Environmental Assessment for Final Rule, 10 CFR 433, "Energy Efficiency Standards for New Federal Commercial and Multi-Family High-Rise Residential Buildings" (DOE/EA-1918)

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SUMMARY

The U.S. Department of Energy (DOE) has prepared this environmental assessment (EA) for DOE's Final Rule, 10 CFR Part 433, "Energy Efficiency Standards for New Federal Commercial and Multi-Family High-Rise Residential Buildings". The Final Rule updates the baseline standard in 10 CFR 433 to the latest private sector standard based on cost-effectiveness and DOE's determination that energy efficiency has been improved in these codes as required by 42 U.S.C 6831 et seq. DOE has previously published a final determination with regard to the comparison of American National Standards Institute (ANSI)/American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE)/Illuminating Engineering Society of North America (IESNA) Standard 90.1-2010 (90.1- 2010) to the prior version, ASHRAE 90.1-2007. (76 FR 64904; October 19, 2011.)

Section 305(a) of the Energy Conservation and Production Act (ECPA) requires that DOE establish by rule Federal building energy efficiency standards for all Federal commercial and multi-family high-rise residential buildings. EPCA requires DOE to establish by rule revised Federal building energy efficiency performance standards. (42 U.S.C. 6834(a)(3)(A)) The revised standards must require, in part, that new Federal buildings be designed to achieve energy consumption levels that are at least 30 percent below the minimum standard referenced in Section 305(a)(2), if life-cycle cost-effective. (42 U.S.C. 6834(a)(3)(A)(i)(I)) The current reference standard for commercial and multi-family high-rise buildings is ANSI/ASHRAE/IESNA Standard 90.1-2007. In general, life-cycle cost-effective means the savings associated with the improved efficiency are greater than the associated costs. See 10 CFR Part 436.

ECPA also requires that not later than 1-year after the date of approval of each subsequent revision of the ASHRAE Standard, DOE must determine whether to amend the Federal building standards with the revised voluntary standard based on the cost-effectiveness of the revised voluntary standard (42 U.S.C. 6834(a)(3)(B)). The Final Rule is the result of DOE's determination that the revised standards should be updated to reflect the amendments made in ASHRAE Standard 90.1-2010.

DOE has previously issued standards for all new Federal commercial and multi-family high-rise residential (over three stories in height above ground) buildings pursuant to the requirements of ECPA, as amended. The Final Rule would update the current rule for commercial and multi-family high-rise residential buildings, 10 CFR 433 "Energy Efficiency Standards for New Federal Commercial and Multi-Family High-Rise Residential Buildings," to replace ASHRAE Standard 90.1-2007 with the more energy

efficient ASHRAE Standard 90.1-2010. The Final Rule would make no other changes to the Federal Building Energy Efficiency Standards.

The EA examines the potential incremental environmental impacts of the Final Rule on building habitability and the outdoor environment. To identify the potential environmental impacts that may result from implementing the Final Rule, DOE compared the Final Rule with the "no-action alternative" of using the minimum requirements of the previous version of the Federal standard – 10 CFR Part 433 (referred to as the "no-action alternative").

Building Habitability (Indoor Air) Impacts

The Final Rule would not change mechanical ventilation rates or affect sources of indoor air pollutants from the no-action alternative. For commercial and multi-family high-rise residential buildings, ASHRAE Standard 90.1-2010 does not require specific mechanical ventilation rates and the rule does not require any changes in mechanical ventilation rates. The Final Rule contains essentially the same requirements for sealing of the building envelope that have been in all previous versions of ASHRAE Standard 90.1. Accordingly, indoor air pollutant levels are not expected to increase under the Final Rule.

Outdoor-Air Environmental Impacts

Table S-1 summarizes the estimated emissions impacts for each of the alternatives for the Federal building energy efficiency standard. It shows cumulative changes in emissions for CO_2, NO_x, mercury, and SO_2 for 30 years of construction (2013 through 2042) and 30 years of energy reduction for each building built during that period. Cumulative CO_2, NO_x, and mercury emissions are reduced compared to the Reference case for all alternatives. Emission reductions for SO_2 are negligible.

Table S-2 summarizes the estimated emissions impacts for six additional pollutants – methane, nitrous oxide (NO), halocarbons, carbon monoxide (CO), particulate matter (PM), and lead. It shows cumulative changes in emissions for a thirty year period for each of the alternatives. Cumulative emissions are reduced compared to the Reference case for all alternatives. Emissions impacts for all but methane are negligible.

Table S-1 Air Emissions Reductions in Metric Tons (30-Years of Commercial Construction)

Baseline (no-action alternative)	Final Rule- Code or Standard	Carbon Dioxide	Nitrogen Oxides	Mercury	Sulfur Dioxide
ASHRAE 90.1-2007	90.1-2010	89,888,200	91,851	1.2795	Negligible
	10% below 90.1-2010	126,091,100	128,857	1.7950	Negligible
	20% below 90.1-2010	162,293,900	165,864	2.3105	Negligible
	30% below 90.1-2010	198,496,800	202,870	2.8260	Negligible
	40% below 90.1-2010	234,699,600	239,876	3.3415	Negligible
	50% below 90.1-2010	270,902,400	276,882	3.8570	Negligible
30% Below ASHRAE 90.1-2007	30% below 90.1-2010	62,921,800	64,296	0.8957	Negligible
	40% below 90.1-2010	99,124,600	101,302	1.4112	Negligible
	50% below 90.1-2010	135,327,500	138,308	1.9267	Negligible

