FINAL ENVIRONMENTAL ASSESSMENT

FOR

Final Rule, 10 CFR Part 433, "Energy Efficiency Standards for New Federal Commercial and Multi-Family High-Rise Residential Buildings' Baseline Standards Update"
(RIN 1904-AE44)
(DOE/EA-2112)

Prepared by the
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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
CSAPR	Cross-State Air Pollution Rule
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
IES	Illuminating Engineering Society of North America
kBtu	one thousand British thermal units
Hg	mercury
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

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1 INTRODUCTION

1.1 NEPA

The National Environmental Policy Act (NEPA; 42 U.S. Code [USC] 4321 et seq.), the Council on Environmental Quality's (CEQ's) NEPA regulations (40 Code of Federal Regulations [CFR], 1500 to 1508), and the U.S. Department of Energy's (DOE's) NEPA-implementing procedures (10 CFR Part 1021) require that DOE consider the potential environmental impacts of a major federal action. This requirement applies to DOE's decisions that concern establishing or updating energy efficiency standards.

DOE must meet its obligations under NEPA before making a final decision whether to proceed with any proposed federal action that could cause adverse impacts to human health or the environment. This Environmental Assessment (EA) evaluates the potential individual and cumulative impacts of the Proposed Action and provides DOE the information needed to make an informed decision about the Proposed Action.

In compliance with NEPA and the regulations cited above, this EA evaluates the potential direct, indirect, and cumulative environmental impacts of DOE's Proposed Action to update, by rule, energy efficiency standards for new Federal commercial and multi-family high rise residential buildings. The Proposed Action would update the baseline Federal energy efficiency performance standards, found in 10 CFR 433, to the latest current model industry code, based on a finding that it is cost-effective and saves energy compared to the previous version of the model industry code, as required by 42 U.S.C. 6831 et seq. In this EA, DOE also evaluates the impacts that could occur if DOE were not to adopt the latest current model industry code as the energy efficiency baseline standard for new Federal commercial and high-rise residential buildings (the No Action Alternative).

1.2 Background

DOE is required to establish the building energy efficiency standards for all new Federal buildings pursuant to section 305 of the Energy Conservation and Production Act (ECPA), as amended. (42 U.S.C. 6834 (a)(1)). In turn, each Federal agency and the Architect of the Capitol must adopt procedures to ensure that new Federal buildings will meet or exceed these Federal building energy efficiency standards. (42 U.S.C. 6835(a)). The head of a Federal agency is barred from expending Federal funds for the construction of a new Federal building unless the building meets or exceeds the applicable baseline Federal building energy standards established under section 305. (42 U.S.C. 6835(b)).

The standards established under section 305(a)(1) of ECPA must contain energy efficiency measures that are technologically feasible and economically justified, and that 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) - (3)). Under section 305 of ECPA, the referenced voluntary consensus code for Federal commercial and high-rise residential buildings is the American National Standards Institute (ANSI)/American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE) Standard 90.1, hereafter "ASHRAE".

DOE must also establish, by rule, revised Federal building energy efficiency performance standards for new Federal buildings that require such buildings be designed to achieve energy consumption levels that are at least 30 percent below the levels established in the referenced code (baseline Federal building standard), if life-cycle cost-effective. (42 U.S.C. 6834(a)(3)(A)(i)(I)).

The current 10 CFR 433 baseline standard is based on ASHRAE 90.1-2013. ASHRAE has updated the standard to ASHRAE 90.1-2016. Under section 305 of ECPA, not later than one year after the date of approval of each subsequent revision of the ASHRAE Standard 90.1, DOE must determine whether to amend the baseline 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)). It is this requirement that the Proposed Action seeks to address.

DOE determined that ASHRAE 90.1-2016 would achieve greater energy efficiency than the ASHRAE 90.1-2013 (See, 80 FR 68749; November 6, 2015). The Proposed Action, if implemented, would require that Federal agencies design new Federal commercial and high-rise residential buildings to meet ASHRAE 901.-2016; and, if life-cycle cost-effective, achieve energy consumption levels that are at least 30 percent below the levels of the 2015 IECC.

The preliminary determination regarding the greater energy efficiency of Standard 90.1-2016 was published in the Federal Register on July 25, 2017 (see 82 FR 34513). The final determination for Standard 90.1-2016 was published February 27, 2018 (see 83 FR 8463).

