<sub>2</sub> emissions. This analysis therefore includes separate estimates of the effect of standards on household NO<sub>x</sub> and SO<sub>2</sub> emissions, based on simple emissions factors derived from the literature. Although small, household SO<sub>2</sub> emissions savings are reported because the SO<sub>2</sub> emissions caps do not apply to the residential sector. Appendix W provides a detailed description of the methodology and sources for deriving the emissions factors for combustion processes in residential furnaces and boilers.

#### **4.2.2.5 Fuel-Cycle Emissions**

Fuel-cycle emissions refer to all the emissions associated with the amount of energy used in the upstream and downstream production of energy, including energy used at the power plant. The NEMS-BT does a thorough accounting of emissions at the power plant due to downstream energy consumption, but does not account for upstream emissions (i.e., emissions from energy use during coal and natural gas production). The upstream processes include the mining of coal or extraction of natural gas, physical preparatory and cleaning processes, and transportation to the power plant (see section 5.1.2 for further discussion).

#### **4.2.2.6 Interpolation**

Because the energy savings from residential furnace and boiler standards are too small to produce stable power sector results in NEMS-BT, DOE estimated results for the TSLs using interpolation. This is similar to the process it used to estimate the utility impact analysis results. Appendix U of the Residential Furnace and Boiler TSD describes the interpolation methodology in detail.<sup>2</sup>

#### **4.2.2.7 Extrapolation**

The current time horizon of NEMS-BT is 2025 (modeling a 10-year period, 2015-2025), yet other parts of the appliance energy-efficiency work reach 2038. To address this concern, the Department has developed an adjunct version of the NEMS model called NEMS-BT2 that is capable, although in limited form, to model to year 2050. As with the *AEO2005* Reference Case in general, the implicit assumption is that the regulatory environment does not change from the current, known situation during the extrapolation period. Only changes that have been announced with date-certain introduction are included in NEMS-BT. The NEMS-BT2 2050 extension model based on the 2004 version of NEMS-BT was developed by OnLocation, Inc., under a subcontract to the Department. Extensive code and input file changes were required to allow NEMS-BT2 to run to 2050, unfortunately rendering it impossible to extend the 2005 version. Therefore, the Department used the 2005 version of NEMS-BT to conduct the analysis through 2025 and the 2004 NEMS-BT2 2050 extension to conduct the analysis from 2026-2038. Some assumptions and adjustments were required to ease the transition from year 2025 to 2026, thereby removing the inherent differences between these two versions of the model (see Appendix V for discussion). To emphasize the extrapolated results wherever they appear, they are shaded in grey to distinguish them from actual NEMS-BT output.

#### **4.2.2.8 Discounting Emissions**

DOE also calculated discounted avoided emissions results. The Department used the same discount rates that it used in calculating the NPV (seven percent and three percent real) to calculate discounted cumulative emission reductions. The seven-percent and three-percent real discount rate values are meant to capture the present value of costs and benefits associated with projects facing an average degree of risk. Other discount rates may be more applicable to

discount costs and benefits associated with projects facing different risks and uncertainties.

### **4.3 Socioeconomics**

As part of the rulemaking process, DOE evaluated the socioeconomic effects of standards for non-weatherized gas furnaces on senior and low-income households, sub-groups that DOE identified as possibly being disproportionately affected by a national standard level. The Department is especially concerned that increases in the purchase price of equipment could have negative impacts on these groups that may not be able to afford significant increases in equipment price. The analysis on consumer sub-groups included determining the differences in LCC as well as the payback periods for the four TSLs analyzed. Chapter 11 of the Residential Furnaces and Boilers TSD provides more details on the sub-group analysis.<sup>2</sup>

### **4.4 Environmental Justice**

A consideration of Environmental Justice is made pursuant to the Executive Order 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations. The Executive Order requires federal agencies to assess whether a proposed federal action causes any disproportionately high and adverse human health or environmental effects on low-income or minority populations. As mentioned above, DOE evaluated the socioeconomic effects of standards on low-income households.

### **4.5 Energy Consumption**

The Department used a detailed Shipments and National Energy Savings (NES) Spreadsheet Model to determine national energy savings as a result of increases in furnaces and boilers efficiency standards. This spreadsheet model forecasts the national shipments and energy use of residential furnaces and boiler with and without new standards. The shipments and NES analyses are described in detail in Chapters 9 and 10, respectively, of the Residential Furnaces and Boilers TSD.<sup>2</sup> The NES results include a 15 percent rebound effect.

