DOE/EA-1892

Environmental Assessment

for

Energy Conservation Program: Energy Conservation Standards for Residential Furnaces and Residential Central Air Conditioners and Heat Pumps

June 2011

CHAPTER 15. ENVIRONMENTAL IMPACTS ANALYSIS

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CHAPTER 15. ENVIRONMENTAL ASSESSMENT

15.1 INTRODUCTION

This chapter describes potential environmental effects that may result from amended energy conservation standards for residential furnaces, central air conditioners (CAC), and heat pumps. The U.S. Department of Energy (DOE)'s energy conservation standards are not site-specific, and would apply to all 50 States and U.S. territories. Therefore, none of the standards would impact land uses, cause any direct disturbance to the land, or directly affect biological resources in any one area.

All of the considered trial standard levels (TSLs) are expected to reduce energy consumption in comparison to the base case. These changes in energy consumption are the primary drivers in analyzing environmental effects. The estimates of energy savings that serve as inputs to the environmental impacts analysis can be found in the utility impact analysis in chapter 14 of this technical support document (TSD).

The primary impact of the TSLs is on air emissions resulting from power plant operations. Therefore, much of this chapter describes the air emissions analysis, and the latter part of the chapter describes potential impacts to other environmental resources.

15.2 AIR EMISSIONS ANALYSIS

A primary focus of the environmental assessment is the impact on air emissions of amended energy conservation standards for residential furnaces, central air conditioners, and heat pumps. Important outcomes of the environmental assessment are driven by changes in power plant types and quantities of electricity generated under each of the TSLs as well as changes in site emissions from the direct use of fuel-burning furnaces. Changes in residential sector electricity generation and fossil fuel consumption under each TSL are described in the utility impact analysis in chapter 14.

15.2.1 Air Emissions Descriptions

For each of the TSLs, DOE calculated total power-sector emissions based on output from the NEMS-BT model (see chapter 14 for description of the model). This analysis considers three pollutants: sulfur dioxide (SO_2), nitrogen oxides (NO_X), and mercury (Hg). 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 (i.e., anthropogenic) and may take the form of solid particles (i.e., particulates or particulate matter), liquid droplets, or gases.[a] This analysis also considers carbon dioxide (CO_2).

[a] More information on air pollution characteristics and regulations is available on the U.S. Environment Protection Agent (EPA)'s website at www.epa.gov.

Sulfur Dioxide. Sulfur dioxide, or SO_2, belongs to the family of sulfur oxide gases (SOx). These gases dissolve easily in water. Sulfur is prevalent in all raw materials, including crude oil, coal, and ore that contains common metals like aluminum, copper, zinc, lead, and iron. SOx gases are formed when fuel containing sulfur, such as coal and oil, is burned, and when gasoline is extracted from oil, or metals are extracted from ore. SO_2 dissolves in water vapor to form acid, and interacts with other gases and particles in the air to form sulfates and other products that can be harmful to people and their environment.[1]

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

Nitrogen Oxides. Nitrogen oxides**,** or NO_X, is the generic term for a group of highly reactive gases, all of which contain nitrogen and oxygen in varying amounts. Many of the nitrogen oxides are colorless and odorless. However, one common pollutant, nitrogen dioxide (NO_2), along with particles in the air can often be seen as a reddish-brown layer over many urban areas. NO_2 is the specific form of NO_X reported in this document. NO_X is one of the main ingredients involved in the formation of ground-level ozone, which can trigger serious respiratory problems. It can contribute to the formation of acid rain, and can impair visibility in areas such as national parks. NO_X also contributes to the formation of fine particles that can impair human health.[1]

Nitrogen oxides form when fossil fuel is burned at high temperatures, as in a combustion process. The primary manmade sources of NO_X are motor vehicles, electric utilities, and other industrial, commercial, and residential sources that burn fossil fuels. NO_X can also be formed naturally. Electric utilities account for about 22 percent of NO_X emissions in the United States.[2]

There is a cap on NO_x emissions in 28 eastern states and the District of Columbia. All these States and D.C. have elected to reduce their NOx emissions by participating in cap-and-trade programs for EGUs. Therefore, energy conservation standards for furnaces and central air conditioners may have little or no physical effect on these emissions in the 28 eastern states and the D.C. for the same reasons that they may have little or no physical effect on NO_X emissions.

DOE used NEMS-BT to estimate NOx emissions reductions from possible standards in the States where emissions are not capped.

Mercury. Coal-fired power plants emit mercury (Hg) found in coal during the burning process. While coal-fired power plants are the largest remaining source of human-generated Hg emissions in the United States, they contribute very little to the global Hg pool or to contamination of U.S. waters.[1] U.S. coal-fired power plants emit Hg in three different forms: oxidized Hg (likely to deposit within the United States); elemental Hg, which can travel thousands of miles before depositing to land and water; and Hg that is in particulate form. Atmospheric Hg is then deposited on land, lakes, rivers, and estuaries through rain, snow, and dry deposition. Once there, it can transform into methylmercury and accumulate in fish tissue through bioaccumulation.