Table S-2 Other Air Emissions Reductions in Metric Tons (30-Years of Commercial Construction)

Baseline (no-action alternative)	Final Rule- Code or Standard	Methane	Nitrous Oxide and Halocarbons	Carbon Monoxide, Particulate Matter, and Lead
ASHRAE 90.1-2007	90.1-2010	996,011	Negligible	Negligible
	10% below 90.1-2010	1,397,236	Negligible	Negligible
	20% below 90.1-2010	1,798,462	Negligible	Negligible
	30% below 90.1-2010	2,199,687	Negligible	Negligible
	40% below 90.1-2010	2,600,913	Negligible	Negligible
	50% below 90.1-2010	3,002,138	Negligible	Negligible
30% Below ASHRAE 90.1-2007	30% below 90.1-2010	697,208	Negligible	Negligible
	40% below 90.1-2010	1,098,433	Negligible	Negligible
	50% below 90.1-2010	1,499,659	Negligible	Negligible

ABBREVIATIONS AND ACRONYMS

ANSI	American National Standards Institute
ASHRAE	American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc.
CAIR	Clean Air Interstate Rule
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
CH_4	methane
CO_2	carbon dioxide
CO	carbon monoxide
D.C.	District of Columbia
DOE	Department of Energy
EA	environmental assessment
ECPA	Energy Conservation and Production Act
EGU	electric generating unit
EPA	Environmental Protection Agency
EUI	Energy use intensity, kBtu/ft2-yr
FR	Federal Register
ft^2	square feet
GHG	greenhouse gas
HVAC	heating, ventilation, and air conditioning
IPCC	Intergovernmental Panel on Climate Change
IESNA	Illuminating Engineering Society of North America
kBtu	one thousand British thermal units
NAS	National Academy of Sciences
NEPA	National Environmental Policy Act of 1969
NESHAP	national emissions standards for hazardous air pollutants
N_2O	nitrous oxide
NO_2	nitrogen dioxide
NO_x	nitrogen oxide
NRC	National Research Council
O_3	ozone
PM	particulate matter
SO_2	sulfur dioxide
SO_x	sulfur oxide gases
UNEP	United Nations Environment Programme
U.S.C.	United States Code
VOC	volatile organic compounds

CONTENTS

TABLES

1 PURPOSE AND NEED FOR AGENCY ACTION

This environmental assessment (EA) complies with the National Environmental Policy Act of 1969 (42 U.S.C. 4321 et seq.), the implementing regulations of the Council on Environmental Quality (40 CFR Parts 1500-1508), and DOE's regulations for implementing National Environmental Policy Act (NEPA) (10 CFR Part 1021).

Section 305 of the Energy Conservation and Production Act (ECPA), requires DOE to establish building energy efficiency standards for all new Federal buildings. (42 U.S.C. 6834) Section 305(a)(1) requires standards that contain energy efficiency measures that are technologically feasible and economically justified but, at a minimum, require the subject buildings to meet the energy saving and renewable energy specifications in the applicable voluntary consensus energy code specified in Section 305(a)(2) (42 U.S.C. 6834(a)(1) and (2)).

Section 305 of ECPA also requires that "Not later than one-year after the date of approval of each subsequent revision of the ASHRAE Standard or the IECC, as appropriate, the Secretary shall determine, based on the cost-effectiveness of the requirements under the amendment, whether the revised standards established under this paragraph should be updated to reflect the amendment." (42 USC 6834(a)(3)(B)).

The Final Rule is the result of DOE's determination that the revised standards should be updated to reflect the amendments made in the ASHRAE Standard 90.1-2010 based on the cost-effectiveness of the latest private sector standards and DOE's determinations as to the energy efficiency improvements of ANSI/ASHRAE/IESNA Standard 90.1-2010 as required by Title III of ECPA, which establishes requirements for the Building Energy Efficiency Standards Program (42 U.S.C. 6831 et seq.). Prior to today's Final Rule, DOE reviewed ASHRAE Standard 90.1 for DOE's state building codes program and determined that the 2010 version of ASHRAE Standard 90.1 would achieve greater energy efficiency than the prior version. This determination was subject to notice and comment. See 76 FR 43298 (July 20, 2011).

2 THE FINAL RULE AND ALTERNATIVES

Section 2.1 describes the Final Rule and the no-action alternatives for commercial and multi-family high-rise residential buildings.

2.1 Commercial and Multi-Family High-Rise Residential Buildings

The potential environmental impacts that would result from implementing the Final Rule for new Federal commercial buildings and multi-family high-rise residential buildings (over three stories in height and containing three or more dwelling units) were examined by comparing the Final Rule with the minimum that Federal agencies must achieve under the existing 10 CFR Part 433, ASHRAE Standard 90.1-2007. The Final Rule was also compared with a level of energy efficiency 30 percent better than Standard 90.1-2007, because the existing 10 CFR Part 433 requires buildings to be at least 30 percent better than Standard 90.1-2007 if life-cycle cost-effective.

The proposed action is the Final Rule, which would update the baseline standard to ASHRAE Standard 90.1-2010. This new baseline is compared against two alternative, "No-Action" scenarios.

