DOE/EA-1643

ENVIRONMENTAL ASSESSMENT FOR

10 CFR Part 431

Energy Conservation Program for Commercial and Industrial Equipment: Energy Conservation Standards for Commercial Ice-Cream Freezers; Self-Contained Commercial Refrigerators, Commercial Freezers, and Commercial Refrigerator-Freezers without Doors; and Remote Condensing Commercial Refrigerators, Commercial Freezers, and Commercial Refrigerator-Freezers

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CHAPTER 16. ENVIRONMENTAL IMPACT ANALYSIS

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CHAPTER 16. ENVIRONMENTAL IMPACT ANALYSIS

16.1 INTRODUCTION

This chapter describes potential environmental effects that may result from amended energy conservation standards for commercial refrigeration equipment (CRE). The U.S. Department of Energy (DOE) 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 from imposing CRE standards. Estimates of source energy savings can be found in the utility impact analysis in Chapter 14 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. The latter part of the chapter describes potential impacts to other environmental resources.

16.2 AIR QUALITY ANALYSIS

The primary focus of the environmental analysis is the impact on air quality of amended energy conservation standards for Commercial Refrigeration Equipment. 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 Pollutant Descriptions

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

Sulfur Dioxide (SO_2)

In addressing SO_2 emissions, the Clean Air Act Amendments of 1990 set an SO_2 emissions cap on all power generation, but permitted flexibility among generators through the use of emissions allowances and tradable permits. This SO_2 trading process (sometimes called

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

“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 may 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 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.

Nitrogen oxides form when fossil fuel is burned at high temperatures, as in a combustion process. The primary man-made 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

Coal-fired power plants emit mercury found in coal during the burning process. While coal-fired power plants are the largest remaining source of human-generated mercury emissions in the United States, they contribute very little to the global mercury pool or to contamination of U.S. waters. U.S. coal-fired power plants emit mercury in three different forms: oxidized mercury (likely to deposit within the United States); elemental mercury, which can travel thousands of miles before depositing to land and water; and mercury that is in particulate form. Atmospheric mercury is 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)

Carbon dioxide (CO_2) is not a regulated or criteria pollutant (see below), but it is of interest because of its classification as a greenhouse gas (GHG) and its impact on global climate change. 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. The Earth's imbalance between emissions and absorption results in the continuing growth of GHGs in the atmosphere, causing surface air temperatures and sub-surface ocean temperatures to rise. In the United States, CO_2 emissions from both energy generation and industrial processes account for 84.6 percent of total U.S. GHG emissions.[7]

16.2.2 Air Quality Regulation

In 1990, EPA amended its regulations implementing Title VI of the Clean Air Act to phase out in 2010 chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFC) refrigerants. As a result, the refrigeration industry is transitioning to hydrofluorocarbon-based (HFC-based) refrigerants in its equipment. For the commercial refrigeration equipment covered in this rulemaking, DOE understands that much of the industry has already been using HFC-based refrigerants for both remote condensing and self-contained equipment. Therefore, DOE considered the effects of HFC-based refrigerants from the outset by using HFC refrigerants in its analyses. For remote condensing equipment, the compressor efficiency values used in its analysis are based on ARI 1200, which uses an HFC-based compressor rack with R-404a refrigerant. Likewise for self-contained equipment, DOE's analysis uses R-134a and R-404a, both HFC-based refrigerants. The anticipated use of these refrigerants is not an impact of this rulemaking. Therefore, the effects of this conversion are outside the scope of this environmental analysis.

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 that is intended to help control acid rain. 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). CAIR would permanently cap emissions of SO_2 and NO_x in the eastern United States. CAIR would achieve large reductions of SO_2 and/or NO_x emissions across 28 eastern states and the District of Columbia. Under CAIR, 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 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, is closely related to the CAIR and establishes standards of performance for mercury emissions from new and existing coal-fired electric utility steam generating units. The Clean Air Mercury Rule regulates mercury emissions from coal-fired power plants. The rule creates a market-based cap-and-trade program that will permanently cap utility mercury emissions in two phases. The first phase of the rule sets a cap of 38 tons per year and, due to incentives created by the cap-and-trade program, EPA projects that emissions will decrease from 48 tons to 31 tons beginning in 2010. Emissions will continue to decline thereafter until they are reduced to the second phase cap of 15 tons when the program is fully implemented, beginning in 2015.

In 2007, the U.S. Supreme Court ruled that the EPA had authority to regulate CO_2 emissions. EPA is currently formulating these regulations (Massachusetts v. Environmental Protection Agency, No. 05-1120, (549 U.S. 2007)).

