ENVIRONMENTAL ASSESSMENT FOR PROPOSED ENERGY CONSERVATION STANDARDS FOR SMALL ELECTRIC MOTORS

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15.1 INTRODUCTION

This chapter describes potential environmental effects that may result from energy conservation standards for small electric motors. The U.S. Department of Energy (DOE)'s proposed energy conservation standards are not site-specific and would apply to all 50 states and U.S. territories. Therefore, none of the proposed standards would impact land uses, cause any direct disturbance to the land, or directly affect biological resources in any one area.

All of the trial standard levels (TSLs) are expected to reduce energy consumption in comparison to the baseline efficiency levels. These changes in the demand for electricity are the primary drivers in analyzing environmental effects. Estimates of source energy savings can be found in the utility impact analysis in chapter 13 of this technical support document (TSD).

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

15.2 AIR EMISSIONS ANALYSIS

The primary focus of the environmental analysis is the impact on air quality of energy conservation standards for small electric motors. The outcomes of the environmental analysis are driven by changes in power plant types and quantities of electricity generated under each of the alternatives. Changes in generation are described in the utility impact analysis in TSD chapter 13.

15.2.1 Air Emissions Descriptions

For each of the TSLs, DOE calculated total power-sector emissions based on output from NEMS-BT model (see chapter 13 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[1]. This analysis also considers carbon dioxide (CO_2).

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

15.2.1.1 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. SO_x 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. SO2 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]

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 create uncertainty about standard's 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 (D.C.) are also limited under the Clean Air Interstate Rule (CAIR, published in the *Federal Register* on May 12, 2005. 70 FR 25162 (May 12, 2005), which creates an allowance-based trading program that will gradually replace the Title IV program in those States and D.C.. (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 SO2 emission allowances resulting from the lower electricity demand caused by the imposition of an efficiency standard could be used to permit offsetting increases in SO2 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 SO2 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 SO2 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.

15.2.1.2 Nitrogen Oxides

Nitrogen oxides**,** or NO_x, are 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.[2]

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.

15.2.1.3 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. 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.

15.2.1.4 Carbon Dioxide (CO_2)

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.[3]

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.[3]

15.2.1.5 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.

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 PM emissions. Meanwhile other pollutants such as SO_2 and NO_x interact with other elements in the atmosphere to produce PM at some distance from the power plant.

In general, the relative impacts of direct PM emissions reduction compared to other pollutants on PM exposures are much more difficult to estimate than other emissions reductions. This is 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 and the proportion of impacts and exposures attributable to different emissions can vary dramatically for different emissions sources and types of particulate precursors. These variations in emissions impacts depend on the distance to the source, land use and land cover, and the local and regional meteorology responsible for pollutant transport, deposition and atmospheric chemistry.

The Environmental Protection Agency (EPA) has compiled and summarized technical studies regarding PM source apportionment. In this compilation of studies, sources are classified into seven categories: (1) Secondary sulfate/coal, (2) Secondary organic matter/mobile sources, (3) Nitrate dominated sources, (4) Biomass burning, (5) Industrial, (6) Crustal and salt (7) Other. In these studies, the PM exposures attributed to coal power plants are not disaggregated between direct particulate emissions and SO_2 emissions from these power plants. This is because both SO_2 and direct PM emissions aggregate and interact with water droplets and emissions from other sources to create final particulates that are a complex mixture of different constituents. Both the SO_2 and direct PM are emitted from the power plant at the same time and if the final aerosol particle contains both sulfur compounds and other PM components it is not possible to attribute that aerosol particle to one source or the other. Therefore, DOE is not currently able to perform modeling that can make reliable estimates of the impact of direct PM emissions on air quality at this time.

15.2.2 Air Quality Regulation

The Clean Air Act Amendments of 1990 list 188 toxic air pollutants that EPA is required to control.[1] 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 intended to help control acid rain.[1] 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).[4] [2] CAIR will permanently cap emissions of SO_2 and NOx in eastern States of the United States. CAIR achieves large reductions of SO_2 and/or NOx emissions across 28 eastern States and the District of Columbia. 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 are to be in place in 2009. Phase 1 caps for SO_2 are to be in place in 2010. The Phase 2 caps for both NO_x and SO_2 are due in 2015.

Also 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) [5]. 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,[3] in which the Court, among other actions, vacated the CAMR referenced above.

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

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

[3] No. 05-1097, 2008 WL 341338, at *1 (D.C. Cir. Feb. 8, 2008).

vacated the CAIR issued by the U.S. Environmental Protection Agency on March 10, 2005.[4] CAIR was the vehicle for capping NOx emissions.[5] 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).[6]

15.2.3 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.

15.2.3.1 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.[7]

The World Meteorological Organization and United Nations Environment Programme (UNEP) established the Intergovernmental Panel on Climate Change (IPCC) to provide an 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.[7]

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.[6]

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 (GHG)s, 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

[4] North Carolina v. EPA, 531 F.3d 896 (D.C. Cir. 2008) See http://www.epa.gov/cleanairinterstaterule/.

