DOE/EA-1664

Environmental Assessment
for

10 CFR Part 430 Energy Conservation Standards: Energy Conservation Standards for Fluorescent and Incandescent Lamps

June 2009

CHAPTER 16. ENVIRONMENTAL ASSESSMENT

TABLE OF CONTENTS

LIST OF TABLES

CHAPTER 16. ENVIRONMENTAL ASSESSMENT

16.1 INTRODUCTION

This chapter describes potential environmental effects that may result from amended energy conservation standards for incandescent reflector lamps (IRL) and general service fluorescent lamps (GSFL). 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 potential trial standard levels (TSLs) are expected to reduce energy consumption in comparison to a baseline efficiency level. These changes in the demand for electricity and the costs of achieving these savings are the primary drivers in analyzing environmental effects. Estimates of source energy savings can be found in the national impact analysis in Chapter 11 of this technical support document (TSD). Detailed discussion on TSLs can be found in Chapter 9 of this 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.

16.2 AIR EMISSIONS ANALYSIS

The primary focus of the environmental analysis is the impact on air quality of amended energy conservation standards for residential, commercial and industrial IRL and GSFL. 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 Chapter 14.

16.2.1 Air Emissions Descriptions

For each of the TSLs, DOE calculated total power-sector emissions based on output from NEMS-BT model (see Chapter 14). This analysis considers three pollutants: nitrogen oxides (NO_x), mercury (Hg), and sulfur dioxide (SO_2). 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 http://www.epa.gov

Sulfur Dioxide (SO_2)

In addressing SO_2 emissions, the Clean Air Act Amendments of 1990 set an SO_2 emissions cap on all affected electric generating units. The attainment of the emissions cap is flexible among generators and is enforced through the use of emissions allowances and tradeable permits. This SO_2 trading process (sometimes called "cap and trade") implies that the standard will have no affect on total physical emissions because emissions will always be at, or near, the allowed emissions ceiling. Consequently, there is no direct SO_2 environmental benefit from a reduction in electricity use due to the proposed energy conservation standards, as long as there is enforcement of the emissions ceiling. But to the extent reduced power generation demand decreases the demand for and price of emissions allowance permits, there would be an environmentally-related economic benefit from the proposed energy conservation standards reducing SO_2 emissions allowance demand. Furthermore, over time, if emissions decline, there is greater flexibility in reducing the ceiling amount. However, since DOE does not anticipate a change in SO_2 emissions, SO_2 emission results are not reported in this Chapter.

Nitrogen Oxides (NO_x)

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 NOx 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.

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.

Mercury(Hg)

Coal-fired power plants emit Hg present 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.

Carbon Dioxide (CO_2)

EPA does not currently require emissions controls for CO_2 under the Clean Air Act. However, CO_2 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. During the past 20 years, about three-quarters of anthropogenic (i.e., human-made) CO_2 emissions resulted from burning fossil fuels.

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 U. S., CO_2 emissions account for 84.6 percent of total U.S. GHG emissions.

16.2.2 Air Quality Regulation

The Clean Air Act Amendments of 1990 list 188 toxic air pollutants that EPA is required to control. 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 from certain sources. The cap-and-trade program is intended to help control acid rain and 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).[b] CAIR would permanently cap emissions of SO_2 and NOx in eastern States of the United States. CAIR required 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

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

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 pollutants 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). This rule, also 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,[c] 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 vacated the CAIR issued by the U.S. Environmental Protection Agency on March 10, 2005.[d] But 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. Environmental Protection Agency, 550 F.3d 1176 (D.C. Cir. 2008) (remand of vacatur).

16.2.3 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 that are associated with IRLs and GSFLs and are 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.

---

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

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

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.

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 % 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.

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

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 (GHGs) 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% of the total CO_2-equivalent[e] global

[e] 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.

warming potential in GHGs emitted from human activities, with the vast majority (74%) of the CO_2 attributable to fossil fuel use. 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% of the total global warming potential.