### **4.6 Noise and Aesthetics**

The Department considered how amended energy conservation standards for residential furnaces and boilers would affect the noise and aesthetics of the equipment. To improve the efficiency of residential furnaces and boilers, some design changes can enlarge the size of the equipment or necessitate the use of more efficient motors and fans. The Department determined if noise and aesthetics were impacted by these design changes.

### **4.7 Indoor Air Environment**

The Department considered how amended energy conservation standards for residential furnaces and boilers would affect the indoor air environment. The Department considered the potential for furnace and boiler standards to pose public health risks due to carbon monoxide

release into the home as a result of venting system failure.

## **5.0 ENVIRONMENTAL IMPACTS**

### **5.1 Air Quality/Emissions Impacts**

#### **5.1.1 Power Sector and Household Emissions**

The results for the environmental analysis are similar to a complete NEMS run as published in the *AEO*, and include power sector emissions for  $\text{NO}_x$  and  $\text{CO}_2$  in five-year forecast increments extrapolated to the year 2038. The Department reports the outcome of the analysis for each TSL as a deviation from the TMY System Load Reference Case. This is also referred to as the base case, as well as the no-action alternative.

As discussed earlier in section 4.2, the Clean Air Act Amendments of 1990 set an  $\text{SO}_2$  emissions cap on all power generation, but permitted flexibility among generators through the use of emissions allowances and tradable permits. Moreover,  $\text{SO}_2$  trading implies that physical emissions effects of a standard will be zero because emissions will always be at, or near, the ceiling. Consequently, there is no physical  $\text{SO}_2$  environmental benefit from electricity conservation as long as there is enforcement of the emissions ceiling. An economic benefit may result if coal generation falls and the resulting reduced demand for  $\text{SO}_2$  emission allowances lowers the allowance price. Because the  $\text{SO}_2$  effects considered here are too small to provide reasonable estimates of impacts on allowance prices, the environmental assessment does not attempt to estimate this benefit. If this price impact is big enough to be detectable in NEMS-BT, the Department will report this value in future appliance standards rulemakings.

Table EA.4 shows annual total power sector  $\text{CO}_2$  and  $\text{NO}_x$  emissions for the base case (no-action alternative) and each of the five TSLs. Table EA.5 shows the annual results for the household emissions and shows the High and Low Economic Growth scenario results for TSL 2, the proposed action. Table EA.6 shows the cumulative power sector emissions impacts through 2025 and 2038 for  $\text{CO}_2$  and  $\text{NO}_x$ . The cumulative emissions through 2038 increase from TSL 1 to TSL 5 due to a rise in electricity generation resulting from a market shift from gas to electric heating equipment at the higher standard levels.

As discussed earlier in section 4.2, the cap on  $\text{NO}_x$  emissions would possibly result in no physical emissions effects from equipment efficiency standards in the affected states. When  $\text{NO}_x$  emissions are subject to emissions caps, the Department's emissions reduction estimate corresponds to incremental changes in emissions allowance credits in cap-and-trade emissions markets rather than physical emissions reductions.

Table EA.7 shows the cumulative household emissions reductions through 2025 and 2038 for  $\text{CO}_2$ ,  $\text{NO}_x$ , and  $\text{SO}_2$ . The emissions reductions become larger from TSL 1 to TSL 5 due to the decline in fuel consumption at these standard levels.

Table EA.8 shows the total cumulative emissions reductions from both the power sector and households. The emissions reductions become larger from TSL 1 to TSL 5 because the decrease in household emissions outweighs the increase in power sector emissions.

Tables EA.4 through EA.8 also include results for the Low and High Economic Growth cases for the proposed standard (TSL 2). The differences between the reference and sensitivity cases are due to changes in the macroeconomic assumptions of NEMS-BT.

Table EA.9 shows the discounted cumulative emissions impacts from both the power sector and households, using seven and three percent real discount rates.