[5] *See id.* at 903.

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

to 6.4 °C at the end of the century relative to today. These increases vary depending on the model and emissions scenarios.[6]

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.

15.2.3.2 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[7] global warming potential in GHGs emitted from human activities, with the vast majority (74 percent) of the CO_2 attributable to fossil fuel use.[7] 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.[7]

15.2.3.3 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.[8] [8]

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[7] 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.

[8] 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.

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[9] (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 populations 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.[9]

15.2.3.4 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. In the United States, the U.S. Energy Information Administration (EIA) reports in its 2009 Annual Energy Outlook (*AEO2009*)[11] that U.S. annual energy-related emissions of CO_2 in 2006 were about 6.0 billion metric tons, of which 2.3 billion tons were attributed to the electricity consumption (including related energy–using products such as small electric motors). Most of the greenhouse gas emissions attributed to commercial and industrial electricity are emitted from fossil fuel-fired power plants that generate the electricity used in these sectors. In the *AEO2009* Reference Case, EIA projected that annual energy-related CO_2 emissions would grow from 5.7 billion metric tons in 2010 to 6.2 billion metric tons in 2030, an increase of 8 percent (see *AEO2009*), while electricity-related emissions would grow to from 2.3 billion metric tons to 2.6 billion metric tons, an increase of 13 percent.

The estimated cumulative CO_2 emission reductions from a small electric motors efficiency standard (shown as a range of alternative TSLs) during the 30-year forecast period are indicated in Table EA.2.1. Estimated CO_2 emission reductions in Table EA.2.1 come from electricity generation (i.e., power plants). The estimated CO_2 emission reductions from electricity generation are calculated using the NEMS-BT model.

[9] IPCC Working Group 3 Table TS 2

Table 15.2.1 Impact of Small Electric Motors Efficiency Standards on Cumulative Electricity-Related Emissions of CO_2 between 2010 and 2045 (Million Metric Tons of CO_2)

	Trial Standard Levels							
	TSL 1	**TSL 2**	**TSL 3**	**TSL 4**	**TSL 4b**	**TSL 5**	**TSL 6**	**TSL 7**
Polyphase Motors*	-2.3	-4.6	-8.3	-9.3	-15.4	-18.3	-19.5	-21.2
	TSL 1	**TSL 2**	**TSL 3**	**TSL 4**	**TSL 5**	**TSL 6**	**TSL 7**	**TSL 8**
Capacitor Start Motors*	-62.9	-63.5	-71.7	-80.5	-81.0	-88.5	-96.8	-111.4
Total*	-64.4	-68.1	-80.0	-89.8	-96.4	-106.8	-116.3	-132.6
Percent of Total Cumulative Power Sector Emissions from 2010 to 2045 compared with the AEO 2009 Reference Case	-0.09%	-0.09%	-0.10%	-0.11%	-0.12%	-0.14%	-0.14%	-0.18%

* All results in million metric tons, equivalent to 1.1 short tons; negative values refer to a reduction compared with the Base Case.

15.2.3.5 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 rates will impact global warming. However, as Table 15.2.1 indicates, the proposed rule is expected to reduce CO_2 emissions from the electricity-generation sector.

15.2.4 Analytical Methods for Air Emissions

NEMS-BT incorporates capabilities to assess compliance with SO_2 restrictions specified in the Clean Air Act and its amendments. Clean Air Act provisions include New Source Performance Standards, and Revised New Source Performance Standards. The version of NEMS-BT in 2008 included provisions for the CAIR, which imposes stricter restrictions on SO_2

and NO_X for some states, and the CAMR, which imposed a national Hg constraint. As discussed earlier is section EA.2.2, 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. Carolina v. Environmental Protection Agency, 550 F.3d 1176 (D.C. Cir. 2008) (remand of vacatur). But actions taken on February 8, 2008 by the U.S. Court of Appeals for the District of Columbia Circuit (D.C. Circuit) issued in its decision in State of New Jersey, *et al.* v. Environmental Protection Agency, remain in effect vacating the CAMR. Thus, the version of NEMS-BT in 2009 used in this analysis does not include provisions for the CAMR.

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.

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 assumed the presence of nationwide emission caps on SO_2 and caps on NOx emissions in the 28 States covered by the CAIR. In the presence of these caps, the NEMS-BT modeling system that DOE used to forecast emissions reduction indicated that no physical reductions in power sector emissions would occur for SO_2, but that the standards could put slight downward pressure on the prices of emissions allowances in cap-and-trade markets.

In contrast to the modeling forecasts of NEMS-BT that SO_2 emissions reductions will remain at the cap, during the years 2007 and 2008, SO_2 emissions have been below the trading cap.[11] 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. Because of such uncertainties, DOE is unable to estimate the economic and physical benefit from SO_2 emissions reductions at this time.

As noted in chapter 13, NEMS-BT model forecasts end in year 2030. Emissions impacts beyond 2030 were extrapolated for this rulemaking in Table EA.2.3 through EA.2.4.

15.2.5 Effects on Power Plant Emissions

Table EA.2.2 shows AEO2009 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).