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,[b] in which the court vacated the CAIR rule. Even though the D.C. Circuit vacated CAIR, DOE notes that the D.C. Circuit left intact EPA's 1998 NO_x SIP Call rule, which capped seasonal (summer) NO_x emissions from electric generating units and other sources in 23 jurisdictions, and gave those jurisdictions the option to participate in a cap and trade program. 63 FR 57356, 57359 (Oct. 27, 1998).[c] The SIP Call rule may provide a similar, although less extensive, regional cap and may

[b] Case No. 05-1244, 2008 WL 2698180 at *1 (D.C. Cir. July 11, 2008).
[c] In the NOx SIP Call rule, EPA found that sources in the District of Columbia and 22 "upwind" states were emitting NOx (an ozone precursor) at levels that significantly contributed to "downwind" states not attaining the ozone NAAQS or at levels that interfered with states in attainment maintaining the ozone NAAQS. To ensure that downwind states attain or continue to attain the ozone NAAQS, EPA established a region-wide cap for NOx emissions from certain large combustion sources and set a NOx emissions budget for each State. Unlike the cap that CAIR would have established, the NOx SIP Call Rule's cap only constrains seasonal (summertime) emissions. To comply with the NOx SIP Call Rule, states could elect to participate in the NOx Budget Trading Program. Under this program, each emission source is required to have one allowance for each ton of NOx emitted during the ozone season. States have flexibility in how they allocate allowances through their State Implementation Plans, but states must remain within the EPA-established budget. Emission sources are allowed to buy, sell, and bank NOx allowances as appropriate. On April 16, 2008, EPA determined that Georgia is no longer subject to the NOx SIP Call rule. 73 FR 21528 (April 22, 2008).

limit actual reduction in NO_x emissions from revised standards occurring in states participating in the SIP Call rule. However, the possibility that the SIP Call rule would have the same effect as CAIR is highly uncertain.

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 GHGs, such as carbon dioxide (CO_2), as major contributors to climate change. Because this Rule, if finalized, will likely decrease CO_2 emission rates from the fossil fuel sector in the United States, the Department here examines the impacts and causes of climate change and then the potential impact of the Rule on CO_2 emissions and global warming.

Impacts of Climate Change on the Environment

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

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 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.

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 GHGs, and aerosols. After that period, the rate of increase is less certain. The IPCC Report describes increases in average global temperatures of about 1.1°C to 6.4°C at the end of the century relative to today. These increases vary depending on the model and emissions scenarios.

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 (e.g., 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 with likely 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 GHGs (e.g., 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 CO_2 currently makes up about 77 percent of the total CO_2-equivalent[d] global warming potential in GHGs emitted from human activities, with the vast majority (74 percent) of the CO_2 attributable to fossil fuel use. For the future, the IPCC Report describes a wide range of GHG emissions scenarios. However, under each scenario, CO_2 would continue to comprise above 70 percent of the total global warming potential.

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

Stabilization of CO_2 Concentrations

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

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[f] (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 GHGs to levels that are 50 percent 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 GHG 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.

The Beneficial Impact of the Rule on CO_2 Emissions

If finalized, 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 2008 Annual Energy Outlook (AEO 2008)[g] that U.S. annual energy-related emissions of CO_2 in 2005 were about 5.98 billion metric tons (about 20 percent of the world energy-related CO_2 emissions and about 12 percent of total global GHG emissions), of which 2.32 billion tons were attributed to residential and commercial buildings sector (including related energy–using equipment, such as CRE). Most of the GHG emissions attributed to residential and commercial buildings are emitted from fossil fuel-fired power plants that generate electricity used in this sector. In the AEO2008 reference case, EIA projected that annual energy-related CO_2 emissions would grow from 6.0 billion metric tons in 2005 to 6.85 billion metric tons in 2030, an increase of 14.5 percent (see Table 16.2., based on AEO 2008), while emissions attributable to buildings would grow to 2.92 billion tons, an increase of 26.1 percent.

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[e] 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.

[f] IPCC Working Group 3 Table TS 2

[g] www.eia.doe.gov/oiaf/archive/aeo08/index.html

As computed for the AEO 2008 reference case, the cumulative U.S. energy-related CO_2 emissions between 2012 and 2042 are described at about 209 billion metric tons. The estimated cumulative CO_2 emission reductions from a CRE Efficiency Standard (shown as a range of alternative Trial Standard Levels) during this same 30-year period are indicated in Table 16.2.1. The estimated CO_2 emission reductions in Table 16.2.1 are calculated using NEMS-BT model. As noted in Chapter 14, NEMS-BT model forecasts end in year 2030. Energy and emissions impacts beyond 2030 were extrapolated for this rulemaking.

Table 16.2.1 Impact of the CRE Efficiency Standard on Cumulative Energy-Related Emissions Reductions of CO_2 between 2012 and 2042 by Trial Standard Level (TSL)

	TSL 1	TSL 2	TSL 3	TSL 4	TSL 5
CO_2 (Million metric tons)	8.5	32.8	50.7	52.6	66.0

The estimated savings shown in Table 16.2.1, which are at most 0.01 percent of U.S. energy-related emissions of CO_2 (for TSL 5), comprise an even smaller fraction of U.S. emissions of GHGs and of world emissions of GHGs. However, the savings would likely reduce overall U.S. CO_2 emissions, as compared to U.S. CO_2 emissions absent an increase in the required efficiency of CRE.

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 CO_2 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 16.2.1 indicates, the Rule will likely reduce CO_2 emissions rates from the fossil fuel sector.

16.2.4 Analytical Methods for Air Quality

NEMS-BT incorporates capabilities to assess compliance with SO_2 and NO_x 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. NEMS-BT also includes provisions for the Clean Air Interstate Rule, which imposes stricter restrictions on SO_2 and NO_x for some states, and the Clean Air Mercury Rule, which imposes a national mercury constraint.

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 and mercury contents of the fuel used when determining optimal dispatch.