1.3 Purpose and Need

It is estimated that future construction of Federal commercial and high-rise residential buildings will be approximately 2120 new Federal buildings per year.[1] Newly constructed buildings consume large amounts of fossil fuel each year in heating, cooling, ventilating, and providing domestic hot water because they lack adequate energy conservation features. Accordingly, EPCA directs DOE to establish building energy efficiency standards for all new Federal commercial and high-rise residential buildings to make them more energy efficient. The purpose for the Proposed Action is to improve energy efficiency in new Federal commercial and high-rise residential buildings in a manner consistent with the statutory mandate under EPCA.

The Proposed Action is needed to reduce energy consumption, manage energy costs for Federal commercial and high-rise residential buildings, reduce outdoor pollutants from the combustion of

[1] This number is based upon the FRPPMS extraction described below in Section 3.3.2.3. The total square footage of Federal buildings (minus the square footage of family housing) was divided by the total number of Federal buildings (minus the number of family housing buildings) to determine that the average size of a new Federal building built to during the past 10 years was 12,200 square feet. (Federal Family Housing is addressed in 10 CFR 435, not 10 CFR 433.) Dividing this number into the 25.85 million square feet per year of Federal construction described in Section 3.3.2.3 below yields an estimate of 2120 buildings per year.

fossil fuels, and reduce the emissions of greenhouse gases that may lead to climate change. This reduction will prevent waste of energy, can help the U.S. government reduce dependence on imported energy, and strengthen its strategic position.

1.4 Public Participation and Agency Consultation

In accordance with Council on Environmental Quality CEQ regulations in 40 CFR 1508.9(b), DOE states that no additional persons/agencies were consulted during the development of this environmental assessment.

Public involvement is an important requirement of the NEPA process. The public review period for the Draft EA was 15 days after its publication. DOE received no comments on the Draft EA.

2 ALTERNATIVES INCLUDING THE PROPOSED ACTION

Section 2 describes the Proposed Action and the No Action Alternative for updating energy efficiency baseline standards for new Federal commercial and high-rise residential buildings. The updated Federal energy efficiency baseline standard establishes the minimum level of energy savings that DOE requires Federal agencies to achieve in new building designs, including 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 Proposed Action

Under the Proposed Action DOE would revise its building energy efficiency baseline standard for all new Federal commercial and multi-family high-rise residential buildings. The Proposed Action would update 10 CFR 433, "Energy Efficiency Standards for New Federal Commercial and Multi-Family High-Rise Residential Buildings," by replacing ASHRAE Standard 90.1-2013 with the more energy efficient ASHRAE Standard 90.1-2016. The proposed action would also make edits to the Federal Building Energy Efficiency Standards regarding the specific energy load types that must be included when agencies determine if they're building designs result in energy savings that are 30 percent or more below the ASHRAE 90.1 Standard. The Proposed Action also makes minor technical edits to the Federal Building Energy Efficiency Standards.

DOE examined the potential environmental impacts of the Proposed Action by comparing it with the standards that Federal agencies must achieve under the existing regulations in 10 CFR 433, which require that new Federal commercial and multi-family high-rise residential building designs achieve energy performance levels of ASHRAE Standard 90.1-2013.

2.2 No Action Alternative

The no-action alternative is defined as a DOE decision not to adopt ASHRAE Standard 90.1-2016 as the energy efficiency baseline standard for new Federal commercial and multi-family high-rise residential buildings. Instead, DOE would retain ASHRAE Standard 90.1-2013, which is the current requirement in 10 CFR 433.

3 AFFECTED ENVIRONMENT AND IMPACTS

This section describes the existing environmental setting for environmental resources with potential to be affected by the Proposed Action, as well as provides the potential environmental impacts that may result from implementing the Proposed Action and the No Action Alternative. The Proposed Action would apply to all new Federal commercial and high-rise residential buildings.

This section includes consequences of the No Action Alternative; a brief description of environmental resource areas not evaluated for potential impacts; analysis of those resources that could potentially be impacted from the Proposed Action and the No Action Alternative; and analysis of cumulative impacts.