Table 15.2.2 Power Sector Emissions Forecast from *AEO2009* Reference Case

NEMS-BT Results*						
	2005	**2010**	**2015**	**2020**	**2025**	**2030**
CO_2 (Million metric tons/year)**	2,397	2,343	2,381	2,466	2,535	2,636
NO_X (Million metric tons/year)†	3.30	2.07	1.87	1.88	1.88	1.91
Hg (metric tons/year)†	51.5	43.8	29.5	28.9	29.3	28.7

* All results in metric tons, equivalent to 1.1 short tons and negative values refer to a reduction compared with the Base Case

** Comparable to Table A17 of *AEO2009*: Electric Generators

† Comparable to Table A8 of *AEO2009*: Emissions

Table 15.2.3 through Table 15.2.4 show the estimated changes in power plant emissions in selected years for all the TSLs. Changes in NO_x and Hg emissions from power plants calculated by NEMS-BT are shown in these tables. Changes in CO_2 emissions from all sources are also shown in these tables.

Compared to the anticipated reference case emissions impacts forecast shown in Table 15.2.2, changes in emission levels shown in Table 15.2.3 though 15.2.4 are extremely small.

Table 15.2.3 Power Sector Emissions Impact Forecasts for Polyphase Small Electric Motors

NEMS-BT Results	Difference from AEO 2009 Reference Case					Extrapolation			Cumulative
	2010	**2015**	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2010-2045**
Standard Level 1									
CO_2 (Mt/a)	0.02	0.03	-0.05	-0.09	-0.10	-0.10	-0.10	-0.10	**-2.27**
NOx (kt/a)	0.01	0.03	-0.04	-0.07	-0.07	-0.07	-0.07	-0.08	**-1.62**
Hg (t/a)	-0.0001	-0.0002	-0.0004	-0.0003	-0.0004	-0.0004	-0.0004	-0.0004	**-0.0125**
Standard Level 2									
CO_2 (Mt/a)	0.03	0.07	-0.09	-0.19	-0.21	-0.21	-0.21	-0.21	**-4.60**
NOx (kt/a)	0.03	0.05	-0.07	-0.14	-0.15	-0.15	-0.15	-0.15	**-3.29**
Hg (t/a)	-0.0002	-0.0004	-0.0007	-0.0007	-0.0007	-0.0007	-0.0007	-0.0007	**-0.0254**
Standard Level 3									
CO_2 (Mt/a)	0.06	0.12	-0.17	-0.34	-0.37	-0.37	-0.38	-0.38	**-8.25**
NOx (kt/a)	0.05	0.09	-0.13	-0.25	-0.27	-0.27	-0.27	-0.27	**-5.91**
Hg (t/a)	-0.0004	-0.0008	-0.0013	-0.0013	-0.0013	-0.0013	-0.0013	-0.0013	**-0.0456**
Standard Level 4									
CO_2 (Mt/a)	0.07	0.13	-0.19	-0.38	-0.42	-0.42	-0.43	-0.43	**-9.31**
NOx (kt/a)	0.06	0.10	-0.15	-0.28	-0.30	-0.31	-0.31	-0.31	**-6.67**
Hg (t/a)	-0.0005	-0.0009	-0.0014	-0.0014	-0.0015	-0.0015	-0.0015	-0.0015	**-0.0515**
Standard Level 4b									
CO_2 (Mt/a)	0.11	0.22	-0.32	-0.63	-0.69	-0.70	-0.70	-0.71	**-15.37**
NOx (kt/a)	0.10	0.17	-0.24	-0.47	-0.50	-0.50	-0.51	-0.51	**-11.00**
Hg (t/a)	-0.0008	-0.0014	-0.0024	-0.0024	-0.0024	-0.0025	-0.0025	-0.0025	**-0.0850**
Standard Level 5									
CO_2 (Mt/a)	0.14	0.26	-0.38	-0.75	-0.82	-0.83	-0.84	-0.84	**-18.29**
NOx (kt/a)	0.12	0.21	-0.29	-0.56	-0.60	-0.60	-0.60	-0.61	**-13.09**
Hg (t/a)	-0.0010	-0.0017	-0.0028	-0.0028	-0.0029	-0.0029	-0.0029	-0.0030	**-0.1011**
Standard Level 6									
CO_2 (Mt/a)	0.14	0.28	-0.40	-0.80	-0.88	-0.88	-0.89	-0.89	**-19.46**
NOx (kt/a)	0.13	0.22	-0.31	-0.59	-0.63	-0.64	-0.64	-0.65	**-13.93**
Hg (t/a)	-0.0010	-0.0018	-0.0030	-0.0030	-0.0031	-0.0031	-0.0031	-0.0032	**-0.1076**
Standard Level 7									
CO_2 (Mt/a)	0.16	0.30	-0.44	-0.87	-0.96	-0.96	-0.97	-0.97	**-21.22**
NOx (kt/a)	0.14	0.24	-0.33	-0.65	-0.69	-0.70	-0.70	-0.70	**-15.19**
Hg (t/a)	-0.0011	-0.0020	-0.0033	-0.0033	-0.0034	-0.0034	-0.0034	-0.0034	**-0.1173**