The CAIR and mercury rules allow for emissions banking for NO_x and mercury, which is simulated in the NEMS-BT model. Emissions banking refers to regulated power plant operators releasing fewer emissions than what they have allowances for in an earlier year in order to release more emissions than permitted by their allowances in a later year. If a power plant produces fewer emissions than they are allotted in one year, the regulations (and the NEMS-BT model) allow the operator to over-emit in a later year by this same amount. This banking activity can mean that outer years end up with levels of emissions that may be greater than anticipated or targeted. However, the bank tends to encourage greater short-term emissions reductions.

The value of an emission allowance within the NEMS-BT model is assumed to be the market-clearing price, which is based on the revenue requirements for the capital and operating expenses associated with compliance. Banking would lower the overall cost of compliance if the discounted, present value of the compliance costs in a given year is less than the corresponding cost in a later year. Similarly, banking mercury allowances may reduce the overall cost of complying with the mercury emissions limits specified in the Clean Air Mercury Rule.

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 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.[1]

As with SO_2 emissions, caps on NO_x and mercury emissions will possibly result in no physical emissions effects resulting from equipment energy conservation standards, but reduced power generation demand will have the benefit of generating net emissions allowance credits relative to a base case of no energy conservation standard. It was not possible to remove the modeling of emission caps for NO_x and mercury emissions from the NEMS-BT model to simulate the impact on emissions under an uncapped scenario. Therefore, DOE did not use the NEMS-BT model output to estimate the NO_x and mercury emissions reductions in this analysis. DOE instead established a range of possible NO_x reductions for each TSL considered.[h]

DOE's low estimate for NO_x emission reductions was based on the emission rate of the cleanest new natural gas combined-cycle power plant available for electricity generated, under an assumption that energy conservation standards would displace the generation of only the cleanest available fossil fuels. DOE used the emission rate, specified as 0.0341 kilo-tons of NO_x emitted per TWh of electricity generated, associated with an advanced natural gas combined-cycle power plant, as specified by NEMS-BT. To estimate the reduction in NO_x emissions, DOE multiplied this emission rate by the reduction in electricity generation due to the new energy conservation standards considered. DOE's high estimate for an emissions rate was 0.843 kilo-tons of NO_x per TWh based on a nationwide NO_x emission rate for all electrical generation plants today. Use of such an emission rate assumes that displaced future generation from CRE standards comes from power plants no cleaner, in terms of $NO_{x,}$ emission than the plants that are being used currently to generate electricity. DOE based this emission rates on AEO2008 data for 2006, when no regulatory or non-regulatory measures were in effect to limit NO_x emissions. DOE multiplied this emission rate by the reduction in electricity generation for each TSL considered.

Similar to the NO_x emission reduction analysis, DOE established a range of Hg emission rates from existing electrical generation technologies to estimate the Hg emissions that could be reduced through standards. DOE's low estimate assumed that future standards would displace electrical generation from natural gas-fired power plants, resulting in an effective emission rate of zero. The low-end emission rate is zero because natural gas-fired power plants have virtually zero Hg emissions associated with their operation.

DOE's high estimate was based on a nationwide mercury emission rate from AEO2008. 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, DOE believes the most reasonable estimate is based on the assumption that all displaced coal generation would have been emitting at the average emission rate for coal generation as specified by AEO2008. As noted previously, virtually all mercury emitted from electricity generation is from coal-fired power plants. DOE based the high end emission rate on the tons of mercury emitted per TWh of coal-generated electricity. Based on the emission rate for 2006, DOE

[h] 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, No. 05-1244, 2008 WL 5335481 (D.C. Cir. Dec. 23, 2008). Given the uncertain nature of NOx emission regulation during the time that the CRE standards will be in effect, and DOE continued to report a range of potential NOx emission reductions using the methodology discussed in this chapter.

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 as determined through the NEMS-BT modeling.

16.2.5 Effects on Power Plant Emissions

Table 16.2. shows reference power plant emissions in selected years. The AEO 2008 Reference case emissions are the emissions shown by the NEMS-BT model to result if none of the TSLs are promulgated. Table 16.2.3 shows estimated changes in power plant emissions in selected years for all commercial refrigeration equipment analyzed for TSL 1 through TSL 5. Changes in NO_2 and mercury emissions from power plants are shown in these tables. Changes in CO_2 emissions from all sources are also shown in this table.

Table 16.2.2 Power Sector Emissions Impacts Forecast for AEO2008 Reference Case

NEMS-BT Results:*						
	2005	**2010**	**2015**	**2020**	**2025**	**2030**
CO_2 (Million metric tons/year)**	5,982	6,012	6,225	6,390	6,575	6,843
NO_x (Thousand tons/year)†	3,639	2,338	2,112	2,112	2,142	2,169
Hg (tons/year)†	51.72	37.24	24.19	18.48	16.69	15.41

* NOx and Hg reported in short tons, CO_2 reported in metric tons
** Comparable to Table A18 of AEO2008: Electric Generators
† Comparable to Table A8 of AEO2008: Emissions

Table 16.2.3 Power Sector Emissions Impact Forecasts for Commercial Refrigeration Equipment