**Table EA.4 Power Sector Emissions Impacts Forecast (Metric Tons)<sup>1</sup>**

										Difference from AEO2005 TMY System Load Reference Case										
	2000	2005	2010	2015	2020	2025	2030	2035	2038		2000	2005	2010	2015	2020	2025	2030	2035	2038	
							Extrapolation										Extrapolation			
<b>AEO2005 Reference Case with TMY System Load (Base Case)</b>																				
CO <sub>2</sub> (Mt/a) <sup>2,3</sup>	2,283.0	2,372.0	2,624.0	2,800.0	3,024.0	3,312.0	3,427.0	3,521.0	3,596.0											
NOx (kt/a) <sup>3,4</sup>	4,681.1	3,338.4	3,637.8	3,737.6	3,810.2	3,900.9	3,320.5	3,338.6	3,347.7											
<b>Standard Level 1</b>																				
CO <sub>2</sub> (Mt/a)	2,283.0	2,372.0	2,624.0	2,800.0	3,024.0	3,311.9	3,427.0	3,521.1	3,596.2	CO <sub>2</sub> (Mt/a)	0.0	0.0	0.0	0.0	0.0	-0.1	0.0	0.1	0.2	
NOx (kt/a)	4,681.1	3,338.4	3,637.8	3,737.6	3,810.2	3,901.0	3,320.6	3,338.7	3,347.8	NOx (kt/a)	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	
<b>Standard Level 2</b>																				
CO <sub>2</sub> (Mt/a)	2,283.0	2,372.0	2,624.0	2,800.0	3,023.9	3,311.8	3,427.1	3,521.3	3,596.4	CO <sub>2</sub> (Mt/a)	0.0	0.0	0.0	0.0	-0.1	-0.2	0.1	0.3	0.4	
NOx (kt/a)	4,681.1	3,338.4	3,637.8	3,737.6	3,810.3	3,901.2	3,320.7	3,338.8	3,348.0	NOx (kt/a)	0.0	0.0	0.0	0.0	0.2	0.3	0.2	0.2	0.3	
<b>Standard Level 3</b>																				
CO <sub>2</sub> (Mt/a)	2,283.0	2,372.0	2,624.0	2,800.0	3,023.9	3,311.7	3,427.1	3,521.5	3,596.8	CO <sub>2</sub> (Mt/a)	0.0	0.0	0.0	0.0	-0.1	-0.3	0.1	0.5	0.8	
NOx (kt/a)	4,681.1	3,338.4	3,637.8	3,737.6	3,810.5	3,901.4	3,320.8	3,339.0	3,348.2	NOx (kt/a)	0.0	0.0	0.0	0.0	0.3	0.5	0.3	0.4	0.5	
<b>Standard Level 4</b>																				
CO <sub>2</sub> (Mt/a)	2,283.0	2,372.0	2,624.0	2,800.0	3,023.4	3,310.6	3,427.6	3,523.2	3,599.5	CO <sub>2</sub> (Mt/a)	0.0	0.0	0.0	0.0	-0.6	-1.4	0.6	2.2	3.5	
NOx (kt/a)	4,681.1	3,338.4	3,637.8	3,737.7	3,811.5	3,903.2	3,322.0	3,340.3	3,349.8	NOx (kt/a)	0.0	0.0	0.0	0.1	1.3	2.3	1.5	1.6	2.1	
<b>Standard Level 5</b>																				
CO <sub>2</sub> (Mt/a)	2,283.0	2,372.0	2,624.0	2,800.0	3,022.3	3,309.3	3,429.1	3,526.5	3,604.5	CO <sub>2</sub> (Mt/a)	0.0	0.0	0.0	0.0	-1.7	-2.7	2.1	5.5	8.5	
NOx (kt/a)	4,681.1	3,338.4	3,637.8	3,738.0	3,812.5	3,906.2	3,325.2	3,344.2	3,354.1	NOx (kt/a)	0.0	0.0	0.0	0.4	2.3	5.3	4.7	5.6	6.4	
<b>AEO2005 High Growth Ref Case with TMY System Load</b>																				
CO <sub>2</sub> (Mt/a)	2,283.0	2,385.0	2,673.0	2,884.0	3,169.0	3,554.0	3,677.4	3,778.3	3,858.8											
NOx (kt/a)	4,681.1	3,356.6	3,674.1	3,773.9	3,864.6	3,973.5	3,382.1	3,400.6	3,409.8											
<b>Standard Level 2 High Growth</b>																				
CO <sub>2</sub> (Mt/a)	2,283.0	2,385.0	2,673.0	2,884.0	3,168.9	3,553.8	3,677.5	3,778.5	3,859.2	CO <sub>2</sub> (Mt/a)	0.0	0.0	0.0	0.0	-0.1	-0.2	0.1	0.3	0.4	
NOx (kt/a)	4,681.1	3,356.6	3,674.1	3,773.9	3,864.6	3,973.4	3,382.1	3,400.5	3,409.8	NOx (kt/a)	0.0	0.0	0.0	0.0	0.0	-0.1	0.0	0.0	0.0	
<b>AEO2005 Low Growth Ref Case with TMY System Load</b>																				
CO <sub>2</sub> (Mt/a)	2,283.0	2,359.0	2,573.0	2,719.0	2,887.0	3,088.0	3,195.2	3,282.9	3,352.8											
NOx (kt/a)	4,681.1	3,320.3	3,583.4	3,683.2	3,755.7	3,828.3	3,258.5	3,276.3	3,285.2											
<b>Standard Level 2 Low Growth</b>																				
CO <sub>2</sub> (Mt/a)	2,283.0	2,359.0	2,573.0	2,719.0	2,886.9	3,087.8	3,195.3	3,283.1	3,353.2	CO <sub>2</sub> (Mt/a)	0.0	0.0	0.0	0.0	-0.1	-0.2	0.1	0.3	0.4	
NOx (kt/a)	4,681.1	3,320.3	3,583.4	3,683.2	3,755.7	3,828.1	3,258.5	3,276.3	3,285.2	NOx (kt/a)	0.0	0.0	0.0	0.0	0.0	-0.2	0.0	0.0	0.0	