Americans are exposed to methylmercury primarily by eating contaminated fish. Because the developing fetus is the most sensitive to the toxic effects of methylmercury, women of childbearing age are regarded as the population of greatest concern. Children exposed to methylmercury before birth may be at increased risk of poor performance on neurobehavioral tasks, such as those measuring attention, fine motor function, language skills, visual-spatial abilities, and verbal memory.[3]

Carbon Dioxide. Carbon dioxide (CO_2) is not a criteria pollutant (see below), but it is of interest because of its classification as a greenhouse gas (GHG). GHGs trap the sun's radiation inside the Earth's atmosphere and either occur naturally in the atmosphere or result from human activities. Naturally occurring GHGs include water vapor, CO_2, methane (CH_4), nitrous oxide (N_2O), and ozone (O_3). Human activities, however, add to the levels of most of these naturally occurring gases. For example, CO_2 is emitted to the atmosphere when solid waste, fossil fuels (oil, natural gas, and coal), wood, and wood products are burned. In 2007, over 90 percent of anthropogenic (i.e., human-made) CO_2 emissions resulted from burning fossil fuels.[4]

Concentrations of CO_2 in the atmosphere are naturally regulated by numerous processes, collectively known as the "carbon cycle." The movement of carbon between the atmosphere and the land and oceans is dominated by natural processes, such as plant photosynthesis. While these natural processes can absorb some of the anthropogenic CO_2 emissions produced each year, billions of metric tons are added to the atmosphere annually. In the United States, in 2007, CO_2 emissions from electricity generation accounted for 39 percent of total U.S. GHG emissions.[4]

Particulate Matter. Particulate matter (PM) also known as particle pollution, is a complex mixture of extremely small particles and liquid droplets. Particle pollution is made up of a number of components, including acids (such as nitrates and sulfates), organic chemicals, metals, and soil or dust particles.

PM impacts are of concern due to human exposures that can impact health. Particle pollution - especially fine particles - contains microscopic solids or liquid droplets that are so small that they can get deep into the lungs and cause serious health problems. Numerous scientific studies have linked particle pollution exposure to a variety of problems, including: increased respiratory symptoms, such as irritation of the airways, coughing, or difficulty breathing, for example; decreased lung function; aggravated asthma; development of chronic bronchitis; irregular heartbeat; nonfatal heart attacks; and premature death in people with heart or lung disease.

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

Air Quality Regulation. The Clean Air Act Amendments of 1990 list 188 toxic air pollutants that EPA is required to control.[6] EPA has set national air quality standards for six common pollutants (also referred to as “criteria” pollutants), two of which are SO_2 and NO_X. Also, the Clean Air Act Amendments of 1990 gave EPA the authority to control acidification and to require operators of electric power plants to reduce emissions of SO_2 and NO_X. Title IV of the 1990 amendments established a cap-and-trade program for SO_2, in all 50 states and the District of Columbia (D.C.), intended to help control acid rain. [6] This cap-and-trade program serves as a model for more recent programs with similar features.

In 2005, EPA issued the Clean Air Interstate Rule (CAIR) under sections 110 and 111 of the Clean Air Act (40 CFR Parts 51, 96, and 97).[7] [b] CAIR will permanently cap emissions of SO_2 and NO_X in eastern States of the United States. CAIR achieves large reductions of SO_2 and/or NO_X emissions across 28 eastern States and the District of Columbia. CAIR will gradually replace the Title IV program in the 28 states and D.C. States must achieve the required emission reductions using one of two compliance options: 1) meet an emission budget for each regulated state by requiring power plants to participate in an EPA-administered interstate cap-and-trade system that caps emissions in two stages, or 2) meet an individual state emissions budget through measures of the state’s choosing. Phase 1 caps for NO_X have been in place since 2009. Phase 1 caps for SO_2 are to be in place beginning in 2010. The Phase 2 caps for both NO_X and SO_2 are due in 2015.

[b] See http://www.epa.gov/cleanairinterstaterule/.

On July 11, 2008, the U.S. Court of Appeals for the District of Columbia Circuit (D.C. Circuit) issued its decision in North Carolina v. Environmental Protection Agency, which vacated the CAIR issued by the U.S. Environmental Protection Agency on March 10, 2005.[c] CAIR was the vehicle for capping NO_X emissions.[d] On December 23, 2008, the D.C. Circuit decided to allow CAIR to remain in effect until it is replaced by a rule consistent with the court's earlier opinion. North Carolina v. EPA, 550 F.3d 1176 (D.C. Cir. 2008) (remand of vacatur).[e] Thus, CAIR is currently in force. However, on July 6, 2010, EPA proposed the Transport Rule, a replacement for CAIR, which would limit emissions from EGUs in 32 states, potentially through the interstate trading of allowances, among other options. 75 FR 45210 (Aug. 2, 2010).

With respect to Hg emissions, in 2005, EPA issued the final rule entitled "Standards of Performance for New and Existing Stationary Sources: Electric Steam Generating Units," under sections 110 and 111 of the Clean Air Act (40 CFR Parts 60, 63, 72, and 75)[8]. This rule, called the Clean Air Mercury Rule (CAMR), was closely related to the CAIR and established standards of performance for Hg emissions from new and existing coal-fired electric utility steam generating units. The CAMR regulated Hg emissions from coal-fired power plants.