NEMS-BT Results:	Difference from Reference Case						
					Extrapolation		
	2015	**2020**	**2025**	**2030**	**2035**	**2040**	**2042**
Trial Standard Levels 1							
CO_2 (Million metric tons/year)	-0.164	-0.334	-0.374	-0.285	-0.285	-0.285	-0.285
NOx (Thousand tons/year)							
High	-0.1518	-0.3636	-0.5238	-0.6324	-0.6324	-0.6324	-0.6324
Low	-0.0061	-0.0147	-0.0212	-0.0256	-0.0256	-0.0256	-0.0256
Hg (tons/year)							
High	-0.0038	-0.0079	-0.0094	-0.0081	-0.0081	-0.0081	-0.0081
Low	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Trial Standard Level 2							
CO_2 (Million metric tons/year)	-0.631	-1.284	-1.439	-1.095	-1.095	-1.095	-1.095
NO_x (Thousand tons/year)							
High	-0.5837	-1.3980	-2.0140	-2.4317	-2.4317	-2.4317	-2.4317
Low	-0.0236	-0.0565	-0.0815	-0.0984	-0.0984	-0.0984	-0.0984
Hg (tons/year)							
High	-0.0146	-0.0306	-0.0360	-0.0310	-0.0310	-0.0310	-0.0310
Low	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Table 16.2.3 Power Sector Emissions Impact Forecasts for Commercial Refrigeration Equipment - Continued

Trial Standard Level 3							
CO_2 (Million metric tons/year)	-0.977	-1.988	-2.228	-1.696	-1.696	-1.696	-1.696
NO_x (Thousand tons/year)							
High	-0.904	-2.164	-3.118	-3.765	-3.765	-3.765	-3.765
Low	-0.0366	-0.0876	-0.1261	-0.1523	-0.1523	-0.1523	-0.1523
Hg (tons/year)							
High	-0.0226	-0.0473	-0.0558	-0.0480	-0.0480	-0.0480	-0.0480
Low	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Trial Standard Level 4							
CO_2 (Million metric tons/year)	-1.013	-2.061	-2.310	-1.758	-1.758	-1.758	-1.758
NO_x (Thousand tons/year)							
High	-0.9371	-2.2443	-3.2332	-3.9037	-3.9037	-3.9037	-3.9037
Low	-0.0379	-0.0908	-0.1308	-0.1579	-0.1579	-0.1579	-0.1579
Hg (tons/year)							
High	-0.0234	-0.0491	-0.0578	-0.0497	-0.0497	-0.0497	-0.0497
Low	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Trial Standard Level 5							
CO_2 (Million metric tons/year)	-1.271	-2.585	-2.897	-2.205	-2.205	-2.205	-2.205
NO_x (Thousand tons/year)							
High	-1.1753	-2.8147	-4.0549	-4.8959	-4.8959	-4.8959	-4.8959
Low	-0.0475	-0.1139	-0.1640	-0.1980	-0.1980	-0.1980	-0.1980
Hg (tons/year)							
High	-0.0294	-0.0615	-0.0725	-0.0624	-0.0624	-0.0624	-0.0624
Low	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

* 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 AEO2008: Electric Generators
† Comparable to Table A8 of AEO2008: Emissions

Table 16.2.3 shows the range in NO_x emission changes calculated using the low and high estimate scenarios for specific years by TSL. Cumulative NO_x emission reductions over the period from 2012-2042 range from 0.59 to 112.84 kilotons for the TSLs considered. These changes in NO_x emissions are extremely small, ranging from 0.001 to 0.168 percent of the national base case emissions forecast by NEMS-BT, depending on the TSL.

Table 16.2.3 also shows the estimated changes in Hg emissions calculated using the low and high estimate scenarios for specific years by TSL. Cumulative Hg emission reduction over the period from 2012 to 2042 range from from 0 to 1.732 tons for the TSLs considered. These changes in Hg emissions are extremely small, ranging from 0 to 0.003 percent of the national base case emissions forecast by NEMS-BT, depending on the TSL.

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 effects on upstream fuel-cycle emissions. These emissions factors provide the reader with a sense of the possible magnitude of upstream effects. These upstream emissions would be in addition to emissions from direct combustion. Relative to the entire fuel cycle, estimates based on the work of Dr. Mark DeLuchi, and reported in earlier DOE environmental assessment documents, find that an amount approximately equal to 8 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.[1,2] 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 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 16.2.4 for CO_2 and NO_x. 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 16.2.4 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 mercury emissions.

Table 16.2.4 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
NOx	5.8	40

16.2.7 Economic Valuation of Emissions Reductions

In addition to the estimation of reductions in physical emissions from an energy conservation standard, the analysis also considered the monetary benefits associated with these reductions.

Carbon Dioxide (CO_2)

During the preparation of its most recent review of the state of climate science, the Intergovernmental Panel on Climate Change (IPCC) identified various estimates of the present value of reducing CO_2 emissions by 1 ton over the life that these emissions would remain in the atmosphere. The estimates reviewed by the IPCC spanned a range of values. In the absence of a consensus on any single estimate of the monetary value of CO_2 emissions, DOE used an estimate identified by the study cited in Summary for Policymakers prepared by Working Group II of the IPCC's Fourth Assessment Report to calculate the potential monetary value of the CO_2 reductions likely to result from the standards under consideration in this rulemaking.