<sup>1</sup>Negative values refer to a reduction compared to the Reference forecast

<sup>2</sup>Comparable to Table A17 of AEO2005: Electric Generators

<sup>3</sup>Comparable to Table A8 of AEO2005: Emissions

<sup>4</sup>All results in metric tons (t), equivalent to 1.1 short tons

**Table EA.5 Household Emissions Impacts Forecast, Relative to the Base Case<sup>1</sup>**

	2000	2005	2010	2015	2020	2025	2030	2035	2038
							Extrapolation		
<b>Standard Level 1</b>									
CO <sub>2</sub> (Mt/a)	0.00	0.00	0.00	0.00	-0.17	-0.34	-0.53	-0.72	-0.82
NO <sub>x</sub> (kt/a)	0.00	0.00	0.00	0.00	-0.14	-0.27	-0.42	-0.57	-0.65
SO <sub>2</sub> (kt/a)	0.00	0.00	0.00	0.00	-0.01	-0.03	-0.04	-0.04	-0.05
<b>Standard Level 2</b>									
CO <sub>2</sub> (Mt/a)	0.00	0.00	0.00	0.00	-0.37	-0.76	-1.17	-1.55	-1.74
NO <sub>x</sub> (kt/a)	0.00	0.00	0.00	0.00	-0.30	-0.61	-0.93	-1.23	-1.38
SO <sub>2</sub> (kt/a)	0.00	0.00	0.00	0.00	-0.03	-0.06	-0.08	-0.09	-0.10
<b>Standard Level 3</b>									
CO <sub>2</sub> (Mt/a)	0.00	0.00	0.00	0.00	-0.70	-1.46	-2.23	-2.89	-3.19
NO <sub>x</sub> (kt/a)	0.00	0.00	0.00	0.00	-0.58	-1.17	-1.77	-2.30	-2.54
SO <sub>2</sub> (kt/a)	0.00	0.00	0.00	0.00	-0.06	-0.11	-0.16	-0.17	-0.18
<b>Standard Level 4</b>									
CO <sub>2</sub> (Mt/a)	0.00	0.00	0.00	0.00	-3.24	-6.85	-10.37	-13.19	-14.40
NO <sub>x</sub> (kt/a)	0.00	0.00	0.00	0.00	-2.66	-5.47	-8.27	-10.49	-11.44
SO <sub>2</sub> (kt/a)	0.00	0.00	0.00	0.00	-0.28	-0.54	-0.74	-0.80	-0.82
<b>Standard Level 5</b>									
CO <sub>2</sub> (Mt/a)	0.00	0.00	0.00	0.00	-6.67	-14.09	-21.42	-27.63	-30.51
NO <sub>x</sub> (kt/a)	0.00	0.00	0.00	0.00	-5.37	-11.13	-16.89	-21.74	-23.99
SO <sub>2</sub> (kt/a)	0.00	0.00	0.00	0.00	-1.34	-2.71	-3.90	-4.69	-5.11
<b>Standard Level 2 High Growth Scenario</b>									
CO <sub>2</sub> (Mt/a)	0.00	0.00	0.00	0.00	-0.38	-0.76	-1.16	-1.54	-1.73
NO <sub>x</sub> (kt/a)	0.00	0.00	0.00	0.00	-0.30	-0.61	-0.93	-1.23	-1.38
SO <sub>2</sub> (kt/a)	0.00	0.00	0.00	0.00	-0.03	-0.06	-0.08	-0.09	-0.10
<b>Standard Level 2 Low Growth Scenario</b>									
CO <sub>2</sub> (Mt/a)	0.00	0.00	0.00	0.00	-0.38	-0.77	-1.19	-1.57	-1.76
NO <sub>x</sub> (kt/a)	0.00	0.00	0.00	0.00	-0.30	-0.61	-0.93	-1.23	-1.38
SO <sub>2</sub> (kt/a)	0.00	0.00	0.00	0.00	-0.03	-0.06	-0.08	-0.09	-0.10