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.[f]

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[g] (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% 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%. 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.

The Beneficial Impact of the Rule on CO_2 Emissions

If finalized, it is anticipated that the Rule will reduce energy-related CO_2 emission rates, 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*)[1] that U.S. annual energy-related emissions of CO_2 in 2005 were about 6.0 billion metric tons (about 20 percent of the world energy-related CO_2 emissions and about 12 percent of total global greenhouse gas emissions), of which 2.4 billion tons were attributed to the electric

[f] 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.

[g] IPCC Working Group 3 Table TS 2

power sector. In the *AEO2009* Updated Reference Case, EIA projected that annual energy-related CO_2 emissions would grow from 6.0 billion metric tons in 2005 to 6.2 billion metric tons in 2030, an increase of 4 percent (see *AEO2009*), while emissions attributable to the electric power sector would grow to 2.6 billion tons, an increase of 10 percent.

As shown in Table 16.2.2 in the *AEO2009* Reference Case, the cumulative U.S. energy-related power sector CO_2 emissions between 2012 and 2042 are described at about 79 billion metric tons. The estimated cumulative CO_2 emission reductions from IRL and GSFL during this same 30-year period are indicated in Table 16.2.1. Estimated CO_2 emission reductions in Table 16.2.1 come from electricity generation (i.e., power plants). The estimated CO_2 emission reductions from electricity generation are calculated using the NEMS-BT model.

Table 16.2.1 Impact of IRL and GSFL Efficiency Standards on Cumulative Energy-Related Emissions of CO_2 between 2012-2042 by Trial Standard Level (Million Metric Tons of CO_2)

GSFL TSL	Estimated Cumulative CO_2 (MMt) Emission Reductions
1	66.4 to 130.3
2	86.0 to 133.9
3	148.3 to 296.6
4	174.6 to 487.6
5	262.0 to 552.0
IRL TSL	**Estimated Cumulative CO_2 (MMt) Emission Reductions**
1	7.5 to 19.8
2	19.1 to 48.9
3	37.8 to 85.1
4	44.0 to 105.7
5	53.3 to 118.1

The estimated savings shown in Table 16.2.1, which are at most 0.9 percent of U.S. emissions of CO_2 from electricity generation (total emissions reported for TSL 5 in Table 16.2.1 combining IRL and GSFL), comprise an even smaller fraction of U.S. emissions of greenhouse gases and of world emissions of greenhouse gases. However, the savings would likely reduce the overall U.S. CO_2 emissions rate, as compared to the U.S. CO_2 emissions rate absent an increase in the required efficiency of IRLs and GSFLs.

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 the complexity of global climate systems, it is difficult to know to what extent and when particular CO_2 emissions rates will impact global warming. However, as Table 16.2.1 indicates, the Rule will likely reduce CO_2 emissions rates from the electric power sector.

16.2.4 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 also 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 16.2.2, 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. Although the constraints on Hg in CAMR have since been vacated by a court decision, the *AEO2009* Reference Case assumes that emissions of Hg would decline over time as shown in Table 16.2.2.

Because the courts had vacated both CAIR and CAMR at the time that DOE was drafting the NOPR, the 2008 version of NEMS-BT could not be used directly to estimate emissions impacts for NO_X and Hg. Instead, for the NOPR DOE established a range of NO_X and Hg reductions due to standards. For the final rule, DOE is able to use the AEO2009 version of NEMS-BT to estimate NO_X reductions that result from States not covered under CAIR.