2.1.1 No-Action Alternative One – Standard 90.1-2007

The first no-action alternative is defined as the use of Standard 90.1-2007, as required by the current 10 CFR Part 433. This standard establishes the minimum level of energy savings that Federal agencies should achieve under the current Federal commercial standard. 10 CFR Part 433 incorporates by reference design, and performance-based energy efficiency requirements for building envelope; heating, ventilation, and air-conditioning (HVAC) systems and equipment; service water heating systems and equipment; electrical distribution systems and equipment for electric power; and lighting.

2.1.2 No-Action Alternative Two - 30 Percent Better than Standard 90.1-2007

The second no-action alternative is defined as a level of energy efficiency 30 percent better than Standard 90.1-2007. Although the second no-action alternative is not explicitly required, 10 CFR Part 433 does require new Federal buildings to achieve a level of energy consumption 30 percent below Standard 90.1-2007 if that level is life-cycle cost-effective.

3 DESCRIPTION OF THE AFFECTED ENVIRONMENT

The Final Rule would establish requirements that may impact building habitability (indoor environment), the outdoor environment, and the Federal agencies that procure commercial and residential buildings. Section 3.1 addresses air emissions that can affect indoor-air quality and related human health effects. Section 3.2 addresses air emissions in the outdoor environment.

3.1 Indoor Habitability

Energy efficiency codes can potentially affect indoor-air quality, either adversely or beneficially. The primary indoor-air emissions that can adversely affect human health in typical commercial and residential buildings are particulate matter, carbon monoxide (CO), carbon dioxide (CO_2), nitrogen dioxide (NO_2), radon, formaldehyde, volatile organic compounds, and biological contaminants.

Building energy code requirements could influence the concentration levels of indoor-air emissions in several ways. First, they could increase or decrease the ventilation and/or infiltration of fresh air from outdoors, which generally could reduce or increase indoor-generated pollutant concentration levels, respectively. The Final Rule would not change ventilation or infiltration relative to the no-action alternatives for commercial and high-rise multi-family residential buildings. Standard 90.1-2010 does provide an expanded list of potential openings to be sealed and new requirements for air barriers. However, Standard 90.1-2010 and the previous version both require all openings in the building envelope to be sealed. (See Standard 90.1-2007, Section 5.4.3.1 Building Envelope Sealing, and Standard 90.1-2010, Section 5.4.3.1 Continuous Air Barrier.) Therefore, there should be no impact on overall building infiltration from use of Standard 90.1-2010. Additionally, Standard 90.1-2010 continues to reference ASHRAE Standard 62.1, which specifies minimum amounts of outdoor air that are to be provided. In specifying the minimum amounts of outdoor air to be provided, ASHRAE Standard 62.1 does not consider any air leakage through the building envelope.

Second, requirements in energy efficiency codes have the potential to impact internally generated indoor emissions by changing the materials or equipment used within the buildings. Various emissions can be continuously or intermittently released within commercial and residential buildings. These emissions can originate from furnishings within a building (e.g., carpet, furniture), from building materials (e.g., insulation material, particle board), from the ground (e.g., radon), from the building occupants' indoor activities (e.g., tobacco smoking, painting), or from the mechanical equipment (e.g., fossil-fuel appliances). Potential combustion emissions include CO, CO_2, nitrogen oxides, and sulfur dioxide (SO_2). Fossil-fuel-burning (including gas stoves/ovens) equipment and, if allowed, tobacco smoke, are the main sources of combustion products. In addition, sources from outside the building (particularly vehicle exhaust) can be drawn into the building.

Table 1 summarizes the principal indoor-air emissions that can potentially be of concern within buildings.

Table 1 Indoor-Air Emissions

Pollutant	Health Impacts	Sources
Particulate Matter	Lung cancer, bronchitis and respiratory infections. Eye, nose, and throat irritations.	Fossil fuel combustion, dust, smoking.
Carbon Monoxide	CO is an odorless and colorless gas that is an asphyxiate and disrupts oxygen transport. At high concentration levels, CO causes loss of consciousness and death.	Unvented kerosene and gas space heaters; leaking chimneys and furnaces; back drafting from furnaces, gas water heaters, wood stoves, and fireplaces; gas stoves; and automobile exhaust from attached garages.
Carbon Dioxide	An excessive concentration of CO_2 triggers increased breathing to maintain the proper exchange of oxygen and CO_2. Concentrations above 3 percent can cause headaches, dizziness, and nausea. Concentrations above 6 percent can cause death (NRC 1981)	Sources include human respiration, tobacco smoking, gas stoves, and gas ovens.
Nitrogen Dioxide	NO_2 acts mainly as an irritant, affecting the eyes, nose, throat, and respiratory tract. Extremely high-dose exposure to NO_2 (as in a building fire) may result in pulmonary edema and diffuse lung injury. Continued exposure to high NO_2 levels can lead to acute bronchitis (EPA 1994)	Sources include kerosene heaters, gas stoves, ovens, and tobacco smoke.
Radon	Radon decay products in breathed air can deposit and stay in the lungs, sometimes contributing to lung cancer. The National Academy of Sciences (NAS) estimates that 15,400 to 21,800 people in the United States die from lung cancer attributable to radon, although the number could be as low as 3,000 or as high as 32,000 (NAS 1998). A large majority of the deaths happen to cigarette smokers. Radon is much less of a concern in commercial buildings than in residential buildings because these buildings usually have mechanical ventilation and occupants are typically not in the buildings as many hours a week as they are in their homes.	Radon is a radioactive gas that occurs in nature. The greatest single source of radon is from the soil. It can be found in soils and rocks containing uranium, granite, shale, phosphate, and pitchblende (Moffat 1997).