<sup>1</sup>Negative values refer to a reduction compared to the Base Case

**Table EA.6 Cumulative Power Sector Emissions Impacts Forecast, Relative to the Base Case<sup>1</sup>**

	Cumulative 2000-2025	Cumulative 2000-2038
<b>Standard Level 1</b>		
CO <sub>2</sub> (Mt)	-0.3	0.7
NO <sub>x</sub> (kt)	0.7	1.8
<b>Standard Level 2</b>		
CO <sub>2</sub> (Mt)	-0.7	1.5
NO <sub>x</sub> (kt)	1.6	3.9
<b>Standard Level 3</b>		
CO <sub>2</sub> (Mt)	-1.3	2.7
NO <sub>x</sub> (kt)	3.1	7.4
<b>Standard Level 4</b>		
CO <sub>2</sub> (Mt)	-5.9	12.3
NO <sub>x</sub> (kt)	14.5	34.2
<b>Standard Level 5</b>		
CO <sub>2</sub> (Mt)	-10.1	40.2
NO <sub>x</sub> (kt)	33.9	99.1
<b>Standard Level 2 High Growth</b>		
CO <sub>2</sub> (Mt)	-0.7	1.5
NO <sub>x</sub> (kt)	-0.6	-0.5
<b>Standard Level 2 Low Growth</b>		
CO <sub>2</sub> (Mt)	-0.7	1.5
NO <sub>x</sub> (kt)	-1.0	-0.9

<sup>1</sup>Negative values correspond to emissions reductions

**Table EA.7 Cumulative Household Emissions Impacts Forecast, Relative to the Base Case<sup>1</sup>**

	Cumulative 2000-2025	Cumulative 2000-2038
<b>Standard Level 1</b>		
CO <sub>2</sub> (Mt)	-1.8	-9.7
NOx (kt)	-1.5	-7.8
SO <sub>2</sub> (kt)	-0.2	-0.7
<b>Standard Level 2</b>		
CO <sub>2</sub> (Mt)	-4.0	-21.1
NOx (kt)	-3.3	-16.9
SO <sub>2</sub> (kt)	-0.3	-1.5
<b>Standard Level 3</b>		
CO <sub>2</sub> (Mt)	-7.7	-39.7
NOx (kt)	-6.4	-31.9
SO <sub>2</sub> (kt)	-0.6	-2.7
<b>Standard Level 4</b>		
CO <sub>2</sub> (Mt)	-35.6	-183.3
NOx (kt)	-29.6	-147.2
SO <sub>2</sub> (kt)	-3.0	-12.7
<b>Standard Level 5</b>		
CO <sub>2</sub> (Mt)	-73.4	-381.2
NOx (kt)	-60.0	-302.5
SO <sub>2</sub> (kt)	-14.8	-69.0
<b>Standard Level 2 High Growth</b>		
CO <sub>2</sub> (Mt)	-3.9	-20.9
NOx (kt)	-3.3	-16.9
SO <sub>2</sub> (kt)	-0.3	-1.5
<b>Standard Level 2 Low Growth</b>		
CO <sub>2</sub> (Mt)	-4.0	-21.3
NOx (kt)	-3.3	-16.9
SO <sub>2</sub> (kt)	-0.3	-1.5