The NEMS-BT has only rough estimates of mercury emissions, and it was decided that the range of emissions used in the NOPR remained appropriate given these circumstances. Therefore, rather than using the NEMS-BT model, DOE established a range of Hg emission rates to estimate the Hg emissions that could be reduced through standards. DOE's low estimate assumed that future standards would displace electrical generation only from natural gas-fired power plants, thereby resulting in an effective emission rate of zero. (Under this scenario, coal-fired power plant generation would remain unaffected.) The low-end emission rate is zero

because natural gas-fired power plants have virtually zero Hg emissions associated with their operation. Earthjustice stated that basing the low end of the range on the displacement of only gas-fired power plants was inconsistent with DOE's utility impact analysis (Earthjustice, No. 60 at pg. 8-9). However, DOE believes that the estimate should provide the full range of possible outcomes and has selected the low and high values to bracket the uncertainties associated with estimating mercury emission reductions.

DOE's high estimate, which assumed that standards would displace only coal-fired power plants, was based on an estimate of the 2006 nationwide mercury emission rate from AEO2008. (Under this scenario, DOE assumed that no future reductions in the rate of mercury emissions from such sources would occur.) Because power plant emission rates are a function of local regulation, scrubbers, and the mercury content of coal, it is extremely difficult to identify a precise high-end emission rate. Therefore, the most reasonable high estimate is based on the assumption that all displaced coal generation would have been emitting at the 2006 average emission rate for coal generation as specified by the April Update to AEO2009. This is viewed as a high estimate because it is likely that future emission controls will be installed at coal-fired power plants which will reduce their average emission rate. As noted previously, because virtually all mercury emitted from electricity generation is from coal-fired power plants, DOE based the emission rate on the tons of mercury emitted per TWh of coal-generated electricity. Based on the emission rate for 2006, DOE derived a high-end emission rate of 0.0255 tons per TWh. To estimate the reduction in mercury emissions, DOE multiplied the emission rate by the reduction in coal-generated electricity due to the standards considered in the utility impact analysis. These changes in Hg emissions are extremely small, ranging from 0.2 to 1.0 percent of the national base-case emissions forecast by NEMS-BT for GFSL, depending on the TSL and scenario, and less than 0.2 percent for all IRL levels.

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.

Modeling of SO_2 trading tends to imply that the physical emissions effects will be zero, as long as emissions are at the allowed ceiling. Because SO_2 has been regulated with emissions caps for more than a decade, and no emissions reductions are reported from the NEMS-BT

forecast model, DOE does not report SO_2 results here. This assumption is consistent with previous DOE environmental assessment documents.

As noted in Chapter 14, NEMS-BT model forecasts end in year 2030. Emissions impacts beyond 2030 were extrapolated for this rulemaking in Table 16.2.3 through 16.2.6.

16.2.5 Effects on Power Plant Emissions

Table 16.2.2 shows the *AEO2009* Updated Reference Case power plant emissions in selected years along with the extrapolation to 2042. The Reference case emissions are the emissions shown by the NEMS-BT model to result if none of the TSLs are promulgated.

Table 16.2.2 Power Sector Emissions Forecast from *AEO2009* Reference Case

NEMS-BT Results*:							
	2005	**2010**	**2015**	**2020**	**2025**	**2030**	**Total 2012-2042**††
CO_2 (Million metric tons)**	2,397	2,343	2,384	2,462	2,533	2,637	78,824
NO_X (Million metric tons)†	3.64	2.29	2.05	2.07	2.07	2.09	59.0
Hg (Metric tons)†	51.49	43.69	29.37	28.75	29.00	28.63	846.1

** Comparable to Table A18 of *AEO2009*: Electric Power

† Comparable to Table A8 of *AEO2009*: Electric Power Sector Emissions

†† Extrapolated by assuming 2030 end values in all subsequent years 2031-2042.

Table 16.2.3 through Table 16.2.6 show the estimated changes in power plant emissions in selected years for all the TSLs. Changes in CO_2, NO_X and Hg emissions from power plants are shown in these tables. Compared to the anticipated reference case emissions impacts forecast shown in Table 16.2.2, changes in emission levels shown in Table 16.2.3 though 16.2.6 are extremely small.