On February 8, 2008, the U.S. Court of Appeals for the District of Columbia Circuit (D.C. Circuit) issued its decision in State of New Jersey, *et al.* v. Environmental Protection Agency,[f] in which the Court, among other actions, vacated the CAMR referenced above.

15.2.2 Global Climate Change

Climate change has evolved into a matter of global concern because it is expected to have widespread, adverse effects on natural resources and systems. A growing body of evidence points to anthropogenic sources of greenhouse gases, such as carbon dioxide (CO_2), as major contributors to climate change. Because this Rule, if finalized, will likely decrease CO_2 emission rates from the fossil fuel sector in the United States, the Department here examines the impacts and causes of climate change and then the potential impact of the Rule on CO_2 emissions and global warming.

Impacts of Climate Change on the Environment. Climate is usually defined as the average weather, over a period ranging from months to many years. Climate change refers to a change in the state of the climate, which is identifiable through changes in the mean and/or the variability of its properties (e.g., temperature or precipitation) over an extended period, typically decades or longer.[9]

The World Meteorological Organization and United Nations Environment Programme (UNEP) established the Intergovernmental Panel on Climate Change (IPCC) to provide an

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[c] See http://www.epa.gov/cleanairinterstaterule/.

[d] *See id.* at 903.

[e] State of North Carolina, et al. v. Environmental Protection Agency, 550 F.3d 1176 (D.C. Cir. 2008).

[f] 517 F.3d 574, 583 (D.C. Cir. 2008).

objective source of information about climate change. According to the IPCC Fourth Assessment Report (IPCC Report), published in 2007, climate change is consistent with observed changes to the world's natural systems; the IPCC expects these changes to continue.[9]

Changes that are consistent with warming include warming of the world's oceans to a depth of 3000 meters; global average sea level rise at an average rate of 1.8 mm per year from 1961 to 2003; loss of annual average Arctic sea ice at a rate of 2.7 percent per decade, changes in wind patterns that affect extra-tropical storm tracks and temperature patterns, increases in intense precipitation in some parts of the world, as well as increased drought and more frequent heat waves in many locations worldwide, and numerous ecological changes.[9]

Looking forward, the IPCC describes continued global warming of about 0.2 °C per decade for the next two decades under a wide range of emission scenarios for carbon dioxide (CO_2), other greenhouse gases (GHGs), and aerosols. After that period, the rate of increase is less certain. The IPCC Report describes increases in average global temperatures of about 1.1 °C to 6.4 °C at the end of the century relative to today. These increases vary depending on the model and emissions scenarios.[9]

The IPCC Report describes incremental impacts associated with the rise in temperature. At ranges of incremental increases to the global average temperature, IPCC reports, with either high or very high confidence, that there is likely to be an increasing degree of impacts such as coral reef bleaching, loss of wildlife habitat, loss to specific ecosystems, and negative yield impacts for major cereal crops in the tropics, but also projects that there likely will be some beneficial impacts on crop yields in temperate regions.

Causes of Climate Change. The IPCC Report states that the world has warmed by about 0.74 °C in the last 100 years. The IPCC Report finds that most of the temperature increase since the mid-20th century is very likely due to the increase in anthropogenic concentrations of CO_2 and other long-lived greenhouse gases such as methane and nitrous oxide in the atmosphere, rather than from natural causes.

Increasing the CO_2 concentration partially blocks the earth's re-radiation of captured solar energy in the infrared band, inhibits the radiant cooling of the earth, and thereby alters the energy balance of the planet, which gradually increases its average temperature. The IPCC Report estimates that currently, CO_2 makes up about 77 percent of the total CO_2-equivalent[g] global warming potential in GHGs emitted from human activities, with the vast majority (74 percent) of the CO_2 attributable to fossil fuel use.[10] For the future, the IPCC Report describes a wide range of GHG emissions scenarios, but under each scenario CO_2 would continue to comprise above 70 percent of the total global warming potential.[10]

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[g] GHGs differ in their warming influence (radiative forcing) on a global climate system due to their different radiative properties and lifetimes in the atmosphere. These warming influences may be expressed through a common metric based on the radiative forcing of CO_2, i.e., CO_2-equivalent. CO_2 equivalent emission is the amount of CO_2 emission that would cause the same- time integrated radiative forcing, over a given time horizon, as an emitted amount of other long- lived GHG or mixture of GHGs.

Stabilization of CO_2 Concentrations. Unlike many traditional air pollutants, CO_2 mixes thoroughly in the entire atmosphere and is long-lived. The residence time of CO_2 in the atmosphere is long compared to the emission processes. Therefore, the global cumulative emissions of CO_2 over long periods determine CO_2 concentrations because it takes hundreds of years for natural processes to remove the CO_2. Globally, 49 billion metric tons of CO_2 – equivalent of anthropogenic (man-made) greenhouse gases are emitted every year. Of this annual total, fossil fuels contribute about 29 billion metric tons of CO_2.[11] [h]