To put the potential monetary benefits from reduced CO_2 emissions into a form that is likely to be most useful to decision makers and interested parties, the estimated year-by-year reductions in CO_2 emissions were converted into monetary values. The resulting annual values were then discounted over the life of the affected appliances to the present using both 3 percent and 7 percent discount rates. DOE applied an annual growth rate of 2.4 percent to the value of the social cost of carbon (SCC), as suggested by the IPCC Working Group II (2007, p. 822), based on estimated increases in damages from future emissions reported in published studies. As a result, DOE is assigned a range for the SCC of $0 to $20 ($2007) per ton of CO_2 emissions. These estimates were based on an assumption of no benefit to an average benefit value reported by the IPCC as the SCC.[i] The resulting estimates of the potential range of the present value of benefits associated with the reduction of CO_2 emissions are reflected in Table 16.2.8.

The IPCC estimate used as the upper bound value was derived from an estimate of the mean value of worldwide impacts from potential climate impacts caused by CO_2 emissions, and not just the effects likely to occur within the United States. DOE considers that in estimating a monetary value for CO_2 emission reductions, the values should be restricted to a representation of those costs/benefits likely to be experienced in the United States and expects that such values would be lower than comparable global values. There currently are no consensus estimates for the U.S. benefits likely to result from CO_2 emission reductions. However, DOE believes it is appropriate to use U.S. benefit values, where available and not world benefit values, in its analysis.[j]

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[i] During the preparation of its most recent review of the state of climate science, the Intergovernmental Panel on Climate Change (IPCC) identified various estimates of the present value of reducing carbon-dioxide emissions by one ton over the life that these emissions would remain in the atmosphere. The estimates reviewed by the IPCC spanned a range of values. In the absence of a consensus on any single estimate of the monetary value of CO_2 emissions, DOE used the estimates identified by the study cited in Summary for Policymakers prepared by Working Group II of the IPCC's Fourth Assessment Report to estimate the potential monetary value of CO_2 reductions likely to result from standards finalized in this rulemaking. According to IPCC, the mean social cost of carbon (SCC) reported in studies published in peer-reviewed journals was $43 per ton of carbon. This translates into about $12 per ton of carbon dioxide. The literature review (Tol 2005) from which this mean was derived did not report the year in which these dollars were denominated. However, we understand this estimate was denominated in 1995 dollars. Updating that estimate 1995 estimate to 2007 dollars yields a SCC of $15 per ton of carbon dioxide.

[j] In contrast, most of the estimates of costs and benefits of increasing the efficiency of CRE include only economic values of impacts that would be experienced in the U.S. For example, in determining impacts on manufacturers, DOE generally does not consider impacts that occur solely outside of the United States.

Table 16.2.2 Estimates of Savings from CO_2 Emissions Reductions under CRE Trial Standard Levels at 7% Discount Rate and 3% Discount Rate

Trial Standard Level	Estimated Cumulative CO_2 (Million metric tons) Emission Reductions	Value of Estimated CO_2 Emission Reductions Based on IPCC Range (Million 2007$) at 7% Discount Rate	Value of Estimated CO_2 Emission Reductions Based on IPCC Range (Million 2007$) at 3% Discount Rate
TSL 1	8.52	$0 to $76.01	$0 to $154.73
TSL 2	32.76	$0 to $292.26	$0 to $594.94
TSL 3	50.71	$0 to $452.49	$0 to $921.10
TSL 4	52.59	$0 to $469.19	$0 to $955.10
TSL 5	65.95	$0 to $588.44	$0 to $1197.85

Given the uncertainty surrounding estimates of the SCC, relying on any single study may be inadvisable since its estimate of the SCC will depend on many assumptions made by its authors. The Working Group II's contribution to the Fourth Assessment Report of the IPCC notes that:

The large ranges of SCC are due in the large part to differences in assumptions regarding climate sensitivity, response lags, the treatment of risk and equity, economic and non-economic impacts, the inclusion of potentially catastrophic losses, and discount rates.k

DOE believes that the most appropriate monetary values for consideration in the development of efficiency standards are those drawn from studies that attempt to estimate the present value of the marginal economic benefits likely to result from reducing GHG emissions, rather than estimates that are based on the market value of emission allowances under existing cap-and-trade programs or estimates that are based on the cost of reducing emissions—both of which are largely determined by policy decisions that set the timing and extent of emission reductions and do not necessarily reflect the benefit of reductions. DOE also believes that the studies it relies upon generally should be studies that were the subject of a peer-review process and were published in reputable journals.

The upper bound of the range used by DOE is based on Tol (2005), which reviewed 103 estimates of the SCC from 28 published studies, and concluded that when only peer-reviewed studies published in recognized journals are considered, "that climate change impacts may be very uncertain but [it] is unlikely that the marginal damage costs of carbon dioxide emissions exceed $50 per ton carbon [comparable to a 2007 value of $20 per ton carbon dioxide when expressed in 2007 U.S. dollars with a 2.4 percent growth rate.]"

[k] *Climate Change 2007 – Impacts, Adaptation and Vulnerability*
Contribution of Working Group II to the Fourth Assessment Report of the IPCC, 17. *Available at* http://www.ipcc-wg2.org (last accessed Aug. 7, 2008).