<sup>1</sup>Negative values correspond to emissions reductions

**Table EA.8 Cumulative Power Sector and Household Emissions Impacts Forecast, Relative to the Base Case<sup>1</sup>**

	Cumulative 2000-2025	Cumulative 2000-2038
<b>Standard Level 1</b>		
CO <sub>2</sub> (Mt)	-2.1	-9.0
NO <sub>x</sub> (kt)	-0.8	-6.0
SO <sub>2</sub> (kt)	-0.2	-0.7
<b>Standard Level 2</b>		
CO <sub>2</sub> (Mt)	-4.7	-19.6
NO <sub>x</sub> (kt)	-1.7	-13.0
SO <sub>2</sub> (kt)	-0.3	-1.5
<b>Standard Level 3</b>		
CO <sub>2</sub> (Mt)	-8.9	-37.0
NO <sub>x</sub> (kt)	-3.3	-24.5
SO <sub>2</sub> (kt)	-0.6	-2.7
<b>Standard Level 4</b>		
CO <sub>2</sub> (Mt)	-41.5	-171.1
NO <sub>x</sub> (kt)	-15.1	-113.0
SO <sub>2</sub> (kt)	-3.0	-12.7
<b>Standard Level 5</b>		
CO <sub>2</sub> (Mt)	-83.5	-341.0
NO <sub>x</sub> (kt)	-26.1	-203.4
SO <sub>2</sub> (kt)	-14.8	-69.0
<b>Standard Level 2 High Growth</b>		
CO <sub>2</sub> (Mt)	-4.5	-19.4
NO <sub>x</sub> (kt)	-3.9	-17.4
SO <sub>2</sub> (kt)	-0.3	-1.5
<b>Standard Level 2 Low Growth</b>		
CO <sub>2</sub> (Mt)	-4.7	-19.9
NO <sub>x</sub> (kt)	-4.3	-17.8
SO <sub>2</sub> (kt)	-0.3	-1.5

<sup>1</sup>Negative values correspond to emissions reductions

**Table EA.9 Discounted Cumulative Power Sector and Household Emissions Impacts Forecast, Relative to the Base Case**

	<b>7% Discount Rate</b>	<b>3% Discount Rate</b>
<b>Standard Level 1</b>		
CO <sub>2</sub> (Mt)	-1.7	-4.2
NO <sub>x</sub> (kt)	-1.0	-2.7
SO <sub>2</sub> (kt)	-0.1	-0.3
<b>Standard Level 2</b>		
CO <sub>2</sub> (Mt)	-3.6	-9.2
NO <sub>x</sub> (kt)	-2.2	-5.8
SO <sub>2</sub> (kt)	-0.3	-0.7
<b>Standard Level 3</b>		
CO <sub>2</sub> (Mt)	-6.9	-17.4
NO <sub>x</sub> (kt)	-4.1	-11.0
SO <sub>2</sub> (kt)	-0.5	-1.3
<b>Standard Level 4</b>		
CO <sub>2</sub> (Mt)	-31.8	-80.6
NO <sub>x</sub> (kt)	-18.9	-51.0
SO <sub>2</sub> (kt)	-2.4	-6.0
<b>Standard Level 5</b>		
CO <sub>2</sub> (Mt)	-63.2	-160.4
NO <sub>x</sub> (kt)	-33.5	-91.2
SO <sub>2</sub> (kt)	-12.5	-32.1
<b>Standard Level 2 High Growth</b>		
CO <sub>2</sub> (Mt)	-3.5	-9.1
NO <sub>x</sub> (kt)	-3.1	-8.1
SO <sub>2</sub> (kt)	-0.3	-0.7
<b>Standard Level 2 Low Growth</b>		
CO <sub>2</sub> (Mt)	-3.7	-9.3
NO <sub>x</sub> (kt)	-3.3	-8.3
SO <sub>2</sub> (kt)	-0.3	-0.7

<sup>1</sup>Negative values correspond to emissions reductions

### 5.1.2 Fuel-Cycle Emissions

As discussed earlier, fuel-cycle emissions refer to the emissions associated with the amount of energy used in the upstream and downstream production of energy, including energy used at the power plant. The amount of energy used to perform the upstream processes is not directly linked to the downstream consumption of these fuels. For this reason, changes in upstream emissions due to proposed standards are not counted in NEMS-BT. DOE does not report estimates of the effects of alternatives on upstream emissions, thus makes no conclusions regarding differences in upstream impacts among the alternatives. However, the emissions factors described here provide the reader with a sense for the possible magnitude of the effects.