Table 15.2.4 Power Sector Emissions Impact Forecasts for Capacitor Start Small Electric Motors

NEMS-BT Results	Difference from AEO2009 Reference Case					Extrapolation			Cumulative
	2010	2015	2020	2025	2030	2035	2040	2045	2010-2045
Standard Level 1									
CO_2 (Mt/a)	0.48	0.78	-1.65	-2.49	-2.70	-2.73	-2.74	-2.76	**-62.87**
NOx (kt/a)	0.42	0.61	-1.25	-1.85	-1.95	-1.97	-1.98	-1.99	**-45.10**
Hg (t/a)	-0.0025	-0.0060	-0.0081	-0.0133	-0.0062	-0.0063	-0.0063	-0.0064	**-0.2647**
Standard Level 2									
CO_2 (Mt/a)	0.48	0.79	-1.66	-2.52	-2.73	-2.75	-2.77	-2.78	**-63.48**
NOx (kt/a)	0.43	0.62	-1.27	-1.86	-1.97	-1.99	-2.00	-2.01	**-45.54**
Hg (t/a)	-0.0025	-0.0061	-0.0082	-0.0134	-0.0063	-0.0064	-0.0064	-0.0064	**-0.2672**
Standard Level 3									
CO_2 (Mt/a)	0.54	0.89	-1.88	-2.84	-3.08	-3.11	-3.13	-3.14	**-71.71**
NOx (kt/a)	0.48	0.70	-1.43	-2.11	-2.23	-2.25	-2.26	-2.27	**-51.44**
Hg (t/a)	-0.0028	-0.0069	-0.0093	-0.0152	-0.0071	-0.0072	-0.0072	-0.0073	**-0.3019**
Standard Level 4									
CO_2 (Mt/a)	0.61	1.00	-2.11	-3.19	-3.46	-3.49	-3.51	-3.53	**-80.49**
NOx (kt/a)	0.54	0.78	-1.60	-2.36	-2.50	-2.52	-2.54	-2.55	**-57.74**
Hg (t/a)	-0.0031	-0.0077	-0.0104	-0.0170	-0.0080	-0.0081	-0.0081	-0.0081	**-0.3388**
Standard Level 5									
CO_2 (Mt/a)	0.61	1.00	-2.12	-3.21	-3.48	-3.51	-3.54	-3.55	**-81.00**
NOx (kt/a)	0.54	0.79	-1.61	-2.38	-2.52	-2.54	-2.56	-2.57	**-58.11**
Hg (t/a)	-0.0032	-0.0078	-0.0105	-0.0171	-0.0080	-0.0081	-0.0082	-0.0082	**-0.3410**
Standard Level 6									
CO_2 (Mt/a)	0.67	1.10	-2.32	-3.51	-3.81	-3.84	-3.86	-3.88	**-88.49**
NOx (kt/a)	0.60	0.86	-1.76	-2.60	-2.75	-2.78	-2.79	-2.80	**-63.48**
Hg (t/a)	-0.0035	-0.0085	-0.0114	-0.0187	-0.0088	-0.0089	-0.0089	-0.0090	**-0.3725**
Standard Level 7									
CO_2 (Mt/a)	0.73	1.20	-2.53	-3.84	-4.16	-4.20	-4.23	-4.25	**-96.84**
NOx (kt/a)	0.65	0.94	-1.93	-2.84	-3.01	-3.04	-3.06	-3.07	**-69.47**
Hg (t/a)	-0.0038	-0.0093	-0.0125	-0.0205	-0.0096	-0.0097	-0.0098	-0.0098	**-0.4077**
Standard Level 8									
CO_2 (Mt/a)	0.85	1.38	-2.92	-4.42	-4.79	-4.84	-4.87	-4.89	**-111.45**
NOx (kt/a)	0.75	1.08	-2.22	-3.27	-3.46	-3.49	-3.52	-3.53	**-79.95**
Hg (t/a)	-0.0044	-0.0107	-0.0144	-0.0236	-0.0111	-0.0112	-0.0112	-0.0113	**-0.4692**

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. 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 qualitative estimates of affects 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 DeLucchi, 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.[10] 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. DeLucchi's work, DOE estimated that approximately an amount equal to 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 EA.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. The percentage effects presented in Table EA.2.5 provide a qualitative approach to viewing effects on fuel cycle emissions. The previous section indicates slight overall reductions in CO_2 and NO_x. Thus, very small reductions in upstream emissions of air pollutant could be expected. 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 SOCIAL COST OF CARBON DIOXIDE EMISSIONS

Under Executive Order 12866, agencies are required, to the extent permitted by law, "to assess both the costs and the benefits of the intended regulation and, recognizing that some costs and benefits are difficult to quantify, propose or adopt a regulation only upon a reasoned determination that the benefits of the intended regulation justify its costs." The purpose of the SCC estimates presented here is to allow agencies to incorporate the social benefits of reducing carbon dioxide (CO_2) emissions into cost-benefit analyses of regulatory actions that have small, or "marginal," impacts on cumulative global emissions. The estimates are presented with an acknowledgement of the many uncertainties involved and with a clear understanding that they should be updated over time to reflect increasing knowledge of the science and economics of climate impacts.