In setting a lower bound of $0, DOE agrees with the IPCC Working Group II (2007) report that "significant warming across the globe and the locations of significant observed changes in many systems consistent with warming is very unlikely to be due solely to natural variability of temperatures or natural variability of the systems" (pp. 9), and thus tentatively concludes that a global value of zero for reducing emissions cannot be justified. However, DOE also believes it is reasonable to allow for the possibility that the U.S. portion of the global cost of CO_2 emissions may be quite low. In fact, some of the studies looked at in Tol (2005) reported negative values for the SCC. As stated in the NOPR, DOE is using U.S. benefit values, and not world benefit values, in its analysis and, further, DOE believes that U.S. domestic values will be lower than the global values. Additionally, the statutory criteria in EPCA do not require consideration of global effects. Therefore, DOE is using a lower bound of $0 per ton of CO_2 emissions in estimating the potential benefits.

Nitrogen Oxides (NO_x) and Mercury

DOE also investigated the monetary impact of efficiency standards on NO_x, mercury (Hg), and SO_2. National SO_2 emissions are currently subject to a national cap-and-trade system by regulation, while NO_x and Hg are not. For the range of NO_x reduction estimates (and Hg reduction estimates), DOE estimated the national monetized benefits of emissions reductions based on environmental damage estimates from the literature. The effect of the SO_2 caps is that equipment efficiency standards will have almost no effect on physical emissions of SO_2, but if large enough, could cause incremental changes in the prices of emissions allowances in cap-and-trade emissions markets.

Because of the court ruling discussed in Section 16.2.2, emissions of NO_x from electricity generation are not controlled by the regulatory caps. For these emissions, DOE estimated the national monetized benefits of emissions reductions based on environmental damage estimates from the literature. Available estimates suggest a very wide range of monetary values for NO_x emissions, ranging from $370 per ton to $3800 per ton of NO_x from stationary sources, measured in 2001 dollars[l] or a range of $432 per ton to $4441 per ton in 2007 dollars.

DOE conducted research and determined that the basic science linking mercury emissions from power plants to impacts on humans is considered highly uncertain. However, DOE located two estimates of the environmental damages of mercury based on two estimates of the adverse impact of childhood exposure to methylmercury on IQ for American children, and subsequent loss of lifetime economic productivity resulting from these IQ losses. The high-end estimate is based on an estimate of the current aggregate cost of the loss of IQ that results from exposure of American children of U.S. power plant origin of $1.3 billion per year in year 2000$, which works out to $32.6 million per ton emitted per year (2007$).[m] The low-end estimate is

[l] 2006 Report to Congress on the Costs and Benefits of Federal Regulations and Unfunded Mandates on State, Local, and Tribal Entities. Office of Management and Budget Office of Information and Regulatory Affairs, Washington, D.C.

[m] Trasande, L., et al., "Applying Cost Analyses to Drive Policy that Protects Children" 1076 ANN. N.Y. ACAD. SCI. 911 (2006).

$664,000 per ton emitted in 2004$ or $729,000 per ton in 2007$), which DOE derived from a published evaluation of mercury control using different methods and assumptions from the first study, but also based on the present value of the lifetime earnings of children exposed.[n] The resulting estimates of the potential range of the present value benefits associated with the national reduction of NO_x and Hg emissions are reflected in Table 16.2.9 and Table 16.2.10.

Table 16.2.3 Estimates of Savings from Reductions of NO_x and Hg under CRE Trial Standard Levels at a 7% Discount Rate

Trial Standard Level	Estimated Cumulative NO_x (kt) Emission Reductions	Value of Estimated NO_x Emission Reductions (Thousand 2007$)	Estimated Cumulative Hg (tons) Emission Reductions	Value of Estimated Hg Emission Reductions (Thousand 2007$)
TSL 1	0.59-14.58	$64-$1,578	0-0.224	$0-$46
TSL 2	2.27-56.04	$245-$6,067	0-0.86	$0-$177
TSL 3	3.51-86.77	$380-$9,394	0-1.332	$0-$274
TSL 4	3.64-89.97	$394- $9,741	0-1.381	$0-$284
TSL 5	4.56-112.84	$494-$12,216	0-1.732	$0-$356

Table 16.2.4 Preliminary Estimates of Savings from Reductions of NO_x and Hg under CRE Trial Standard Levels at a 3% Discount Rate

Trial Standard Level	Estimated Cumulative NO_x (kt) Emission Reductions	Value of Estimated NO_x Emission Reductions (Thousand 2007$)	Estimated Cumulative Hg (tons) Emission Reductions	Value of Estimated Hg Emission Reductions (Thousand 2007$)
TSL 1	0.59-14.58	$135-$3,329	0-0.224	$0-$91
TSL 2	2.27-56.04	$518-$12,799	0-0.86	$0-$349
TSL 3	3.51-86.77	$802-$19,815	0-1.332	$0-$540
TSL 4	3.64-89.97	$831- $20,547	0-1.381	$0-$560
TSL 5	4.56-112.84	$1,042-$25,769	0-1.732	$0-$702

[n] Ted Gayer and Robert Hahn, Designing Environmental Policy: Lessons from the Regulation of Mercury Emissions, Regulatory Analysis 05-01. AEI-Brookings Joint Center For Regulatory Studies, Washington, D.C., 31 pp., 2004. A version of this paper was published in the *Journal of Regulatory Economics* in 2006. The estimate was derived by back-calculating the annual benefits per ton from the net present value of benefits reported in the study.