Table 16.2.3 Power Sector Emissions Impact Forecasts IRL, Shift

IRL Existing Technologies, Shift, R-CFL Substitution

NEMS-BT Results **Difference From Updated AEO2009 Reference**

						Exptrapolation			Total
Trial Standard Level 1	2010	2015	2020	2025	2030	2035	2040	2042	2012-2042
Power Sector CO2 (MMT CO2)	0.06	(0.72)	(0.57)	(0.64)	(0.68)	(0.68)	(0.68)	(0.68)	(19.8)
Nitrogen Oxide - (x000 t)	(0.01)	(0.04)	(0.02)	(0.03)	(0.02)	(0.02)	(0.02)	(0.02)	(1.9)
Mercury (Hg) - Low (t)	-	-	-	-	-	-	-	-	-
Mercury (Hg) - High (t)	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.3)
Trial Standard Level 2									
Power Sector CO2 (MMT CO2)	0.20	(1.76)	(1.31)	(1.47)	(1.67)	(1.67)	(1.67)	(1.67)	(48.9)
Nitrogen Oxide - (x000 t)	0.08	(0.03)	0.06	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(5.5)
Mercury (Hg) - Low (t)	-	-	-	-	-	-	-	-	-
Mercury (Hg) - High (t)	0.00	(0.03)	(0.01)	(0.02)	(0.03)	(0.03)	(0.03)	(0.03)	(0.7)
Trial Standard Level 3									
Power Sector CO2 (MMT CO2)	0.31	(3.02)	(2.41)	(2.71)	(2.93)	(2.93)	(2.93)	(2.93)	(85.1)
Nitrogen Oxide - (x000 t)	0.10	(0.07)	0.16	(0.06)	0.01	0.01	0.01	0.01	(7.6)
Mercury (Hg) - Low (t)	-	-	-	-	-	-	-	-	-
Mercury (Hg) - High (t)	0.00	(0.05)	(0.03)	(0.03)	(0.05)	(0.05)	(0.05)	(0.05)	(1.3)
Trial Standard Level 4									
Power Sector CO2 (MMT CO2)	0.35	(3.70)	(2.85)	(3.15)	(3.71)	(3.71)	(3.71)	(3.71)	(105.7)
Nitrogen Oxide - (x000 t)	0.02	0.02	(0.08)	(0.18)	0.10	0.10	0.10	0.10	(8.4)
Mercury (Hg) - Low (t)	-	-	-	-	-	-	-	-	-
Mercury (Hg) - High (t)	0.00	(0.06)	(0.03)	(0.04)	(0.07)	(0.07)	(0.07)	(0.07)	(1.7)
Trial Standard Level 5									
Power Sector CO2 (MMT CO2)	0.49	(4.24)	(3.32)	(3.55)	(4.06)	(4.06)	(4.06)	(4.06)	(118.1)
Nitrogen Oxide - (x000 t)	0.18	0.12	0.16	(0.02)	0.08	0.08	0.08	0.08	(9.3)
Mercury (Hg) - Low (t)	-	-	-	-	-	-	-	-	-
Mercury (Hg) - High (t)	0.00	(0.07)	(0.04)	(0.04)	(0.07)	(0.07)	(0.07)	(0.07)	(1.8)

Note: All units are metric tons, equivalent to 1.1 short tons

Table 16.2.4 Power Sector Emissions Impact Forecasts for IRL, Roll-up

IRL Emerging Technologies, Rollup, BR Lamp Substitution
NEMS-BT Results **Difference From Updated AEO2009 Reference**