Table 1. Continued

Pollutant	Health Impacts	Sources
Formaldehyde	The Environmental Protection Agency (EPA) has classified formaldehyde as a "probable human carcinogen" (EPA 1989). In low concentration levels, formaldehyde irritates the eyes and mucous membranes of the nose and throat (NRC 1981). Formaldehyde can cause watery eyes; burning sensations in the eyes, nose, and throat; nausea; coughing; chest tightness; wheezing; skin rashes; and allergic reactions (CPSC 1997).	Various pressed-wood products can emit formaldehyde, including particle board, plywood, pressed wood, paneling, some carpeting and backing, some furniture and dyed materials, urea-formaldehyde insulating foam, and pressed textiles (CPSC 1997). Cigarette smoke also produces formaldehyde.
Volatile organic compounds (VOCs)	VOCs can cause a wide variety of health problems. Some examples of potential health effects include increased cancer risks, depression of the central nervous system, irritation to the eyes and respiratory tract, and liver and kidney damage. Some evidence exists that VOCs can provoke some of the symptoms typical of sick-building syndrome and cause severe reactions for individuals who appear to demonstrate multiple chemical sensitivities (EPA 1991).	VOCs contain carbon and exist as vapors at room temperatures. Over 900 VOCs have been identified in indoor air (EPA 1991). Formaldehyde is one type of VOC. Many products give off VOCs as they dry, cure, set, or otherwise age (Moffat 1997).
Biological Contaminants	Biological agents in indoor air are known to cause three types of human disease: infections, where pathogens invade human tissue; hypersensitivity diseases, where specific activation of the immune system causes diseases; and toxicosis, where biologically produced chemical toxins cause direct toxic effects (EPA 1994). Evidence is available showing that some episodes of sick-building syndrome may be related to microbial contamination of buildings (EPA 1994).	Sources include outdoor air and human occupants who shed viruses and bacteria, animal occupants (insects and other arthropods, mammals) that shed allergens, and indoor surfaces and water reservoirs such as humidifiers where fungi and bacteria can grow (EPA 1994).

3.2 Outdoor Air

The Final Rule would reduce energy consumption, and therefore, impact pollutant emissions associated with energy consumption.

3.2.1 Air Emissions Descriptions and Regulation

This analysis first considers three air pollutants: sulfur dioxide (SO_2), nitrogen oxides (NO_X), and mercury (Hg). An air pollutant is any substance in the air that can cause harm to humans or the environment. Pollutants may take the form of solid particles (i.e., particulates or particulate matter), liquid droplets, or gases.[1] DOE's analysis also considers carbon dioxide (CO_2), which is of interest because of its classification as a greenhouse gas (GHG). Seven additional pollutants – methane, nitrous oxide, halocarbons, carbon monoxide, particulate matter, and lead – are also analyzed.

Carbon Dioxide. Carbon dioxide (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. In 2007, over 90 percent of anthropogenic (i.e., human-made) CO_2 emissions resulted from burning fossil fuels (EPA 2009).

Concentrations of CO_2 in the atmosphere are naturally regulated by numerous processes, collectively known as the "carbon cycle." The movement of carbon between the atmosphere and the land and oceans is dominated by natural processes, such as plant photosynthesis. While these natural processes can absorb some of the anthropogenic CO_2 emissions produced each year, billions of metric tons are added to the atmosphere annually. In the United States, in 2007, CO_2 emissions from electricity generation accounted for 39 percent of total U.S. GHG emissions.[2]

Nitrogen Oxides. Nitrogen oxides, or NO_x, is the generic term for a group of highly reactive gases, all of which contain nitrogen and oxygen in varying amounts. Many of the nitrogen oxides are colorless and odorless. However, one common pollutant, nitrogen dioxide (NO_2), along with particles in the air can often be seen as a reddish-brown layer over many urban areas. NO_2 is the specific form of NO_x reported in this document. NO_x is one of the main ingredients involved in the formation of ground-level ozone, which can trigger serious respiratory problems. It can contribute to the formation

[1] More information on air pollution characteristics and regulations is available on EPA's website at www.epa.gov.
[2] IPCC Working Group 3, Table TS2.

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 (EPA 2011b).

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. Coal-fired power plants emit mercury (Hg) found in coal during the burning process. Coal-fired power plants are the largest remaining source of human-generated Hg emissions in the United States (EPA 2011c). 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 (Trasande et al. 2006).

Sulfur Dioxide. Sulfur dioxide, or SO_2, belongs to the family of sulfur oxide gases (SO_x). These gases dissolve easily in water. Sulfur is prevalent in all raw materials, including crude oil, coal, and ore that contains common metals like aluminum, copper, zinc, lead, and iron. SO_x gases are formed when fuel containing sulfur, such as coal and oil, is burned, and when gasoline is extracted from oil or metals are extracted from ore. SO_2 dissolves in water vapor to form acid, and interacts with other gases and particles in the air to form sulfates and other products that can be harmful to people and their environment (EPA 2011a).