Researchers have focused on considering atmospheric CO_2 concentrations that likely will result in some level of global climate stabilization, and the emission rates associated with achieving the "stabilizing" concentrations by particular dates. They associate these stabilized CO_2 concentrations with temperature increases that plateau in a defined range. For example, at the low end, the IPCC Report scenarios target CO_2 stabilized concentrations range between 350 ppm and 400 ppm (essentially today's value)—because of climate inertia, concentrations in this low-end range would still result in temperatures projected to increase 2.0 °C to 2.4 °C above pre-industrial levels[i] (about 1.3 °C to 1.7 °C above today's levels). To achieve concentrations between 350 ppm to 400 ppm, the IPCC scenarios present that there would have to be a rapid downward trend in total annual global emissions of greenhouse gases to levels that are 50 to 85 percent below today's annual emission rates by no later than 2050. Since it is assumed that there would continue to be growth in global population and substantial increases in economic production, the scenarios identify required reductions in greenhouse gas emissions intensity (emissions per unit of output) of more than 90 percent. However, even at these rates, the scenarios describe some warming and some climate change is projected due to already accumulated CO_2 and GHGs in the atmosphere.[12]

The Beneficial Impact of the Rule on CO_2 Emissions. It is anticipated that the Rule will reduce energy-related CO_2 emissions, particularly those associated with energy consumption in buildings. The U.S. Energy Information Administration (EIA) reports in its 2010 *Annual Energy Outlook* (*AEO2010*)[13] that U.S. annual energy-related emissions of CO_2 in 2007 were about 6.0 billion metric tons, of which 1.2 billion tons were attributed to the residential buildings sector (including related energy–using products such as residential furnaces and central air conditioner products). Most of the greenhouse gas emissions attributed to residential buildings are emitted from fossil fuel-fired power plants that generate electricity used in this sector. In the *AEO2010* Reference Case, EIA projected that annual energy-related CO_2 emissions would grow from 5.7 billion metric tons in 2015 to 6.3 billion metric tons in 2035, an increase of 10 percent (see *AEO2010*), while residential emissions would grow to from 1.2 billion metric tons to 1.3 billion metric tons, an increase of 12 percent.

The estimated cumulative CO_2 emission reductions from the considered residential furnace, central air conditioner and heat pump energy conservation standards (shown as a range of alternative TSLs) during the analysis period are given in Table 15.2.1. Estimated CO_2

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[h] Other non-fossil fuel contributors include CO_2 emissions from deforestation and decay from agriculture biomass; agricultural and industrial emissions of methane; and emissions of nitrous oxide and fluorocarbons.

[i] IPCC Working Group 3 Table TS 2

emission reductions in Table 15.2.1 come from power sector electricity generation and from site emissions resulting from operation of these appliances. The estimated CO_2 emission reductions from electricity generation are calculated using the NEMS-BT model. Household emissions are calculated outside of the NEMS-BT model, using emissions factors for fuel combustion. For a complete description of the household emissions methodology, see Appendix-14-A.

Table 15.2.1 Reduction in Cumulative Energy-Related Emissions of CO_2 from Residential Furnace, Central Air Conditioner, and Heat Pump Energy Conservation Standards

	Trial Standard Levels						
	TSL 1	**TSL 2**	**TSL 3**	**TSL 4**	**TSL 5**	**TSL 6**	**TSL 7**
	Million Metric Tons						
Power Plant Emissions	15.2	(9.6) to (39.8)	25.9 to 1.40	24.0 to 3.8	1.9	85.9	493
Household Emissions	0.00	72.4 to 101	71.2 to 112	81.0 to 130	114	114	279
Total	15.2	62.8 to 61.3	97.1 to 113	105 to 134	116	200	772
Percent of Total Cumulative Emissions Reduction compared with the *AEO2010* Reference Case in 2016-2045	0.019	0.083 to 0.081	0.129 to 0.150	0.128 to 0.163	0.155	0.265	1.03

The Incremental Impact of the Rule on Climate Change. It is difficult to correlate specific emission rates with atmospheric concentrations of CO_2 and specific atmospheric concentrations with future temperatures because the IPCC Report describes a clear lag in the climate system between any given concentration of CO_2 (even if maintained for long periods) and the subsequent average worldwide and regional temperature, precipitation, and extreme weather regimes. For example, a major determinant of climate response is "equilibrium climate sensitivity", a measure of the climate system response to sustained radioactive forcing. It is defined as the global average surface warming following a doubling of carbon dioxide concentrations. The IPCC Report describes its estimated, numeric value as about 3 °C, but the likely range of that value is 2 °C to 4.5 °C, with cloud feedbacks the largest source of uncertainty. Further, as illustrated above, the IPCC Report scenarios for stabilization rates are presented in terms of a range of concentrations, which then correlates to a range of temperature changes. Thus, climate sensitivity is a key uncertainty for CO_2 mitigation scenarios that aim to meet specific temperature levels.

Because of how complex global climate systems are, it is difficult to know to what extent and when particular CO_2 emissions reductions will impact global warming. However, as Table 15.2.1 indicates, the standards are expected to reduce CO_2 emissions associated with energy consumption in buildings.