The SCC is an estimate of the monetized damages associated with an incremental increase in carbon emissions in a given year. It is intended to include (but is not limited to) changes in net agricultural productivity, human health, property damages from increased flood risk, and the value of ecosystem services due to climate change.

As part of the interagency process that developed these SCC estimates, technical experts from numerous agencies met on a regular basis to consider public comments, explore the technical literature in relevant fields, and discuss key model inputs and assumptions. The main objective of this process was to develop a range of SCC values using a defensible set of input assumptions grounded in the existing scientific and economic literatures. In this way, key uncertainties and model differences transparently and consistently inform the range of SCC estimates used in the rulemaking process.

The interagency group selected four SCC values for use in regulatory analyses. Three values are based on the average SCC from three integrated assessment models, at discount rates of 2.5, 3, and 5 percent. The fourth value, which represents the 95th percentile SCC estimate across all three models at a 3 percent discount rate, is included to represent higher-than-expected impacts from temperature change further out in the tails of the SCC distribution.

Table 15.3.1 Social Cost of CO_2, 2010 – 2050 (in 2007 dollars)

	Discount Rate			
	5%	3%	2.5%	3%
Year	Avg	Avg	Avg	95th
2010	4.7	21.4	35.1	64.9
2015	5.7	23.8	38.4	72.8
2020	6.8	26.3	41.7	80.7
2025	8.2	29.6	45.9	90.4
2030	9.7	32.8	50.0	100.0
2035	11.2	36.0	54.2	109.7
2040	12.7	39.2	58.4	119.3
2045	14.2	42.1	61.7	127.8
2050	15.7	44.9	65.0	136.2

15.3.1 Monetizing Carbon Dioxide Emissions

The "social cost of carbon" (SCC) is an estimate of the monetized damages associated with an incremental increase in carbon emissions in a given year. It is intended to include (but is not limited to) changes in net agricultural productivity, human health, property damages from increased flood risk, and the value of ecosystem services. Estimates of the social cost of carbon are provided in dollars per metric ton of carbon dioxide.[10]

When attempting to assess the incremental economic impacts of carbon dioxide emissions, the analyst faces a number of serious challenges. A recent report from the National Academies of Science (Hidden Costs of Energy: Unpriced Consequences of Energy Production and Use. National Academies Press. 2009) points out that any assessment will suffer from uncertainty, speculation, and lack of information about (1) future emissions of greenhouse gases, (2) the effects of past and future emissions on the climate system, (3) the impact of changes in climate on the physical and biological environment, and (4) the translation of these environmental impacts into economic damages. As a result, any effort to quantify and monetize the harms associated with climate change will raise serious questions of science, economics, and ethics and should be viewed as provisional.

Despite the serious limits of both quantification and monetization, SCC estimates can be useful in estimating the social benefits of reducing carbon dioxide emissions. Under Executive Order 12866, agencies are required, to the extent permitted by law, "to assess both the costs and the benefits of the intended regulation and, recognizing that some costs and benefits are difficult to quantify, propose or adopt a regulation only upon a reasoned determination that the benefits of the intended regulation justify its costs." The purpose of the SCC estimates presented here is to make it possible for agencies to incorporate the social benefits from reducing carbon dioxide emissions into cost-benefit analyses of regulatory actions that have small, or "marginal," impacts on cumulative global emissions. Most federal regulatory actions can be expected to have marginal impacts on global emissions.

For such policies, the benefits from reduced (or costs from increased) emissions in any future year can be estimated by multiplying the change in emissions in that year by the SCC value appropriate for that year. The net present value of the benefits can then be calculated by multiplying each of these future benefits by an appropriate discount factor and summing across all affected years. This approach assumes that the marginal damages from increased emissions are constant for small departures from the baseline emissions path, an approximation that is reasonable for policies that have effects on emissions that are small relative to cumulative global carbon dioxide emissions. For policies that have a large (non-marginal) impact on global cumulative emissions, there is a separate question of whether the SCC is an appropriate tool for calculating the benefits of reduced emissions; we do not attempt to answer that question here.

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[10] In this document, DOE presents all values of the SCC as the cost per metric ton of CO_2 emissions. Alternatively, one could report the SCC as the cost per metric ton of carbon emissions. The multiplier for translating between mass of CO_2 and the mass of carbon is 3.67 (the molecular weight of CO_2 divided by the molecular weight of carbon = 44/12 = 3.67).