Methane. Methane emissions are primarily from human-related sources, not natural sources. U.S. methane emissions are from three categories of sources, each accounting for about one-third of total emissions: (1) energy sources, (2) emissions from domestic livestock, and (3) decomposition of solid waste in landfills. The methane emitted from energy sources occurs primarily during the production and processing of natural gas, coal, and oil; not in the actual use (combustion) of these fuels. Methane is the primary ingredient in natural gas, and production, processing, storage, and transmission of natural gas account for 56 percent of the energy source emissions (or 25 percent of all methane emissions). (DOE 2005)

Nitrous Oxide. Nitrous oxide emission rates are more uncertain than those for CO_2 and methane, with nitrogen fertilization of agricultural soils being the primary human-related source. Fuel combustion is also a source of nitrous oxide; however, in the commercial and residential sector total emissions are a negligible amount of all U.S. emissions. (DOE 2005)

Halocarbons and Other Gases. One group of human-made greenhouse gases consists of halocarbons and other engineered gases not usually found in nature. Three of these gases are hydrofluorocarbons (HFC), perfluorocarbons (PFC), and sulfur hexafluoride (SF_6). HFCs are compounds containing carbon, hydrogen, and fluorine. HFCs do not reach the stratosphere to destroy ozone so are, therefore, considered more environmentally benign than ozone-depleting substances such as chlorofluoro-carbons (CFCs), even though HFCs are greenhouse gases. HFCs are used as refrigerants and are becoming more common as ozone-depleting refrigerants are phased out. PFCs are compounds containing carbon and fluorine. PFC emissions result as a byproduct of aluminum smelting and semiconductor manufacturing. SF_6 is used an insulator for electric equipment. Energy used in buildings contributes a negligible amount of emissions of these greenhouse gases. (DOE 2005)

Carbon Monoxide. The main source of CO is the incomplete burning of fossil fuels such as gasoline. Exhaust from 'highway vehicles' contributes about 55 percent of all CO emissions. The CO produced from energy use related to buildings is 3 percent of all emissions, but most of this is from wood burning in residential buildings, which should not be impacted by these rules.   0.7% of CO emissions come from fuel combustion for electrical generation by utilities. (EPA 2007)

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

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

Power plant emissions can have either direct or indirect impacts on PM. A portion of the pollutants emitted by a power plant are in the form of particulates as they leave the smoke stack. These are direct, or primary, PM emissions. However, the great majority of PM emissions associated with power plants are in the form of secondary sulfates, which are produced at a significant distance from power plants by complex atmospheric chemical reactions that often involve the gaseous (non-particulate) emissions of power plants, mainly SO_2 and NO_x. The quantity of the secondary sulfates produced is determined by a very complex set of factors including the atmospheric quantities of SO_2

and NO_x, and other atmospheric constituents and conditions. Because these highly complex chemical reactions produce PM comprised of different constituents from different sources, EPA does not distinguish direct PM emissions from power plants from the secondary sulfate particulates in its ambient air quality requirements, PM monitoring of ambient air quality, or PM emissions inventories. Further, as described below, it is uncertain whether efficiency standards will result in a net decrease in power plant emissions of SO_2, and of NO_x in many states because those pollutants are now largely regulated by cap and trade systems. For these reasons, it is not currently possible to determine how the standards impact either direct or indirect PM emissions.

Lead Exposure to lead can cause a variety of health problems. Lead can adversely affect the brain, kidneys, liver, nervous system, and other organs. Today, metals processing is the major source of lead emissions to the atmosphere. Combustion from electric utilities is less than 2 percent of all lead emissions, with most of the combustion emissions are from coal, not natural gas or oil. Lead emissions directly from buildings are a negligible share of national total emissions (EPA 2001).

Air Quality Regulation. The Clean Air Act Amendments of 1990 list 188 toxic air pollutants that EPA is required to control (EPA 1990). EPA has set national air quality standards for six common pollutants (also referred to as "criteria" pollutants), two of which are SO_2 and NO_X. Also, the Clean Air Act Amendments of 1990 gave EPA the authority to control acidification and to require operators of electric power plants to reduce emissions of SO_2 and NO_X. Title IV of the 1990 amendments established a cap-and-trade program for SO_2, in all 50 states and the District of Columbia (D.C.), intended to help control acid rain.[3] This cap-and-trade program serves as a model for more recent programs with similar features.

In 2005, EPA issued the Clean Air Interstate Rule (CAIR) under sections 110 and 111 of the Clean Air Act (40 CFR Parts 51, 96, and 97)[4] 70 FR 25162–25405 (May 12, 2005). CAIR limited emissions from 28 eastern States and D.C. by capping emissions and creating an allowance-based trading program. Although, CAIR was remanded to EPA by the U.S. Court of Appeals for the District of Columbia Circuit (D.C. Circuit), (see *North Carolina v. EPA*, 550 F.3d 1176 (D.C. Cir. 2008),) it remained in effect temporarily, consistent with the D.C. Circuit's earlier opinion in *North Carolina v. EPA*, 531 F.3d 896 (D.C. Cir. 2008).

On July 6, 2011, EPA promulgated a replacement for CAIR, entitled "Federal Implementation Plans: Interstate Transport of Fine Particulate Matter and Ozone and Correction of SIP Approvals," but commonly referred to as the Cross-State Air Pollution Rule or the Transport Rule. 76 FR 48208 (Aug. 8, 2011). On December 30, 2011,

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[3] In contrast to the modeling forecasts of NEMS-BT that SO_2 emissions will remain at the cap, during the years 2007 and 2008, SO2 emissions were below the trading cap. This raises the possibility that standards would cause some reduction in SO_2 emissions. However, because DOE does not have a method to predict when emissions will be below the trading cap, it continues to rely on NEMS-BT and thus does not estimate SO_2 emissions reductions at this time.