						Exptrapolation			Total
Trial Standard Level 1	2010	2015	2020	2025	2030	2035	2040	2042	2012-2042
Power Sector CO2 (MMT CO2)	0.03	(0.30)	(0.22)	(0.21)	(0.24)	(0.24)	(0.24)	(0.24)	(7.5)
Nitrogen Oxide - (x000 t)	0.01	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(1.3)
Mercury (Hg) - Low (t)	-	-	-	-	-	-	-	-	-
Mercury (Hg) - High (t)	0.00	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.1)
Trial Standard Level 2									
Power Sector CO2 (MMT CO2)	0.10	(0.78)	(0.54)	(0.53)	(0.59)	(0.59)	(0.59)	(0.59)	(19.1)
Nitrogen Oxide - (x000 t)	0.05	0.06	0.01	(0.05)	(0.01)	(0.01)	(0.01)	(0.01)	(3.2)
Mercury (Hg) - Low (t)	-	-	-	-	-	-	-	-	-
Mercury (Hg) - High (t)	0.00	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.3)
Trial Standard Level 3									
Power Sector CO2 (MMT CO2)	0.23	(1.63)	(1.07)	(1.07)	(1.20)	(1.20)	(1.20)	(1.20)	(37.8)
Nitrogen Oxide - (x000 t)	0.05	(0.22)	(0.09)	(0.07)	0.05	0.05	0.05	0.05	(5.4)
Mercury (Hg) - Low (t)	-	-	-	-	-	-	-	-	-
Mercury (Hg) - High (t)	0.00	(0.03)	(0.01)	(0.01)	(0.02)	(0.02)	(0.02)	(0.02)	(0.6)
Trial Standard Level 4									
Power Sector CO2 (MMT CO2)	0.26	(1.88)	(1.22)	(1.20)	(1.40)	(1.40)	(1.40)	(1.40)	(44.0)
Nitrogen Oxide - (x000 t)	0.16	0.11	(0.06)	(0.10)	0.06	0.06	0.06	0.06	(6.4)
Mercury (Hg) - Low (t)	-	-	-	-	-	-	-	-	-
Mercury (Hg) - High (t)	0.00	(0.03)	(0.02)	(0.01)	(0.02)	(0.02)	(0.02)	(0.02)	(0.7)
Trial Standard Level 5									
Power Sector CO2 (MMT CO2)	0.32	(2.22)	(1.52)	(1.56)	(1.65)	(1.65)	(1.65)	(1.65)	(53.3)
Nitrogen Oxide - (x000 t)	0.31	(0.13)	(0.12)	(0.10)	0.01	0.01	0.01	0.01	(8.1)
Mercury (Hg) - Low (t)	-	-	-	-	-	-	-	-	-
Mercury (Hg) - High (t)	0.00	(0.03)	(0.02)	(0.02)	(0.03)	(0.03)	(0.03)	(0.03)	(0.8)