Sulfur Dioxide (SO_2)

Unlike the other pollutants considered in this TSD, SO_2 emissions have, for some time, been subject to a national cap with corresponding annual allowances openly traded; therefore, considerable market experience with these instruments has already been accumulated. It has been argued that imposition of any standard that lowers U.S. national electricity consumption creates beneficial downward pressure on the prices of these allowances, and this cost reduction benefit should be considered in any analysis of a proposed standard. While this assertion is fundamentally sound, i.e. reduced electricity demand should *ceteris paribus* bring about lower SO_2 allowance prices, there are a myriad of complications impeding any meaningful quantification of any associated benefit. While complexity of analysis alone clearly cannot justify disregarding a potential consequence of a standard, the Department additionally believes these benefits to be both volatile and *de minimis* when compared to the direct effects of a standard as estimated in this TSD.

Some of the problems to be confronted in an allowance price effect forecast are as listed below.

1. Only any net lowering of the total allowance bill to generators free of transfers is the potential source of a benefit. Any such compliance cost saving would need to be accurately estimated, and this effect is no different from the benefit derived from a cost reduction for other inputs, such as fuel. When the SO_2 allowance market that was created in 1995 under the Clean Air Act Amendments (CA3) began, initial allowance allocations were directly granted to large *affected units* based on their historic (1985-87) use of fuel. For 30 years, allowances for the following year are issued every spring at a declining rate to these entitled parties, and thereafter can be freely used, traded, or banked. Some additional allowances are allocated in diverse ways, e.g. as rewards to generators installing control equipment. In other words, the entitled generators holding emission rights are losers when the value of allowances declines, while the buyers of allowances are gainers. Before they are used, allowances may be traded many times at prices reflecting the marginal not average cost of compliance.
2. The trading system allows for allowance banking. Consequently, any observed change in a forecast year could represent the manifestation of market fundamentals, but could similarly just indicate deposit or withdrawal of allowances. In general, used allowances have fallen short of the cap, so emissions may exceed the specified cap for future years.
3. Control efforts could further reduce the SO_2 cap for some jurisdictions, creating regulatory uncertainty that perturbs the allowance market. The issuance of the proposed and final CAIR rules were likely contributing factors to allowance price increases, leading to a dramatic 2005 allowance price spike. While prices had already fallen far below their historic highs by the time CAIR was vacated in the summer of 2008, spot allowance prices nonetheless made a further precipitous drop following the D.C. Circuit Court ruling.
4. Because allowances can be traded freely by generators, brokers, and investors, they can serve as financial instruments, and, especially since 2003, allowance prices have been volatile. Between 2000—when a tightened CA3 cap came into force—and 2007, allowances traded between a low of about \$120/short ton in 2002 and a high of about

$1600/short ton, with the 2005 spike being particularly dramatic[o]. Since there is no reason to believe that these conditions will alter over the life of a proposed standard, the challenge of forecasting prices is much more complex than a simple supply-demand balance might suggest. Also, note that any quantification of the benefit likely depends on the level of prices as well as their net change. To believe that a simple delta in the prices could be used to estimate the benefit is to believe that the same numerical reduction in price would result from the standard whether the prevailing trading price were $100 or $1000 per short ton.

The forecasting tool used for this TSD is the AEO2008 version of NEMS-BT and generates forecasts of both SO_2 emissions and allowance prices. Unfortunately, this model was released before CAIR was overturned, so its forecast enforces the tighter CAIR cap in the affected east of country, and does not represent current conditions. Given the timing of the CAIR ruling relative to the progress of this analysis, attaining projections without CAIR has not been possible. Nonetheless, as an indicative bounding case, the net changes in the average price were computed for the period 2012 to 2030 for standard size equipment at TSL 5 (the most stringent energy conservation standard considered in this analysis). The estimates represent an average of the various model simulations with different impact multipliers (see Appendix J for explanation of multipliers used)[p].

For CRE equipment, the specific results indicated about a -0.01 percent change in the allowance price in the East region defined within the Electricity Market Module (EMM) of NEMS-BT. The Department considers this effect to be inconsequential relative to other elements in the benefits analysis, and given the significant effort that would be required to develop a refined estimate, the SO_2 allowance price effect is not considered in this TSD. If future analysis suggests that the SO_2 allowance price effect is both significant and estimable using NEMS-BT, it may be added to supporting material.

16.3 WETLAND, ENDANGERED AND THREATENED SPECIES, AND CULTURAL RESOURCES

DOE's proposed action is not site-specific. The efficiency of commercial refrigeration equipment being installed in commercial buildings is not expected to affect land disturbance or use. 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.

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[o] sources of the historic SO_2 allowance prices are http://www.epa.gov/airmarkets/progress/alprices.html, http://camddataandmaps.epa.gov/gdm/

[p] To be specific with regard to the method, for each simulation the arithmetic change in the allowance price between the standards case and the reference was first computed over the period 2012 to 2030. The percentage change was computed as this average change divided by the average allowance price in the reference case over the same period. After scaling to take into account the specific values of the impact multipliers across simulations ("100X", "200X", and "300X" values discussed in Appendix J), the resulting percentage changes were subsequently averaged over the simulations. The percentage change in the allowance price for the 200X case for CRE equipment was slightly positive; this case was not used in the averaging in order to better reflect a bounding case for this equipment.