An interagency group convened on a regular basis to consider public comments, explore the technical literature in relevant fields, and discuss key inputs and assumptions in order to generate SCC estimates. Agencies that actively participated in the interagency process include the Environmental Protection Agency, and the Departments of Agriculture, Commerce, Energy, Transportation, and Treasury. This process was convened by the Council of Economic Advisers and the Office of Management and Budget, with active participation and regular input from the Council on Environmental Quality, National Economic Council, Office of Energy and Climate Change, and Office of Science and Technology Policy. The main objective of this process was to develop a range of SCC values using a defensible set of input assumptions that are grounded in the existing literature. In this way, key uncertainties and model differences can more transparently and consistently inform the range of SCC estimates used in the rulemaking process.

The interagency group selected four SCC estimates for use in regulatory analyses. For 2010, these estimates are $5, $21, $35, and $65 (in 2007 dollars). The first three estimates are based on the average SCC across models and socio-economic and emissions scenarios at the 5, 3, and 2.5 percent discount rates, respectively. The fourth value is included to represent the higher-than-expected impacts from temperature change further out in the tails of the SCC distribution. For this purpose, we use the SCC value for the 95th percentile at a 3 percent discount rate. The central value is the average SCC across models at the 3 percent discount rate. For purposes of capturing the uncertainties involved in regulatory impact analysis, we emphasize the importance and value of considering the full range. These SCC estimates also grow over time. For instance, the central value increases to $24 per ton of CO_2 in 2015 and $26 per ton of CO_2 in 2020. See Appendix A of this chapter for the full range of annual SCC estimates from 2010 to 2050.

It is important to emphasize that the interagency process is committed to updating these estimates as the science and economic understanding of climate change and its impacts on society improves over time. Specifically, we have set a preliminary goal of revisiting the SCC values within two years or at such time as substantially updated models become available, and to continue to support research in this area. In the meantime, we will continue to explore the issues raised by this analysis and consider public comments as part of the ongoing interagency process.

15.3.2 Social Cost of Carbon Values Used in Past Regulatory Analyses

To date, economic analyses for Federal regulations have used a wide range of values to estimate the benefits associated with reducing carbon dioxide emissions. In the final model year 2011 CAFE rule, the Department of Transportation (DOT) used both a "domestic" SCC value of $2 per ton of CO_2 and a "global" SCC value of $33 per ton of CO_2 for 2007 emission reductions (in 2007 dollars), increasing both values at 2.4 percent per year. It also included a sensitivity analysis at $80 per ton of CO_2. A domestic SCC value is meant to reflect the value of damages in the United States resulting from a unit change in carbon dioxide emissions, while a global SCC value is meant to reflect the value of damages worldwide.

A 2008 regulation proposed by DOT assumed a domestic SCC value of $7 per ton CO_2 (in 2006 dollars) for 2011 emission reductions (with a range of $0-$14 for sensitivity analysis), also increasing at 2.4 percent per year. A regulation finalized by DOE in October of 2008 used a domestic SCC range of $0 to $20 per ton CO_2 for 2007 emission reductions (in 2007 dollars). In addition, EPA's 2008 Advance Notice of Proposed Rulemaking for Greenhouse Gases identified what it described as "very preliminary" SCC estimates subject to revision. EPA's global mean values were $68 and $40 per ton CO_2 for discount rates of approximately 2 percent and 3 percent, respectively (in 2006 dollars for 2007 emissions).

In 2009, an interagency process was initiated to offer a preliminary assessment of how best to quantify the benefits from reducing carbon dioxide emissions. To ensure consistency in how benefits are evaluated across agencies, the Administration sought to develop a transparent and defensible method, specifically designed for the rulemaking process, to quantify avoided climate change damages from reduced CO_2 emissions. The interagency group did not undertake any original analysis. Instead, it combined SCC estimates from the existing literature to use as interim values until a more comprehensive analysis could be conducted.

The outcome of the preliminary assessment by the interagency group was a set of five interim values: global SCC estimates for 2007 (in 2006 dollars) of $55, $33, $19, $10, and $5 per ton of CO_2. The $33 and $5 values represented model-weighted means of the published estimates produced from the most recently available versions of three integrated assessment models—DICE, PAGE, and FUND—at approximately 3 and 5 percent discount rates. The $55 and $10 values were derived by adjusting the published estimates for uncertainty in the discount rate (using factors developed by Newell and Pizer (2003)) at 3 and 5 percent discount rates, respectively. The $19 value was chosen as a central value between the $5 and $33 per ton estimates. All of these values were assumed to increase at 3 percent annually to represent growth in incremental damages over time as the magnitude of climate change increases.

These interim values represent the first sustained interagency effort within the U.S. government to develop an SCC for use in regulatory analysis. The results of this preliminary effort were presented in several proposed and final rules and were offered for public comment in connection with proposed rules, including the joint EPA-DOT fuel economy and CO_2 tailpipe emission proposed rules.

15.3.3 Approach and Key Assumptions

Since the release of the interim values, interagency group reconvened on a regular basis to generate improved SCC estimates considered for this final rule. Specifically, the group considered public comments and further explored the technical literature in relevant fields.