Note: All units are metric tons, equivalent to 1.1 short tons

Table 16.2.5 Power Sector Emissions Impact Forecasts for GSFL, Shift

GSFL Existing Technologies, Shift, High Lighting Expertise

NEMS-BT Results	Difference From Updated AEO2009 Reference								
						Exptrapolation			Total
Trial Standard Level 1	2010	2015	2020	2025	2030	2035	2040	2042	2012-2042
Power Sector CO2 (MMT CO2)	0.29	(3.24)	(3.97)	(4.27)	(4.98)	(4.98)	(4.98)	(4.98)	(130.3)
Nitrogen Oxide - (x000 t)	(0.02)	(0.51)	(0.37)	(0.33)	(0.09)	(0.09)	(0.09)	(0.09)	(11.7)
Mercury (Hg) - Low (t)	-	-	-	-	-	-	-	-	-
Mercury (Hg) - High (t)	0.00	(0.05)	(0.05)	(0.05)	(0.08)	(0.08)	(0.08)	(0.08)	(2.0)
Trial Standard Level 2									
Power Sector CO2 (MMT CO2)	0.32	(3.64)	(3.79)	(4.69)	(5.11)	(5.11)	(5.11)	(5.11)	(133.9)
Nitrogen Oxide - (x000 t)	0.05	(0.37)	(0.06)	(0.48)	(0.09)	(0.09)	(0.09)	(0.09)	(10.0)
Mercury (Hg) - Low (t)	-	-	-	-	-	-	-	-	-
Mercury (Hg) - High (t)	(0.00)	(0.07)	(0.06)	(0.07)	(0.10)	(0.10)	(0.10)	(0.10)	(2.4)
Trial Standard Level 3									
Power Sector CO2 (MMT CO2)	0.89	(8.12)	(8.67)	(10.69)	(10.91)	(10.91)	(10.91)	(10.91)	(296.6)
Nitrogen Oxide - (x000 t)	(0.06)	0.10	(0.13)	(0.72)	(0.02)	(0.02)	(0.02)	(0.02)	(17.0)
Mercury (Hg) - Low (t)	-	-	-	-	-	-	-	-	-
Mercury (Hg) - High (t)	(0.00)	(0.14)	(0.13)	(0.15)	(0.19)	(0.19)	(0.19)	(0.19)	(4.8)
Trial Standard Level 4									
Power Sector CO2 (MMT CO2)	1.82	(17.35)	(15.16)	(16.64)	(16.15)	(16.15)	(16.15)	(16.15)	(487.6)
Nitrogen Oxide - (x000 t)	1.09	(2.34)	0.18	(1.00)	0.53	0.53	0.53	0.53	(36.8)
Mercury (Hg) - Low (t)	-	-	-	-	-	-	-	-	-
Mercury (Hg) - High (t)	0.01	(0.27)	(0.19)	(0.21)	(0.26)	(0.26)	(0.26)	(0.26)	(7.3)
Trial Standard Level 5									
Power Sector CO2 (MMT CO2)	1.96	(23.09)	(17.71)	(18.03)	(17.86)	(17.86)	(17.86)	(17.86)	(552.0)
Nitrogen Oxide - (x000 t)	(0.07)	(2.86)	0.20	0.13	(1.13)	(1.13)	(1.13)	(1.13)	(58.1)
Mercury (Hg) - Low (t)	-	-	-	-	-	-	-	-	-
Mercury (Hg) - High (t)	(0.01)	(0.42)	(0.24)	(0.24)	(0.31)	(0.31)	(0.31)	(0.31)	(8.8)