Estimates of upstream emissions for CO<sub>2</sub> and NO<sub>x</sub> are taken from a study conducted in 1993 by Mark A. DeLuchi (sometimes spelled DeLucci), Ph. D., at Argonne National Laboratory.<sup>5</sup> DeLuchi provides estimates of full fuel-cycle emissions factors for CO<sub>2</sub>, methane (CH<sub>4</sub>), carbon monoxide (CO), non-methane organic compounds (NMOC), and NO<sub>x</sub> from coal and natural gas production.<sup>5</sup> The emission factor for SO<sub>2</sub> is taken from the Environmental Protection Agency (EPA) Report, AP-42, *Compilation of Air Pollutant Emission Factors*.<sup>6</sup> The EPA AP-42 report notes that coal cleaning is the primary source for upstream SO<sub>2</sub> emissions from coal production, so the emission factor for SO<sub>2</sub> reflects only the coal-cleaning process. Transportation of coal is not addressed in EPA's study.

Emission factor estimates and corresponding percentages of contributions of upstream emissions from coal and natural gas production, relative to power plant emissions, are shown in Table EA.10 for CO<sub>2</sub>, SO<sub>2</sub>, and NO<sub>x</sub>. The relative percentage to power plant emissions provides a means to estimate upstream emission savings based on the savings from the power plant. The values shown in Table EA.9 represent emissions from upstream processes as mass (g) per deliverable energy in gigajoules (GJ) to end-use consumers.

**Table EA.10 Estimated Upstream Emission Factors and Relative Percentages To Direct Power Plant Combustion Emissions**

	Coal		Natural Gas	
	Emission Factor (g/GJ)	% of Combustion Emissions	Emission Factor (g/GJ)	% of Combustion Emissions
CO <sub>2</sub>	8,147	2.7	20,000	11.9
SO <sub>2</sub>	29.2	0.9	0	0
NO <sub>x</sub>	41.7	5.8	153	40

Relative to the entire fuel cycle, DeLuchi estimates that approximately eight percent by mass of emissions from coal production are due to mining, preparation that includes cleaning the coal, and transportation from the mine to the power plant. Transportation emissions include emissions from the fuel used by the mode of transportation that moves the coal from the mine to the power plant. Also, DeLuchi estimates that approximately 14 percent of emissions from natural gas production results from upstream processes. In sum, emissions factors relative to

power plant emissions are a relatively small proportion of the energy losses attributable to upstream processes. With the exception of NO<sub>x</sub> emissions from natural gas production, upstream emissions are less than 12 percent of power plant emissions.

## **5.2 Wetlands / Endangered and Threatened Species / Cultural Resources**

This action is not site-specific, and would not affect land disturbance. Therefore, this action is not expected to impact the quality of wetlands, or threatened or endangered species. Further, this action is not expected to impact cultural resources such as historical or archaeological sites.

## **5.3 Socioeconomic Impacts**

DOE's analysis has shown that the increase in the first cost of purchasing a more efficient furnace or boiler at the proposed standard level is offset by a reduction in the LCC of owning a more efficient piece of equipment. In other words, the owner will pay less operating costs over the life of the equipment even though the first cost increases.

For the sub-group of consumers that are low-income, DOE determined that for non-weatherized gas furnaces, the proposed standard level would result in slightly less favorable impacts compared to the full sample of consumers. For the sub-group of consumers that are seniors, the average LCC impact is similar to that for the full sample of consumers. Therefore the Department concludes that the proposed action would not have negative socioeconomic impact. For a complete discussion of the LCC impacts on low-income and senior households, see Chapter 11 of the Residential Furnaces and Boilers TSD.<sup>2</sup>

## **5.4 Environmental Justice Impacts**

In view of Executive Order 12898 of February 11, 1994, "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations," the DOE examined the effect of more stringent energy efficiency standards on low-income households. As described in the Life-Cycle Cost Subgroup Analysis, Chapter 11 of the TSD<sup>2</sup>, the Department found that there were no disproportionately high and adverse human health or environmental effects on low-income populations that would result from the proposed energy efficiency standards. DOE believes that the above conclusion would also apply to minority populations.

## **5.5 Energy Consumption Impacts**

The proposed standard level for furnaces and boilers (TSL 2) would result in the national energy savings shown in Table EA.10. Energy savings for the other four TSLs are also provided, see Chapter 10 of the Residential Furnaces and Boilers TSD.<sup>2</sup>

**Table EA.11 Cumulative Energy Savings from Residential Furnaces and Boilers Standards from 2015 to 2038**

<b>Trial Standard Level</b>	<b>No Action</b>	<b>TSL 1</b>	<b>TSL 2</b>	<b>TSL 3</b>	<b>TSL 4</b>	<b>TSL 5</b>
Cumulative Primary Energy Saved (Quads)	0.00	0.18	0.41	0.69	3.19	6.22

**5.6 Noise and Aesthetics**

The proposed action is not likely to affect the sound power levels, sound quality levels or aesthetics associated with residential furnaces and boilers. The impact on noise or aesthetics from the more efficient equipment covered under this EA would be virtually no different from equipment being installed today.