3.1 Environmental Consequences of the No Action Alternative

Under the No Action Alternative DOE would not update energy conservation baseline standards for Federal commercial and high-rise residential buildings. Therefore, there would be no direct, indirect, or cumulative impacts to the environment and resources discussed in this EA from activities related to the proposed rule. The expected reductions in fossil fuel generated energy pollutant emissions realized by the Proposed Action would not be realized under the No Action Alternative.

3.2 Environmental Resources Evaluated and Dismissed from Detailed Analysis

Consistent with NEPA implementing regulations and guidance, DOE focused the analysis in this EA on topics with the greatest potential for environmental impacts [known as the sliding-scale approach (40 CFR 1502.2(b)]. Table 1 presents DOE's evaluations of the environmental resource areas on which the Proposed Action and the No Action Alternative would not be expected to have any measurable effects. These resource areas were not carried forward for detailed analysis.

Table 1: Resources Not Carried Forward for Detailed Analysis

Resource Area	Considerations
Sensitive Ecosystems	Proposed Action is not site specific
Geology and Soils	Proposed Action is not site specific
Wetlands and Floodplains	Proposed Action is not site specific
Prime Agricultural Lands	Proposed Action is not site specific
Historic, Cultural or Archeological Resources	Proposed Action is not site specific

Species, including Threatened and Endangered Species	Proposed Action is not site specific
Solid Waste Management	Proposed Action does not mandate increased waste generation
Hazardous Materials and Hazardous Waste	No hazardous materials used or produced as result of Proposed Action
Intentionally Destructive Acts	Proposed Action is not site specific
Environmental Justice	Proposed Action does not impact any specific group of persons

3.3 Environmental Resources Carried Forward for Analysis

This section of the EA describes the baseline and analyzes the environmental impacts of the Proposed Action on the following resource areas. It is noted that the construction of new Federal low-rise residential buildings would be subject to a separate NEPA analysis.

- Indoor Air
- Outdoor Air
- Climate Change

3.3.1 Indoor Air

Indoor air quality, and specifically building habitability, is a resource area with possible impacts from the Proposed Action.

3.3.1.1 Affected Environment

Energy efficiency baseline standards can affect indoor air quality. Indoor air quality is influenced by sources of pollutants both within and outside of a building, as well as natural and mechanical ventilation of the building. The primary indoor air emissions that can adversely affect human health in typical residential buildings are particulate matter (PM) carbon monoxide (CO) carbon dioxide (CO_2)), nitrogen dioxide (NO_2), radon, volatile organic compounds (VOCs) including formaldehyde, and biological contaminants.

Sources of pollutants that affect indoor air quality occur both inside and outside a building. Various emissions can be continuously or intermittently released within buildings. These emissions can originate from furnishings within a building (e.g., carpet, furniture), building materials (e.g., insulation material, particle board), from the ground (e.g., radon), the building occupants' indoor activities (e.g., tobacco smoking, painting), fossil fuel appliances (e.g. gas stoves, gas water heaters), or wood stoves and fireplaces. Potential combustion emissions include CO, CO_2, nitrogen oxide (NO_x), and sulfur dioxide (SO_2). Fossil-fuel-burning appliances and, if allowed, tobacco smoke, are the main sources of combustion products.

Pollutants that occur outside the building (particularly vehicle exhaust), may be drawn inside, where they affect indoor air quality. These pollutants can enter or be expelled from the residential building through natural and/or mechanical ventilation. Natural ventilation includes air that can enter or be expelled from the residential building through non-mechanical means, often through the building envelope, and due to differences in air pressure inside the building and outside the building. Natural ventilation rates are significantly influenced by weather. Mechanical ventilation involves a system that actively introduces fresh air into the building and expels indoor air to the outside.

Indoor air quality is thus influenced by pollutant sources inside and outside the building, as well as ventilation rates of the building. Table 2 summarizes the principal indoor air emissions that can be of concern within buildings.