15.2.3 Analytical Methods for Air Emissions

Coal-fired electric generation is the single largest source of electricity in the United States. Because the mix of coals used significantly affects the emissions produced, the model includes a detailed representation of coal supply. The model considers the rank of the coal as well as the sulfur contents of the fuel used when determining optimal dispatch.[14]

Within the NEMS-BT model, planning options for achieving emissions restrictions in the Clean Air Act Amendments include installing pollution control equipment on existing power plants and building new power plants with low emission rates. These methods for reducing emission are compared to dispatching options such as fuel switching and allowance trading. Environmental regulations also affect capacity expansion decisions. For instance, new plants are not allocated SO_2 emissions allowances according to the Clean Air Act Amendments. Consequently, the decision to build a particular capacity type must consider the cost (if any) of obtaining sufficient allowances. This could involve purchasing allowances or over complying at an existing unit.

DOE's analysis assumes the presence of nationwide emission caps on SO_2 and caps on NO_X emissions in the 28 States covered by the CAIR. 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. However, in contrast to the modeling forecasts of NEMS-BT that SO_2 emissions will remain at the cap, during the years 2007 and 2008, SO_2 emissions have been below the trading cap. The difference between the emissions levels that NEMS-BT forecasts and those that EPA forecasts is an indicator of the uncertainties associated with long-range energy sector forecasts.

With respect to Hg, in the absence of CAMR or other trading program, a DOE standard would likely reduce Hg emissions and DOE uses NEMS-BT to estimate these emission reductions. However, DOE continues to review the impact of rules that reduce energy consumption on Hg emissions, and may revise its assessment of Hg emission reductions in future rulemakings.

The operation of non-electric heating products requires use of fossil fuels and results in emissions of CO_2, NOx, and SO_2 at the sites where these appliances are used. NEMS-BT provides no means for estimating such emissions. DOE calculated the effect of potential standards in today's proposed rule on the above site emissions based on emissions factors derived from the literature. The emissions factors used are 50.6-68.6 kg/GJ for CO_2, 40-66 g/GJ for NOx, and 0-218 g/GJ for SO_2.

As noted in chapter 14, NEMS-BT model forecasts end in year 2035. Emissions impacts beyond 2035 are assumed to be equal to the impacts in 2035.

A set of seven TSLs were modeled for furnaces and central air conditioners and heat pumps. For TSLs 2, 3, and 4, DOE calculated a range of results that reflect alternative assumptions with respect to how the market for non-weatherized and mobile home furnaces will respond to a standard at 90-percent or 92-percent AFUE. These assumptions are discussed in chapter 10. Results reported in chapter 10 at TSLs 2a, 3a, and 4a represent the low end of the range for forecasting standards-case efficiency distributions, while TSLs 2b, 3b, and 4b represent the high end of the range for forecasting standards-case efficiency distributions.

15.2.4 Effects on Power Plant Emissions

Table 15.2.2 shows *AEO2010* Reference Case power plant emissions in selected years. The Reference Case emissions are the emissions shown by the NEMS-BT model to result if none of the TSLs are promulgated (the base case). Values for CO_2 are given in metric tons, while values for NO_X and Hg are given in short tons.

Table 15.2.2 Power Sector Emissions Forecast from *AEO2010* Reference Case

NEMS-BT Results	2010	2015	2020	2025	2030	2035
CO_2 (million metric tons)	2,218	2,278	2,341	2,421	2,534	2,636
NO_X (million tons)	2.24	2.06	2.02	2.03	2.06	2.07
Hg (tons)	40.6	30.6	30.1	30.0	30.2	30.3

Table 15.2.3 shows the estimated changes in power plant emissions of CO_2, $NO_{X,}$ and Hg in selected years for each of the TSLs. As in Table 15.2.2, values for CO_2 are given in metric tons, while values for NO_X and Hg are given in short tons. “Mt” refers to “million metric tons.”

Table 15.2.3 Power Sector Emissions Impacts Forecasts for Residential Furnace , Central Air Conditioner, and Heat Pump TSLs