It is important to recognize that a number of key uncertainties remain, and that current SCC estimates should be treated as provisional and revisable since they will evolve with improved scientific and economic understanding. The interagency group also recognizes that the existing models are imperfect and incomplete. The National Academy of Science (2009) points out that there is tension between the goal of producing quantified estimates of the economic damages from an incremental ton of carbon and the limits of existing efforts to model these effects. There are a number of concerns and problems that should be addressed by the research community, including research programs housed in many of the agencies participating in the interagency process to estimate the SCC.

The U.S. Government will periodically review and reconsider estimates of the SCC used for cost-benefit analyses to reflect increasing knowledge of the science and economics of climate impacts, as well as improvements in modeling. In this context, statements recognizing the limitations of the analysis and calling for further research take on exceptional significance. The interagency group offers the new SCC values with all due humility about the uncertainties embedded in them and with a sincere promise to continue work to improve them.

In summary, in considering the potential global benefits resulting from reduced CO_2 emissions, DOE used the most recent values identified by the interagency process, adjusted to 2009$ using the standard GDP deflator values for 2008 and 2009. For each of the four cases specified, the values for emissions in 2010 used were approximately $5, $22, $36, and $67 per metric ton avoided (values expressed in 2009$). To monetize the CO_2 emissions reductions expected to result from amended standards for small electric motors in 2015–2045, DOE used the values identified in Table A1 of the "Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866," which is reprinted as Appendix A to this chapter, appropriately escalated to 2009$.

15.4 WETLAND, ENDANGERED AND THREATENED SPECIES, AND CULTURAL RESOURCES

Because small electric motors are not water-consuming products, more efficient motors would not reduce the amount of water discharged into the waste stream. As a result, small electric motor 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.

15.5 SOCIOECONOMIC IMPACTS

DOE's analysis has shown that the increase in the first cost of purchasing more efficient small electric motors at the proposed standard levels is largely 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 analysis and its conclusions are presented in chapter 8 of the TSD.

The primary purchasers of small electric motors are commercial and industrial businesses. Subgroups of space-constrained motor owners will primarily be affected by the standard through impacts on initial cost which DOE estimates can be very large when more efficient motors have difficulty satisfying space constraints. DOE estimates that such costs should be distributed throughout the economy and should not affect any particular socio-economic group more than others. Therefore, DOE concludes that the proposed action would have no significant socioeconomic impact. For a complete discussion on the consumer and national impacts of the proposed standard, see chapters 8 and 10 of the TSD respectively.

15.6 ENVIRONMENTAL JUSTICE IMPACTS

According to Executive Order 12898 of February 11, 1994, "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations," DOE is required to examine the effect of more stringent energy-efficiency standards on (1) small businesses that either manufacture or use small electric motors, (2) manufacturers of niche products related to small electric motors, and (3) small businesses operated by disadvantaged or minority populations.

DOE identified small businesses as a subgroup that possibly could be disproportionately affected by small electric motors energy conservation standards. As described in the Manufacturer Subgroup Analysis, Chapter 12 of the TSD, DOE found that there was no disproportionately high and adverse human health or environmental effects on small businesses that would result from the proposed energy conservation standards. DOE believes that above conclusion also applies to minority populations.

15.7 NOISE AND AESTHETICS

Improvements in efficiency of small electric motors 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. DOE considered noise and aesthetics when evaluating different engineering design options and found that products that meet the proposed standard can maintain the same noise levels as products currently in the market. Products that are currently manufactured in the existing market that would meet the proposed 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.

15.8 SUMMARY OF ENVIRONMENTAL IMPACTS

Table 15.7.1 through Table 15.7.2 summarize anticipated environmental impacts for each of the TSLs across all product types. Air quality impacts were modeled for each of the TSLs. The summary table shows cumulative changes in emissions for CO_2, NO_x, and Hg from 2015 to

2045 for small electric motors. Cumulative CO_2, NO_x, and Hg emissions show a decrease compared to the reference case.

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 qualitative 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.

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

Table 15.8.1 Environmental Impact Analysis Results Summary, Polyphase Small Electric Motors

Environmental Effects	TSL							
	1	**2**	**3**	**4**	**4b**	**5**	**6**	**7**
Cumulative Emissions Reductions**								
CO_2, *Mt*	2.3	4.6	8.3	9.3	15.4	18.3	198.5	21.2
NO_x, *kt*	1.6	3.3	5.9	6.7	11	13.1	13.9	15.2
Hg, *t*	0.013	0.025	0.046	0.051	0.085	0.101	0.108	0.117
Fuel-Cycle (Upstream) Emissions	††	††	††	††	††	††	††	††
Wetlands, Endangered and Threatened Species; Cultural Resources	--	--	--	--	--	--	--	--
Socioeconomic Impacts– Weighted Mean LCC Savings‡	--	--	--	--	--	--	--	--
All Motors	$9	$21	$35	$33	$34	($15)	($62)	($816)
Space-Constrained Motors	$11	$23	$39	$37	$38	($121)	($123)	($2,895)
Environmental Justice	--		--	--	--	--	--	--
Noise and Aesthetics	--		--	--	--	--	--	--

* The reference case values reflect total cumulative emissions and life cycle costs in the absence of an energy conservation standard.
** Cumulative total is from 2010–2045 for standard implemented in 2015.
†† DOE does not report actual estimates of the effects of standards on upstream emissions, but section EA.2.6 provides a sense for the possible magnitude of effects.
‡ Values refer to life-cycle cost savings over the equipment lifetime.