16.4 SOCIOECONOMIC IMPACTS

DOE's analysis has shown that the increase in the first cost of purchasing more-efficient Commercial Refrigeration Equipment at the proposed standard level is completely or nearly 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 fewer 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 the sub-group of customers that reflect small businesses, defined by independent convenience stores and small grocery without access to national accounts, DOE determined that the average LCC impact is similar to that for the full sample of customers. Therefore, DOE concludes that the proposed action would have negligible socioeconomic impact. For a complete discussion on the LCC impacts on independent hotels, see Chapter 12 of the TSD.

Table 16.4.1 shows the mean LCC savings for VCT.RC.L for both the full sample of customers and for the small business subgroup as an example.

Table 16.4.1 Mean Life-Cycle Cost Savings for All Customers and Sub-Group, Independent Convenience Stores and Small Grocery, VCT.RC.L Example

	Trial Standard Level*				
	TSL 1	TSL 2	TSL 3	TSL 4	TSL 5
All Customers	$762	$4,137	$5,450	$5,419	$5,419
Independent Convenience Stores and Small Grocery	$1,001	$5,639	$7,454	$7,447	$7,447

*Values refer to life-cycle cost savings over the equipment lifetime compared with purchase of baseline equipment

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 commercial refrigeration equipment, (2) manufacturers of niche products related to commercial refrigeration equipment, 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 commercial refrigeration equipment energy conservation standards. As described in the Life-Cycle Cost Subgroup Analysis, Chapter 11 of the TSD, DOE found that there were no disproportionately high and adverse human health or environmental effects on small businesses that would result from the proposed energy conservation standards. Because there were no disproportionately high and adverse impacts on small businesses in general, DOE believes this same conclusion also applies to minority populations.

16.6 NOISE AND AESTHETICS

Improvements in efficiency of commercial refrigeration equipment 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. Efficiency improvements result from improved heat exchanger designs using increased levels of copper, higher efficiency evaporator fans, higher efficiency lighting, and more efficient compressors and condenser fans applied to self-contained equipment. These design changes are not expected to change noise levels in comparison to equipment in today's market. In addition, changes to the design to improve the efficiency levels are not anticipated to affect the equipment's aesthetics. None of the design options considered by DOE is believed to result in visual changes perceptible to the store customer, with the exception of lighting. To achieve the equipment efficiencies provided at TSL 4, and 5, for equipment for which case lighting was present in the baseline model and for which the engineering design assumed LED lighting, DOE modeled only the energy consumption and direct cost impacts of the equipment with solid-state lighting. Solid-state lighting provides a functionally equivalent lighting of the product being merchandised. DOE notes that current implementations of solid-state lighting in display cases use light from many discrete point sources directed at the merchandised product rather than the more diffuse lighting obtained using fluorescent bulbs. This may provide a somewhat different presentation of the product; however, not one that would result in a negative aesthetic impact.

16.7 SUMMARY OF ENVIRONMENTAL IMPACTS

Table 16.7.1 summarizes anticipated environmental impacts for each of the TSLs across all equipment 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 mercury over the period 2012 to 2042. The resulting changes in emission quantities are very small, much less than 1 percent in comparison to the reference case. Cumulative CO_2 and NO_x emissions show a decrease compared to the reference case. Mercury emissions show a very small increase in cumulative emissions. This increase may result from the combined effects of emissions banking, a shift in how power plants are dispatched or the timing within the model of when power plants are replaced.

Upstream fuel cycle emission of CO_2 and NO_x are described but not quantified in section 16.2.6. 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.

Socioeconomic impacts are presented as changes in life cycle costs. No impacts are anticipated in the area of environmental justice, wetlands endangered and threatened species, and cultural resources, or noise and aesthetics.

Table 16.7.1 Environmental Impact Analysis Results Summary

Environmental Effects	Reference Case*	TSL 1	TSL 2	TSL 3	TSL 4	TSL 5
Cumulative Emission Reductions**						
CO_2 (Million metric tons)	238,078	8.5	32.8	50.7	52.6	66.0
NO_x (Kilo tons)	69,049	0.59 to 14.58	2.27 to 56.04	3.51 to 86.77	3.64 to 89.97	4.56 to 112.84
Hg (tons)	568.4	0 to 0.224	0 to 0.86	0 to 1.332	0 to 1.381	0 to 1.732
Fuel-Cycle (Upstream) Emissions	NA	†	†	†	†	†
Wetlands, Endangered and Threatened Species, Cultural Resources	NA	None	None	None	None	None
Socioeconomic Impacts - VCT.RC.L, Mean LCC Savings ($) ‡						
All Customers	NA	$762	$4,137	$5,450	$5,419	$5,419
Convenience Stores and Independent Small Grocery	NA	$1,001	$5,639	$7,454	$7,447	$7,447
Environmental Justice	NA	None	None	None	None	None
Noise and Aesthetics	NA	None	None	None	None	None

* The reference case values reflect total cumulative emissions and life-cycle costs in the absence of an energy conservation standard.
** Cumulative total is over a time period from 2012 to 2042.
† DOE does not report actual estimates of the effects of standards on upstream emissions, but section 16.2.5 provides a sense for the possible magnitude of effects.
‡ Values refer to life-cycle cost savings over the equipment lifetime compared with purchase of baseline equipment.

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1 . DOE. 2006. *Environmental Assessment for Proposed Energy Conservation Standards for Distribution Transformers*. DOE/EA-1565. Washington, D.C.

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.