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

however, the D.C. Circuit stayed the new rules while a panel of judges reviews them, and told EPA to continue enforcing CAIR (see *EME Homer City Generation v. EPA*, No. 11-1302, Order at *2 (D.C. Cir. Dec. 30, 2011)).

At the time the analysis was performed following the update to ASHRAE 90.1, EPA had issued national emissions standards for hazardous air pollutants (NESHAPs) for mercury and certain other pollutants emitted from coal and oil-fired electric generating units (EGUs). (77 FR 9304; February, 16, 2012.) The NESHAPs do not include emissions caps and, as such, DOE's energy conservation standards would likely reduce Hg emissions.

3.2.2 Globa 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 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.

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 (IPCC WGI 2007a).

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. (IPCC WGI 2007b)

Looking forward, the IPCC describes continued global warming of about 0.2°C per decade for the next 2 decades under a wide range of emission scenarios for carbon dioxide (CO_2), other greenhouse gases (GHGs), and aerosols. After that period, the rate of increase is less certain. The IPCC Report describes increases in average global temperatures of about 1.1°C to 6.4°C at the end of the century relative to today. These increases vary depending on the model and emissions scenarios. (IPCC WGI 2007b)

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 of 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 caused by the increase in anthropogenic concentrations of CO_2 and other long-lived greenhouse gases such as methane and nitrous oxide in the atmosphere, rather than from natural causes.

Increasing the CO_2 concentration partially blocks the Earth's re-radiation of captured solar energy in the infrared band, inhibits the radiant cooling of the Earth, and thereby alters the energy balance of the planet, which gradually increases its average temperature. The IPCC Report estimates that currently, CO_2 makes up about 77 percent of the total CO_2-equivalent[5] global warming potential in GHGs emitted from human activities, with the vast majority (74 percent) of the CO_2 attributable to fossil fuel use (IPCC 2007b). For the future, the IPCC Report describes a wide range of GHG emissions scenarios, but under each scenario CO_2 would continue to comprise above 70 percent of the total global warming potential. (IPCC 2000)

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.[6] Of this annual total, fossil fuels contribute about 29 billion metric tons of CO_2 (IPCC 2000).

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

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[5] 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.

[6] 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.

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[7] (about 1.3 °C to 1.7 °C above today's levels). To achieve concentrations between 350 ppm to 400 ppm, the IPCC scenarios present that there would have to be a rapid downward trend in total annual global emissions of greenhouse gases to levels that are 50 to 85 percent below today's annual emission rates by no later than 2050. Because it is assumed that there would continue to be growth in global population and substantial increases in economic production, the scenarios identify required reductions in greenhouse gas emissions intensity (emissions per unit of output) of more than 90 percent. However, even at these rates, the scenarios describe some warming and some climate change is projected because of already accumulated CO_2 and GHGs in the atmosphere (IPCC 2007c).

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 radiative 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.

[7] IPCC Working Group 3, Table TS 2.

4 CALCULATING ENERGY SAVINGS BY BUILDING TYPE

4.1 Commercial and Multi-Family High-Rise Residential Buildings

To compare estimated outdoor emissions, it is necessary to determine differences in building energy use by fuel type. This section provides the differences in potential building energy use that may result from implementing the Final Rule, which is evaluated at the ASHRAE Standard 90.1-2010 level, as well as increments of 10 percent increases in energy efficiency, up to 50 percent better than 90.1-2010. These values are then compared to the no-action alternatives, which are ASHRAE Standard 90.1-2007 and 30 percent below 90.1-2007. The Final Rule energy savings were assessed for five common buildings types in 15 cities, representing 15 climate regions within the United States. Energy savings from the Final Rule were estimated using the EnergyPlus whole building energy simulation program (DOE 2010b). Assumptions used in this analysis are described below.

4.1.1 Commercial Building Types Used t Estimate Energy Savings

GSA data was used to find the distribution of existing Federal building types (GSA 2008, GSA 2009). It was assumed that new Federal construction would have a similar distribution between building types. Several less common buildings types were put in the office category because they were not easily characterized or modeled and their use-patterns are likely similar to those of office buildings. The distribution shown in Table 2 was used for new Federal construction.

Table 2 Estimated Floor Area Fraction of New Federal Commercial Building Construction

Building Type	Estimated Fraction of Floor Space
Office	63%
Education/Training	8%
Dormitory Barracks	9%
Warehouse	15%
Hospital	4%

Office and education/training buildings were further subdivided into several common building types: small offices, medium offices, large offices, primary education, and secondary education. The distribution of building floor space within these subcategories was assumed to be the same as national building stock. [8]A total of 22 million square feet of new Federal buildings are assumed to be constructed each year.

Table 3 shows the national average energy savings in terms of energy use intensity (EUI) from the Final Rule by building and fuel type. The table compares various levels of increased efficiency (reduced EUI) against two "No-Action" baselines as described in Section 2. EUI is the energy consumed by a building per square foot per year. The national average EUIs were calculated using a weighted average of EUIs for the types of buildings that the Federal Government is expected to construct shown in Table 2. Site energy includes energy used only at the building site. Source energy includes energy used at the building site and energy lost in producing and delivering the energy to the site. The total source EUI savings for the combined average building indicates the total energy savings averaged across the five building types using the percent distribution given above.