Table 15.8.2 Environmental Impact Analysis Results Summary, Capacitor-Start Small Electric Motors

Environmental Effects	TSL							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Cumulative Emissions Reductions**								

CO_2, *Mt*	62.9	63.5	71.7	80.5	81.0	88.5	96.8	111.4
NO_x, *kt*	45.1	45.5	51.4	57.7	58.1	63.5	69.5	80.0
Hg, *t*	0.265	0.267	0.302	0.339	0.341	0.373	0.408	0.469
Fuel-Cycle (Upstream) Emissions	[††]	[††]	[††]	[††]	[††]	[††]	[††]	[††]
Wetlands, Endangered and Threatened Species; Cultural Resources	--	--	--	--	--	--	--	--
Socioeconomic Impacts– Weighted Mean LCC Savings[‡]	--	--	--	--	--	--	--	--
All Motors:								
CSIR	$62	$62	$51	$17	$17	($370)	($370)	($370)
CSCR	$50	$61	$61	$45	$61	($881)	$61	($16)
Space-Constrained Motors:								
CSIR	$59	$59	$62	($47)	($47)	($1,878)	($1,878)	($1,878)
CSCR	$15	$20	$20	$20	$20	($2,908)	$20	($129)
Environmental Justice	--		--	--	--	--	--	--
Noise and Aesthetics	--		--	--	--	--	--	--

[*] The reference case values reflect total cumulative emissions and life cycle costs in the absence of an energy conservation standard.
[**] Cumulative total is from 2010–2045 for standard implemented in 2015.
[††] DOE does not report actual estimates of the effects of standards on upstream emissions, but section EA.2.6 provides a sense for the possible magnitude of effects.
[‡] Values refer to life-cycle cost savings over the equipment lifetime.

REFERENCES

1. U.S. Environmental Protection Agency, *How Sulfur Dioxide Affects the Way We Live* (Updated June 29st, 2009) <http://www.epa.gov/oar/urbanair/so2/>

2. U.S. Environmental Protection Agency, *Nitrogen Oxides Health and Environmental Impacts of NOx* (Posted July 31st, 2009) <http:// www.epa.gov/air/nitrogenoxides/>

3. U.S. Environmental Protection Agency, *2009 U.S. Greenhouse Gas Inventory Report*, 2009. <http://www.epa.gov/climatechange/emissions/usinventoryreport.html>

4. U.S. Federal Register, *Rule To Reduce Interstate Transport of Fine Particulate Matter and Ozone (Clean Air Interstate Rule); Revisions to Acid Rain Program; Revisions to the NOX SIP Call, Final Rule*, May 12, 2005, 2005.

5. U.S. Federal Register, Standards of Performance for New and Existing Stationary Sources: Electric Utility Steam Generating Units, Final Rule, May 18, 2005, 2005. Report No. 70 FR 28606.

6. Intergovernmental Panel On Climate Change, IPCC WGI Fourth Assessment Report: Climate Change 2007: The Physical Science Basis, 2007. Geneva. <http://ipcc-wg1.ucar.edu/wg1/docs/WG1AR4_SPM_PlenaryApproved.pdf>

7. Intergovernmental Panel On Climate Change, *Climate Change 2007 – Impacts, Adaptation and Vulnerability*. <http://www.ipcc-wg2.gov>

8. Intergovernmental Panel On Climate Change, *IPCC Special Report on Land Use, Land-Use Change And Forestry*, 2000. <http://www.grida.no/publications/other/ipcc_sr/?src=/Climate/ipcc/land_use/index.htm>

9. Intergovernmental Panel On Climate Change, *IPCC Fourth Assessment Report Climate Change 2007: Working Group III Report "Mitigation of Climate Change"*, 2007. <http://www.ipcc.ch/pdf/assessment-report/ar4/wg3/ar4-wg3-ts.pdf>

10. DeLuchi, M. A., *Emissions of Greenhouse Gases from the Use of Transportation Fuels and Electricity, Volume 2: Appendixes A-S*, November, 1993. Argonne National Laboratory. Argonne, IL. Report No. ANL/ESD/TM-22-Vol.2.

11. U.S. Environmental Protection Agency, *Emissions, Compliance, and Market Data | Acid Rain Program Program 2008 Progress Reports | Progress Reports | Clean Air Markets*, 2009. < http://www.epa.gov/airmarkt/progress/ARP_1.html>

12. U.S. Environmental Protection Agency, *Compilation of Existing Studies on Source Apportionment for $PM_{2.5}$*, Emissions, Monitoring, and Analysis Division, Office of Air Quality Planning and Standards, U.S. EPA, Research Triangle Park, North Carolina 27711, August 22, 2003, 2003. <http://www.epa.gov/airtrends/specialstudies/compsareports.pdf>