NEMS-BT Results*	Difference from AEO2010 Reference Case									
							Extrapolation			Total
	2010	2015	2020	2025	2030	2035	2040	2043	2045	2016-2045**
Standard Level 1										
CO_2 (Mt/yr)	0.039	0.167	-0.274	-0.636	-0.560	-0.543	-0.543	-0.543	-0.543	**-15.2**
NOx (1,000 tons/yr)	0.040	0.151	-0.236	-0.534	-0.455	-0.426	-0.426	-0.426	-0.426	**-12.3**
Hg (ton/yr)	0.000	0.000	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	**-0.022**
Standard Level 2 Low										
CO_2 (Mt/yr)	0.124	0.293	0.109	-0.270	0.323	0.692	0.692	0.692	0.692	**9.6**
NOx (1,000 tons/yr)	0.125	0.265	0.094	-0.227	0.262	0.543	0.543	0.543	0.543	**1.8**
Hg (ton/yr)	0.000	0.000	-0.001	-0.001	-0.001	0.000	0.000	0.001	0.001	**-0.011**
Standard Level 2 High										
CO_2 (Mt/yr)	0.089	0.188	0.128	-0.408	0.463	2.891	2.891	2.891	2.891	**39.8**
NOx (1,000 tons/yr)	0.090	0.170	0.110	-0.342	0.376	2.266	2.266	2.266	2.266	**23.1**
Hg (ton/yr)	0.000	0.000	-0.001	-0.001	0.000	0.001	0.002	0.002	0.002	**0.012**
Standard Level 3 Low										
CO_2 (Mt/yr)	0.394	0.854	-0.615	-1.248	-0.994	-0.856	-0.856	-0.856	-0.856	**-25.9**
NOx (1,000 tons/yr)	0.397	0.772	-0.530	-1.048	-0.807	-0.671	-0.671	-0.671	-0.671	**-26.8**
Hg (ton/yr)	0.000	0.000	-0.002	-0.003	-0.004	-0.003	-0.003	-0.003	-0.002	**-0.086**
Standard Level 3 High										
CO_2 (Mt/yr)	0.412	0.885	-0.359	-1.123	0.003	0.503	0.503	0.503	0.503	**-1.4**
NOx (1,000 tons/yr)	0.415	0.800	-0.310	-0.943	0.003	0.394	0.394	0.394	0.394	**-10.3**
Hg (ton/yr)	0.000	0.000	-0.002	-0.003	-0.003	-0.002	-0.001	-0.001	0.000	**-0.059**
Standard Level 4 Low										
CO_2 (Mt/yr)	0.488	0.546	-0.683	-1.834	-0.895	-0.698	-0.698	-0.698	-0.698	**-24.0**
NOx (1,000 tons/yr)	0.492	0.494	-0.589	-1.541	-0.727	-0.547	-0.547	-0.547	-0.547	**-26.1**
Hg (ton/yr)	0.000	-0.001	-0.003	-0.004	-0.004	-0.004	-0.003	-0.003	-0.002	**-0.097**
Standard Level 4 High										
CO_2 (Mt/yr)	0.519	0.477	-0.630	-1.890	0.054	0.516	0.516	0.516	0.516	**-3.8**
NOx (kt/yr)	0.524	0.431	-0.543	-1.588	0.044	0.405	0.405	0.405	0.405	**-14.1**
Hg (ton/yr)	0.000	-0.001	-0.003	-0.004	-0.003	-0.002	-0.001	-0.001	0.000	**-0.071**
Standard Level 5										
CO_2 (Mt/yr)	0.399	0.912	-0.338	-1.205	-0.005	0.396	0.396	0.396	0.396	**-1.9**
NOx (1,000 tons/yr)	0.402	0.825	-0.291	-1.013	-0.004	0.311	0.311	0.311	0.311	**-11.8**
Hg (ton/yr)	0.000	0.000	-0.002	-0.003	-0.003	-0.002	-0.001	-0.001	0.000	**-0.059**
Standard Level 6										
CO_2 (Mt/yr)	1.140	2.644	-1.565	-2.865	-3.487	-3.594	-3.594	-3.594	-3.594	**-85.9**
NOx (1,000 tons/yr)	1.149	2.391	-1.349	-2.407	-2.832	-2.817	-2.817	-2.817	-2.817	**-77.8**
Hg (ton/yr)	0.000	0.000	-0.006	-0.010	-0.011	-0.011	-0.010	-0.010	-0.009	**-0.270**
Standard Level 7										
CO_2 (Mt/yr)	3.72	7.23	-7.36	-14.28	-18.35	-22.83	-22.83	-22.83	-22.83	**-493.3**
NOx (1,000 tons/yr)	3.75	6.54	-6.34	-12.00	-14.90	-17.90	-17.90	-17.90	-17.90	**-419**
Hg (ton/yr)	0.000	0.000	-0.021	-0.035	-0.044	-0.049	-0.051	-0.051	-0.051	**-1.16**

*CO_2 results are in metric tons, NO_X and Hg results are in short tons.

**For TSL 4, the period considered is 2015-2045 for CAC and heat pumps and 2013-2045 for furnaces.

15.2.5 Effects on Household Emissions

Table 15.2.4 shows the estimated changes in household emissions by TSL for residential furnaces, central air conditioners, and heat pumps. The table displays changes in CO_2, NOx, and SO_2 in selected years for each of the TSLs. There are no household emissions impacts for TSL 1.

Table 15.2.4 Household Emissions Impacts Forecasts for Residential Furnace, Central Air Conditioner, and Heat Pump TSLs