Note: All units are metric tons, equivalent to 1.1 short tons

Table 16.2.6 Power Sector Emissions Impact Forecasts for GSFL, Roll-up

GSFL Emerging Technologies, Roll up, Market Segment Based Lighting Expertise

NEMS-BT Results **Difference From Updated AEO2009 Reference**

						Exptrapolation			Total
Trial Standard Level 1	2010	2015	2020	2025	2030	2035	2040	2042	2012-2042
Power Sector CO2 (MMT CO2)	0.15	(1.66)	(1.81)	(2.22)	(2.60)	(2.60)	(2.60)	(2.60)	(66.4)
Nitrogen Oxide - (x000 t)	0.00	(0.19)	0.10	0.05	0.06	0.06	0.06	0.06	(1.9)
Mercury (Hg) - Low (t)	-	-	-	-	-	-	-	-	-
Mercury (Hg) - High (t)	(0.00)	(0.03)	(0.03)	(0.03)	(0.05)	(0.05)	(0.05)	(0.05)	(1.2)
Trial Standard Level 2									
Power Sector CO2 (MMT CO2)	0.26	(3.46)	(2.54)	(2.72)	(2.94)	(2.94)	(2.94)	(2.94)	(86.0)
Nitrogen Oxide - (x000 t)	0.14	(0.34)	0.12	0.00	0.07	0.07	0.07	0.07	(5.1)
Mercury (Hg) - Low (t)	-	-	-	-	-	-	-	-	-
Mercury (Hg) - High (t)	(0.00)	(0.06)	(0.04)	(0.04)	(0.05)	(0.05)	(0.05)	(0.05)	(1.4)
Trial Standard Level 3									
Power Sector CO2 (MMT CO2)	0.53	(5.07)	(4.43)	(5.10)	(5.15)	(5.15)	(5.15)	(5.15)	(148.3)
Nitrogen Oxide - (x000 t)	0.19	(0.40)	0.27	(0.23)	0.15	0.15	0.15	0.15	(7.3)
Mercury (Hg) - Low (t)	-	-	-	-	-	-	-	-	-
Mercury (Hg) - High (t)	(0.00)	(0.09)	(0.06)	(0.07)	(0.09)	(0.09)	(0.09)	(0.09)	(2.3)
Trial Standard Level 4									
Power Sector CO2 (MMT CO2)	0.89	(7.78)	(4.98)	(5.74)	(5.48)	(5.48)	(5.48)	(5.48)	(174.6)
Nitrogen Oxide - (x000 t)	(0.07)	(0.75)	0.33	0.08	0.40	0.40	0.40	0.40	(11.0)
Mercury (Hg) - Low (t)	-	-	-	-	-	-	-	-	-
Mercury (Hg) - High (t)	0.00	(0.13)	(0.06)	(0.08)	(0.10)	(0.10)	(0.10)	(0.10)	(2.8)
Trial Standard Level 5									
Power Sector CO2 (MMT CO2)	0.84	(9.84)	(8.17)	(8.89)	(8.55)	(8.55)	(8.55)	(8.55)	(262.0)
Nitrogen Oxide - (x000 t)	0.16	0.38	0.35	(0.23)	0.59	0.59	0.59	0.59	(12.9)
Mercury (Hg) - Low (t)	-	-	-	-	-	-	-	-	-
Mercury (Hg) - High (t)	(0.00)	(0.16)	(0.11)	(0.12)	(0.14)	(0.14)	(0.14)	(0.14)	(4.0)

Note: All units are metric tons, equivalent to 1.1 short tons

16.2.6 Effects on Upstream Fuel-Cycle Emissions

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 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.[2] 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 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 16.2.9 for CO_2 and NOx. The percentages are relative to power plant emissions and provide a means to estimate upstream emission savings based on changes in emissions from power plants. The percentage effects presented in Table 16.2.9 provides a qualitative approach to viewing effects on fuel cycle emissions. The previous section indicates slight overall reductions in CO_2 and NOx. Thus, very small reductions in upstream emissions of air pollutant could be expected. This approach does not address Hg emissions.

Table 16.2.7 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

16.3 WETLAND, ENDANGERED AND THREATENED SPECIES, AND CULTURAL RESOURCES

DOE's proposed action is not site-specific, nor would it affect land disturbance or use due to IRL and GSFL adoption. Therefore, none of the proposed TSLs is expected to affect the quality of wetlands, or threatened or endangered species. Further, this action is not expected to impact cultural resources such as historical or archaeological sites.

16.4 SOCIOECONOMIC IMPACTS

DOE's analysis has shown that the increase in the first cost of purchasing more efficient lighting products at the proposed standard level is completely offset by a reduction in the life-cycle cost (LCC) of owning a more efficient piece of equipment. In other words, the customer will pay less operating costs over the life of the equipment even through the first cost increases. The complete analysis and its conclusions are presented in Chapter 8 of the TSD.

For subgroups of low-income and senior consumers that purchase lighting products, DOE determined that the average LCC impact is similar to that for the full sample of consumers. Therefore, DOE concludes that the proposed action would have no significant socioeconomic impact. For a complete discussion on the LCC impacts on consumer subgroups, see Chapter 12 of the TSD.

16.5 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 IRL and GSFL, (2) manufacturers of niche products related to IRL and GSFL, and (3) small businesses operated by disadvantaged or minority populations.

DOE identified small businesses as a sub-group that possibly could be disproportionately affected by IRL and GSFL energy conservation standards. As described in the Life-Cycle Cost Subgroup Analysis, Chapter 11 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.