**5.7 Indoor Air Environment**

The Department determined that none of the considered alternatives would lead to carbon monoxide release into the home as a result of venting system failure, with the possible exception of TSL 3. TSL 3 includes a standard for non-weatherized gas furnaces and for mobile home gas furnaces at 81-percent AFUE. At this level, there is some risk of venting system failure due to condensation. Based on its evaluation of all the information considered during the rulemaking, the Department believes that the standard levels in the proposed action would not result in negative impact on the indoor air environment.

**5.8 Summary of Environmental Impacts**

Table EA.11 provides a summary of the analysis results to aid the reader in discerning the benefits and burdens for the different TSLs as well as the no-action alternative.

**Table EA.12 Summary of the Analysis Results**

	No-Action Alternative	Trial Standard Level				
		1	2	3	4	5
Cumulative Emission Reductions*						
CO <sub>2</sub> (Mt)	0.0	9.0	19.6	37.0	171.1	341.0
NO <sub>x</sub> (kt)	0.0	6.0	13.0	24.5	113.0	203.4
Cumulative Primary Energy Saved (Quads)*	0.0	0.18	0.41	0.69	3.19	6.22
Socioeconomic Impacts – Non-Weatherized Gas Furnace, Mean LCC Savings**						
All Consumers	NA	\$2	\$2	\$2	\$5	(\$731)
Low-income Sub-group	NA	\$1	\$1	(\$3)	(\$20)	(\$720)
Senior Sub-group	NA	\$2	\$2	\$1	(\$2)	(\$676)
Environmental Justice Impacts	None	None	None	None	None	None
Wetlands/Endangered and Threatened Species/Cultural Resources Impacts	None	None	None	None	None	None
Fuel-Cycle (Upstream) Emissions Impacts	None	***	***	***	***	***
Noise and Aesthetics Impacts	None	None	None	None	None	None

\* Cumulative total is over a time period starting in 2015 and ending in 2038. The reductions include impacts at power plants (both physical reductions and emissions credits) and at the household level.

\*\* Values refer to savings over the equipment lifetime.

\*\*\* DOE does not report actual estimates of the effects of standards on upstream emissions, but section 5.1.2 provides a sense for the possible magnitude of effects.

The Department has proposed energy efficiency standards for furnaces and boilers at TSL 2. The proposed standards would not result in significant environmental impacts. The proposed standards would apply to all covered products offered for sale in the United States and its Territories, with a compliance date of January 1, 2015.

The Department has found the proposed standard represents the maximum improvement in energy efficiency that is technologically feasible and economically justified. The Department found the benefits to the Nation of the proposed standard (energy savings, consumer average LCC savings, national NPV increase, and emission reductions) outweigh the costs (loss of manufacturer NPV, and LCC increases for some consumers). The justification for selecting the proposed action, TSL 2, over the other TSLs considered is fully explained in Section V.C, Conclusions of the NOPR. The NOPR is available on the internet at: [/http://www.eere.energy.gov/buildings/appliance\\_standards/residential/furnaces\\_boilers.html](http://www.eere.energy.gov/buildings/appliance_standards/residential/furnaces_boilers.html) under “Not yet known.”

The proposed standards represent an improvement in energy efficiency (relative to the baseline equipment) of 2 percent for non-weatherized gas furnaces, 5 percent for weatherized gas furnaces, 5 percent for mobile home gas furnaces, 4 percent for oil-fired furnaces, 4 percent for gas boilers, and 3 percent for oil boilers.

In the 24-year period after the new standards become effective, the Nation will save about 0.48 quads of primary energy. Additionally, these energy savings will reduce emission of air pollutants and greenhouse gases by 22.2 Mt of CO<sub>2</sub> and 19.4 kt of NO<sub>x</sub>.

## REFERENCES

1. U.S. Department of Energy-Office of Building Research and Standards. *Notice of the Public Workshop and Availability of the Framework Document for Residential Furnaces and Boilers*. 2001. (Posted November 5, 2001)  
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