NEMS-BT Results*	Difference from AEO2010 Reference Case									
							Extrapolation			Total
	2010	2015	2020	2025	2030	2035	2040	2043	2045	2016-2045**
Standard Level 1										
CO_2 (Mt/yr)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
NOx (1,000 tons/yr)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
SO_2 (1,000 tons/yr)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
Standard Level 2 Low										
CO_2 (Mt/yr)	0.00	0.00	-0.97	-1.85	-2.72	-3.43	-3.43	-3.43	-3.43	**-72.4**
NOx (1,000 tons/yr)	0.00	0.00	-0.77	-1.47	-2.15	-2.71	-2.71	-2.71	-2.71	**-57.3**
SO_2 (1,000 tons/yr)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
Standard Level 2 High										
CO_2 (Mt/yr)	0.00	0.00	-1.42	-2.63	-3.78	-4.74	-4.74	-4.74	-4.74	**-101**
NOx (1,000 tons/yr)	0.00	0.00	-1.12	-2.08	-2.99	-3.75	-3.75	-3.75	-3.75	**-79.8**
SO_2 (1,000 tons/yr)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
Standard Level 3 Low										
CO_2 (Mt/yr)	0.00	0.00	-0.97	-1.83	-2.67	-3.37	-3.37	-3.37	-3.37	**-71.2**
NOx (1,000 tons/yr)	0.00	0.00	-0.76	-1.44	-2.11	-2.66	-2.66	-2.66	-2.66	**-56.3**
SO_2 (1,000 tons/yr)	0.00	0.00	-0.04	-0.06	-0.08	-0.09	-0.09	-0.09	-0.09	**-2.08**
Standard Level 3 High										
CO_2 (Mt/yr)	0.00	0.00	-1.62	-2.94	-4.18	-5.20	-5.20	-5.20	-5.20	**-112**
NOx (1,000 tons/yr)	0.00	0.00	-1.28	-2.33	-3.30	-4.11	-4.11	-4.11	-4.11	**-88.2**
SO_2 (1,000 tons/yr)	0.00	0.00	-0.04	-0.06	-0.08	-0.09	-0.09	-0.09	-0.09	**-2.08**
Standard Level 4 Low										
CO_2 (Mt/yr)	0.00	-0.51	-1.34	-2.16	-2.95	-3.58	-3.58	-3.58	-3.58	**-81.0**
NOx (1,000 tons/yr)	0.00	-0.41	-1.06	-1.71	-2.34	-2.83	-2.83	-2.83	-2.83	**-64.0**
SO_2 (1,000 tons/yr)	0.00	-0.03	-0.06	-0.08	-0.09	-0.10	-0.10	-0.10	-0.10	**-2.59**
Standard Level 4 High										
CO_2 (Mt/yr)	0.00	-0.77	-2.38	-3.62	-4.74	-5.62	-5.62	-5.62	-5.62	**-130**
NOx (1,000 tons/yr)	0.00	-0.61	-1.88	-2.86	-3.74	-4.45	-4.45	-4.45	-4.45	**-103**
SO_2 (1,000 tons/yr)	0.00	-0.02	-0.06	-0.08	-0.09	-0.10	-0.10	-0.10	-0.10	**-2.58**
Standard Level 5										
CO_2 (Mt/yr)	0.00	0.00	-1.67	-3.01	-4.27	-5.30	-5.30	-5.30	-5.30	**-114**
NOx (1,000 tons/yr)	0.00	0.00	-1.32	-2.38	-3.38	-4.19	-4.19	-4.19	-4.19	**-90.2**
SO_2 (1,000 tons/yr)	0.00	0.00	-0.23	-0.29	-0.36	-0.42	-0.42	-0.42	-0.42	**-9.93**
Standard Level 6										
CO_2 (Mt/yr)	0.00	0.00	-1.67	-3.01	-4.27	-5.30	-5.30	-5.30	-5.30	**-114**
NOx (1,000 tons/yr)	0.00	0.00	-1.32	-2.38	-3.38	-4.19	-4.19	-4.19	-4.19	**-90.2**
SO_2 (1,000 tons/yr)	0.00	0.00	-0.23	-0.29	-0.36	-0.42	-0.42	-0.42	-0.42	**-9.93**
Standard Level 7										
CO_2 (Mt/yr)	0.00	0.00	-4.58	-7.77	-10.50	-12.55	-12.55	-12.55	-12.55	**-279**
NOx (1,000 tons/yr)	0.00	0.00	-3.62	-6.15	-8.31	-9.93	-9.93	-9.93	-9.93	**-221**
SO_2 (1,000 tons/yr)	0.00	0.00	-1.12	-1.75	-2.32	-2.73	-2.73	-2.73	-2.73	**-61.8**

*All results in metric tons (t), equivalent to 1.1 short tons

**For TSL 4, the period considered is 2015-2045 for CAC and heat pumps and 2013-2045 for furnaces.

15.2.6 Effects on Upstream Fuel-Cycle Emissions

Upstream fuel-cycle emissions refer to the emissions associated with the amount of energy used in the upstream production and downstream consumption of electricity, including energy used at the power plant.[17] Upstream processes include the mining of coal or extraction of natural gas, physical preparatory and cleaning processes, and transportation to 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 losses during coal and natural gas production). Thus, this analysis reports only power plant emissions.

However, previous DOE environmental assessment documents have developed approximate estimates of effects on upstream fuel-cycle emissions. These emissions factors provide the reader with a sense of the possible magnitude of upstream effects. These upstream emissions would be in addition to emissions from direct combustion.

Relative to the entire fuel cycle, estimates based on the work of Dr. Mark DeLuchi, and reported in earlier DOE environmental assessment documents, find that an amount approximately equal to eight percent, by mass, of emissions (including SO_2) from coal production are due to mining, preparation that includes cleaning the coal, and transportation from the mine to the power plant.[18] Transportation emissions include emissions from the fuel used by the mode of transportation that moves the coal from the mine to the power plant. In addition, based on Dr. DeLuchi's work, DOE estimated that an amount equal to approximately 14 percent of emissions from natural gas production result from upstream processes.