Table 3 Annual Energy Savings (kBtu/ft^2-yr) of Final Rule Compared to No-Action Alternative

Baseline (no-action alternative)	**Final Rule- Code or Standard**	**Site Energy Breakdown**		**Total**	
		Gas EUI (kBtu/ ft^2-yr)	**Electric EUI (kBtu/ ft^2-yr)**	**Site EUI (kBtu/ ft^2-yr)**	**Source EUI (kBtu/ ft^2-yr)**
ASHRAE 90.1-2007	90.1-2010	1.7	7.6	9.3	26.2
	10% below 90.1-2010	2.4	10.7	13.1	36.8
	20% below 90.1-2010	3.1	13.8	16.8	47.3
	30% below 90.1-2010	3.7	16.8	20.6	57.9
	40% below 90.1-2010	4.4	19.9	24.3	68.5
	50% below 90.1-2010	5.1	23.0	28.0	79.0
30% Below ASHRAE 90.1-2007	30% below 90.1-2010	1.2	5.3	6.5	18.3
	40% below 90.1-2010	1.9	8.4	10.3	28.9
	50% below 90.1-2010	2.5	11.5	14.0	39.5

[8] The 2011 Annual Energy Outlook projects approximately 2.2 billion square feet of commercial floor space will be added annually to the U.S. building stock (http://www.eia.gov/forecasts/aeo/). Since Federal buildings represent about 1 percent of total U.S. building stock, about 22 million square feet of new Federal buildings are added each year.

5 ENVIRONMENTAL IMPACTS

5.1 Commercial and Multi-Family High-Rise Residential

This section provides the potential environmental impacts that may result from implementing the Final Rule, which is evaluated at the ASHRAE Standard 90.1-2010 level, as well as increments of 10 percent increases in energy efficiency, up to 50 percent better than 90.1-2010. These values are then compared to the no-action alternatives, which are ASHRAE Standard 90.1-2007 and 30 percent below 90.1-2007.

5.1.1 Building Habitability (Indoor-Air) Impacts

The Final Rule would not change mechanical ventilation rates or affect sources of indoor-air pollutants from the no-action alternative. For commercial and multi-family high-rise residential buildings, ASHRAE Standard 90.1-2010 does not require specific mechanical ventilation rates and the Final Rule does not require any changes in mechanical ventilation rates. The Final Rule contains essentially the same requirements for sealing of the building envelope that have been in all previous versions of ASHRAE Standard 90.1. Accordingly, indoor-air pollutant levels are not expected to increase under the Final Rule.

5.1.2 Outdoor Air

In general, under all the alternatives examined in this EA, carbon dioxide, nitrogen oxides, and mercury emissions would be reduced because more energy efficient buildings consume less fossil fuels. The emissions reductions described in this section represent the annual savings from only 1 year of Federal commercial building construction (22 million ft^2) and over an arbitrary 30-year time period.

Electricity production ultimately used in Federal commercial buildings is assumed to have the same distribution of fuel/energy sources (e.g., coal, nuclear) as overall national electricity production. The emissions coefficients were calculated using data from the EIA's Electric Power Annual (DOE 2010a).

Table 4 shows the estimated first-year reduction in emissions for one year of Federal construction.

Table 4 Air Emissions Reductions in Metric Tons (Year 1 of Commercial Construction)

Baseline (no-action alternative)	Final Rule-Code or Standard	Carbon Dioxide	Nitrogen Oxides	Mercury	Sulfur Dioxide
ASHRAE 90.1-2007	90.1-2010	99,876	102	0.00142	Negligible
	10% below 90.1-2010	140,101	143	0.00199	Negligible
	20% below 90.1-2010	180,327	184	0.00257	Negligible
	30% below 90.1-2010	220,552	225	0.00314	Negligible
	40% below 90.1-2010	260,777	267	0.00371	Negligible
	50% below 90.1-2010	301,003	308	0.00429	Negligible
30% Below ASHRAE 90.1-2007	30% below 90.1-2010	69,913	71	0.00100	Negligible
	40% below 90.1-2007	110,138	113	0.00157	Negligible
	50% below 90.1-2007	150,364	154	0.00214	Negligible

As can be seen from Table 4, if buildings meets the new minimum requirement rather than the previous requirement (ASHRAE Standard 90.1-2010 versus 90.1-2007), an estimated 99,876 metric tons of carbon dioxide emission will be eliminated in the first year of the Final Rule for the estimated 22 million ft^2 of new construction. These emission reductions compare to 5,835 million metric tons of total carbon dioxide emissions for the U.S. in 2008 (DOE 2010a), or about one-half of one-thousandth of 1 percent of the national total.

Estimated reductions for 30 years of construction (2013 through 2042) and 30 years of energy reduction for each building built during that period are shown in Table 5.