16.6 NOISE AND AESTHETICS

Improvements in efficiency of IRL and GSFL equipment is expected to result from changes in the choice of components and other design features. These changes are described in Chapter 5 of this TSD. Efficiency improvements result from improved heat exchanger designs using increased levels of coppers, and more efficient compressors. These design changes are not expected to change noise levels in comparison to equipment in today's market. Equipment that is currently manufactured in the existing market that would meet the proposed standards is no louder than less efficient equipment. Changes to the design to improve the efficiency levels are not anticipated to affect the equipment's aesthetics.

16.7 SUMMARY OF ENVIRONMENTAL IMPACTS

Table 16.7.1 and Table 16.7.2 summarize anticipated environmental impacts for each of the TSLs across all equipment types. Air quality impacts were estimated for each of the TSLs. The summary table shows cumulative changes in emissions for CO_2, NO_x, and Hg over the period 2012 to 2042. The resulting changes in emission quantities are very small. 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 16.2.7. 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. This approach does not address Hg emissions.

Socioeconomic impacts are presented in TSD Chapter 12.

Table 16.7.1 Environmental Impact Analysis Results Summary for IRL

NEMS-BT Results: Environmental Effects

	Total Reference Case 2012-2042†	TSL 1	TSL 2	TSL 3	TSL 4	TSL 5
IRL Existing Technologies, Shift, R-CFL Substitution						
CO2 (Million metric tons)	78,824	19.8	48.9	85.1	105.7	118.1
NOX (x1000t)	59,033	1.9	5.5	7.6	8.4	9.3
Mercury (t)						
Low Emission Rate	846	0.0	0.0	0.0	0.0	0.0
High Emission Rate	846	0.3	0.7	1.3	1.7	1.8
IRL Emerging Technologies, Rollup, BR Lamp Substitution						
CO2 (Million metric tons)	78,824	7.5	19.1	37.8	44.0	53.3
NOX (x1000t)	59,033	1.3	3.2	5.4	6.4	8.1
Mercury (t)						
Low Emission Rate	846	0.0	0.0	0.0	0.0	0.0
High Emission Rate	846	0.1	0.3	0.6	0.7	0.8

† Extrapolated by assuming 2030 end values in all subsequent years 2031-2042.

Table 16.7.2 Environmental Impact Analysis Results Summary for GSFL

NEMS-BT Results: Environmental Effects

	Total Reference Case 2012-2042†	TSL 1	TSL 2	TSL 3	TSL 4	TSL 5
GSFL Existing Technologies, Shift, High Lighting Expertise						
CO2 (Million metric tons)	78,824	130.3	133.9	296.6	487.6	552.0
NOX (x1000t)	59,033	11.7	10.0	17.0	36.8	58.1
Mercury (t)						
Low Emission Rate	846	0.0	0.0	0.0	0.0	0.0
High Emission Rate	846	2.0	2.4	4.8	7.3	8.8
GSFL Emerging Technologies, Roll up, Market Segment Based Lighting Expertise						
CO2 (Million metric tons)	78,824	66.4	86.0	148.3	174.6	262.0
NOX (x1000t)	59,033	1.9	5.1	7.3	11.0	12.9
Mercury (t)						
Low Emission Rate	846	0.0	0.0	0.0	0.0	0.0
High Emission Rate	846	1.2	1.4	2.3	2.8	4.0

† Extrapolated by assuming 2030 end values in all subsequent years 2031-2042.

REFERENCES

[1] U.S. Department of Energy - Energy Information Administration, *An Updated Annual Energy Outlook 2009 Reference Case Reflecting Provisions of the American Recovery and Reinvestment Act and Recent Changes in the Economic Outlook*. April 2009: Washington, DC. <http://www.eia.doe.gov/oiaf/aeo/>

[2] 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.