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 15.2.5 for CO_2 and NO_X. The percentages provide a means to estimate upstream emission savings based on changes in emissions from power plants. This approach does not address Hg emissions.

Table 15.2.5 Estimated Upstream Emissions of Air Pollutants as a Percentage of Direct Power Plant Combustion Emissions

Pollutant	Percent of Coal Combustion Emissions	Percent of Natural Gas Combustion Emissions
CO_2	2.7	11.9
NO_X	5.8	40

15.3 WETLAND, ENDANGERED AND THREATENED SPECIES, AND CULTURAL RESOURCES

Because residential furnaces and central air conditioners are not water-consuming products, more efficient heating and cooling would not reduce the amount of water discharged into the waste stream. As a result, the energy conservation standards do not have the effect of improving the quality of wetlands, nor threatened or endangered species that reside in these wetlands. This action is also not expected to impact cultural resources such as historical or archaeological sites.

15.4 SOCIOECONOMIC IMPACTS

DOE's analysis has shown that the increase in the first cost of purchasing more efficient residential furnaces and central air conditioners at the proposed standard levels is, in most cases, completely offset by a reduction in the life-cycle cost (LCC) of owning a more efficient product for the average consumer. In other words, the consumer will pay less operating costs over the life of the product even through the first cost increases. The complete LCC analysis and its conclusions are presented in chapter 8 of the TSD.

For subgroups of low-income and senior consumers that purchase furnace and central air conditioning products, DOE determined that the average LCC impact of the standards is similar to that for the full sample of consumers. Therefore, DOE concludes that the proposed standards would have no significant adverse socioeconomic impact. For a complete discussion of the impacts on consumer subgroups, see chapter 11 of the TSD.

15.5 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,” DOE examined the effect of the energy conservation standards on low-income households. As described in the consumer subgroup analysis in chapter 11 of the TSD, DOE 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 conservation standards.

15.6 NOISE AND AESTHETICS

Improvements in efficiency of residential furnaces and central air conditioners are expected to result from changes in the choice of components and other design features. These changes are described in chapter 5 of this TSD. These design changes are not expected to change noise levels in comparison to products in today’s market. Products that are currently manufactured in the existing market that would meet the standards are no louder than less efficient products. Changes to the design to improve the efficiency levels are not anticipated to affect the product aesthetics.

15.7 SUMMARY OF ENVIRONMENTAL IMPACTS

Table 15.7.1 summarizes the estimated emissions impacts for each of the TSLs for residential furnaces and central air conditioners. It shows cumulative changes in emissions for CO_2, NO_X, and Hg for each of the TSLs. Cumulative CO_2, NO_X, and Hg emissions are reduced compared to the Reference case for all TSLs. For comparison, the cumulative power sector emissions in the *AEO2010* Reference case, over the period 2016 through 2045, are 75,267 Mt for CO_2, 61,453 thousand tons for NOx, and 904 tons for Hg.

Upstream fuel cycle emission of CO_2 and NO_X are described but not quantified in section 15.2.6. The text describes potential reductions in fuel cycle emissions as percentage of decreases in power plant emissions. This approach suggests that upstream fuel cycle emissions would decrease and provides a sense for the magnitude of effects; however DOE does not report actual estimates of the effects.

For subgroups of low-income and senior consumers that purchase residential furnaces and central air conditioners and heat pumps, DOE determined that the average impact of the standards is similar to that for the full sample of consumers. Therefore, DOE concludes that the proposed standards would have no significant adverse socioeconomic impact.

No impacts are anticipated in the areas of environmental justice, wetlands, endangered and threatened species, and cultural resources; or noise and aesthetics.

Table 15.7.1 Cumulative Emissions Reductions Under Furnace, Central Air Conditioner, and Heat Pump TSLs from 2016 through 2045*,**

	TSL 1	TSL 2	TSL 3	TSL 4	TSL 5	TSL 6	TSL 7
Power Sector Emissions							
CO_2 (Mt)	15.2	(9.6) to (39.8)	25.9 to 1.4	24.0 to 3.8	1.9	85.9	493
NO_X (1,000 tons)	12.3	(1.8) to (23.1)	26.8 to 10.3	26.1 to 14.1	11.8	77.8	419
Hg (ton)	0.022	0.011 to (0.012)	0.086 to 0.059	0.097 to 0.071	0.059	0.270	1.16
Household Emissions							
CO_2 (Mt)	0.00	72.4 to 101	71.2 to 112	81.0 to 130	114	114	279
NO_X (1,000 tons)	0.00	57.3 to 79.8	56.3 to 88.2	64.0 to 103	90.2	90.2	221
Total Emissions							
CO_2 (Mt)	15.2	62.8 to 61.2	97.1 to 113	105 to 134	116	200	772
NO_X (1,000 tons)	12.3	55.5 to 56.7	83.1 to 98.5	90.1 to 117	102	168	640
Hg (ton)	0.022	0.011 to (0.012)	0.086 to 0.059	0.097 to 0.071	0.059	0.270	1.16

* CO_2 results are in metric tons, NO_X and Hg results are in short tons.

For TSL 4, the period considered is 2015-2045 for CAC and heat pumps and 2013-2045 for furnaces.

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