Table 5 Air Emissions Reductions in Metric Tons (30-Years of Commercial Construction)

Baseline (no-action alternative)	Final Rule- Code or Standard	Carbon Dioxide	Nitrogen Oxides	Mercury	Sulfur Dioxide
ASHRAE 90.1-2007	90.1-2010	89,888,200	91,851	1.2795	Negligible
	10% below 90.1-2010	126,091,100	128,857	1.7950	Negligible
	20% below 90.1-2010	162,293,900	165,864	2.3105	Negligible
	30% below 90.1-2010	198,496,800	202,870	2.8260	Negligible
	40% below 90.1-2010	234,699,600	239,876	3.3415	Negligible
	50% below 90.1-2010	270,902,400	276,882	3.8570	Negligible
30% Below ASHRAE 90.1-2007	30% below 90.1-2010	62,921,800	64,296	0.8957	Negligible
	40% below 90.1-2010	99,124,600	101,302	1.4112	Negligible
	50% below 90.1-2010	135,327,500	138,308	1.9267	Negligible

SO_2 emissions were also considered in this analysis. SO_2 emissions from affected electric generating units (EGUs) are subject to nationwide and regional emissions cap and trading programs, which create uncertainty about the impact of energy efficiency standards on SO_2 emissions. The attainment of emissions caps is typically flexible among EGUs and is enforced through the use of emissions allowances and tradable permits. Under EPA regulations in place at the time this analysis was performed following the update to ASHRAE 90.1, any excess SO_2 emissions allowances resulting from the lower electricity demand caused by the imposition of an efficiency standard could be used to permit offsetting increases in SO_2 emissions by any regulated EGU. However, if the standard resulted in a permanent increase in the quantity of unused emissions allowances, there would be an overall reduction in SO_2 emissions from the standards. While there remains some uncertainty about the ultimate effects of efficiency standards on SO_2 emissions covered by the existing cap and trade system, the National Energy Modeling System (NEMS) [NEMS 2003] model that DOE uses to forecast emissions reductions for many other analyses indicates that no physical reductions in power sector emissions would occur for SO_2. Therefore, no reductions in SO_2 emissions are assumed for this analysis.

Again, at the time this analysis was performed following the update to ASHRAE 90.1, the CAIR established a cap on NO_x emissions in 28 eastern states and the District of Columbia. All these states and D.C. have elected to reduce their NO_x emissions by participating in cap-and-trade programs for EGUs. Therefore, energy conservation standards may have little or no physical effect on these emissions in the 28 eastern states and D.C. for the same reasons that they may have little or no effect on SO_2 emissions.

DOE also considered the emission impacts for methane, nitrous oxide, halocarbons, carbon monoxide, particulate matter, and lead. Tables 6 and 7 show the one-year and 30-year cumulative air emission reductions for these pollutants. All alternatives show savings over the baseline.

Table 6 Other Air Emissions Reductions in Metric Tons (Year 1 of Commercial Construction)

Baseline (no-action alternative)	Final Rule- Code or Standard	Methane	Nitrous Oxide and Halocarbons	Carbon Monoxide, Particulate Matter, and Lead
ASHRAE 90.1-2007	90.1-2010	1107	Negligible	Negligible
	10% below 90.1-2010	1552	Negligible	Negligible
	20% below 90.1-2010	1998	Negligible	Negligible
	30% below 90.1-2010	2444	Negligible	Negligible
	40% below 90.1-2010	2890	Negligible	Negligible
	50% below 90.1-2010	3336	Negligible	Negligible
30% Below ASHRAE 90.1-2007	30% below 90.1-2010	775	Negligible	Negligible
	40% below 90.1-2010	1220	Negligible	Negligible
	50% below 90.1-2010	1666	Negligible	Negligible

Table 7 Other Air Emissions Reductions in Metric Tons (30-Years of Commercial Construction)

Baseline (no-action alternative)	Final Rule- Code or Standard	Methane	Nitrous Oxide and Halocarbons	Carbon Monoxide, Particulate Matter, and Lead
ASHRAE 90.1-2007	90.1-2010	996,011	Negligible	Negligible
	10% below 90.1-2010	1,397,236	Negligible	Negligible
	20% below 90.1-2010	1,798,462	Negligible	Negligible
	30% below 90.1-2010	2,199,687	Negligible	Negligible
	40% below 90.1-2010	2,600,913	Negligible	Negligible
	50% below 90.1-2010	3,002,138	Negligible	Negligible
30% Below ASHRAE 90.1-2007	30% below 90.1-2010	697,208	Negligible	Negligible
	40% below 90.1-2010	1,098,433	Negligible	Negligible
	50% below 90.1-2010	1,499,659	Negligible	Negligible

5.2 Environmental Justice and Other Impacts

A consideration of Environmental Justice is made pursuant to Executive Order 12898, "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations" (59 FR 7629, EO signed Feb. 11, 1994). The Executive Order requires Federal agencies to address disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on low-income or minority populations. The Final Rule would not result in any adverse health effects and therefore does not have the potential for disproportionately high and adverse health effects on minorities and low income population.

The Final Rule is not expected to impact any sensitive environmental resources such as wetlands, endangered species, or historic or archaeological sites. There are no aspects of the Final Rule that would be affected by a terrorist act.

6 AGENCIES AND PERSON CONSULTED DURING THIS RULEMAKING

In accordance with Council on Environmental Quality CEQ regulations in 40 CFR 1508.9(b), a list of persons/agencies consulted during the development of this rulemaking and environmental assessment is provided below.

DOE and Contractor Staff

US Department of Energy - Michael Erbesfeld and Mohammed Khan

Pacific Northwest National Laboratory (DOE contractor) - Mark Halverson, James Hand, Robert Lucas, and Sriram Somasundaram

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