Table 2: Indoor Pollutants in Residential Buildings

Pollutant	Potential Health Impacts	Sources
Particulate Matter	Bronchitis and respiratory infections. Eye, nose, and throat irritations.[‡]	Combustion, dust.[‡]
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.
Carbon Dioxide	An excessive concentration of CO_2 triggers increased breathing to maintain the proper exchange of oxygen and CO_2. Exposure to concentrations of CO_2 in air of 5% for 30 minutes can cause symptoms of intoxication, and exposure to concentrations of 7% to 10% for few minutes can cause loss of consciousness.[*]	Human respiration, tobacco smoking, gas stoves, and gas ovens.
Nitrogen Dioxide	Short term exposure to NO_2 is linked with negative respiratory effects including inflammation of airways and increased symptoms of those with asthma.[**]	Kerosene heaters, gas stoves, ovens, and tobacco smoke.
Radon	Radon in breathed air can deposit and stay in the lungs, contributing to lung cancer. Radon is the leading cause of lung cancer in non-smokers.[†]	Radon is a radioactive gas that occurs in nature and comes from the decay of uranium that is found in soil.[††]
Formaldehyde	The EPA has classified formaldehyde as a probable human carcinogen. In low concentration levels, formaldehyde	Various pressed-wood products can emit formaldehyde, including particle board, plywood, pressed wood,

Pollutant	Potential Health Impacts	Sources
	irritates the eyes and mucous membranes of the nose and throat. Formaldehyde can cause watery eyes; burning sensations in the eyes, nose, and throat; nausea; coughing; chest tightness; wheezing; skin rashes; and allergic reactions.[▫]	paneling, some carpeting and backing, some furniture and dyed materials, urea-formaldehyde insulating foam, and pressed textiles.[▫▫]
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.[‡]	VOCs are emitted from a variety of products including paints and lacquers, paint strippers, cleaning supplies, pesticides, building materials and furnishings, office equipment such as copiers and printers, correction fluids and carbonless copy paper, graphics and craft materials including glues and adhesives, permanent markers, and photographic solutions.[‡]
Biological Contaminants	Many biological pollutants are small enough to be inhaled and can cause allergic reactions as well as infectious illnesses. Molds and mildews in particular release disease-causing toxins. Symptoms of health problems include sneezing, watery eyes, coughing, shortness of breath, dizziness, lethargy, fever, and digestive problems.[‡‡]	Common biological pollutants include mold; dust mites; pet dander; droppings and body parts from cockroaches, rodents and other pests; viruses; and bacteria. These contaminants are typically found in damp or wet areas such as humidifiers, condensate pans, or unvented bathrooms as well as in areas where dust accumulates.[‡‡]

| U.S. Environmental Protection Agency. Particulate Matter | Air & Radiation | US EPA. at <https://www3.epa.gov/pm/>

° U.S. Environmental Protection Agency. Carbon Monoxide | Air & Radiation | US EPA. at <https://www3.epa.gov/airquality/carbonmonoxide/>

* CDC - Immediately Dangerous to Life or Health Concentrations (IDLH): Carbon dioxide. at <http://www.cdc.gov/niosh/idlh/124389.html>

** U.S. Environmental Protection Agency. Health | Nitrogen Dioxide | US EPA. at <http://www.epa.gov/air/nitrogenoxides/health.html>

† U.S. Environmental Protection Agency. Radon Health Risks. at <http://www.epa.gov/radon/healthrisks.html>

†† U.S. Environmental Protection Agency. EPA's Radon Program Home Page. at <http://www.epa.gov/radon/?_ga=1.96254044.1118407248.1426515419>

▫ U.S. Environmental Protection Agency. Formaldehyde. at <http://www2.epa.gov/formaldehyde>

▫▫ U.S. Consumer Product Safety Commission. *An Update on Formaldehyde*. (Washington, DC, 2015).

‡ U.S. Environmental Protection Agency. An Introduction to Indoor Air Quality: Volatile Organic Compounds (VOCs). at <http://www.epa.gov/iaq/voc.html>

‡‡ U.S. Environmental Protection Agency. An Introduction to Indoor Air Quality: Biological Pollutants. at <http://www.epa.gov/iaq/biologic.html>

3.3.1.2 Impacts of the Proposed Action

The proposed action 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 90.1-2016 does not require specific mechanical ventilation rates and the proposed action does not require any changes in mechanical ventilation rates. The proposed action contains 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 change under the Proposed Action.

3.3.2 Outdoor Air

Outdoor air quality is a resource area with possible impacts from the Proposed Action. Specifically, impacts would include changes in pollutant emissions due to changes in fossil fuel generated energy use associated with operation of the building.

3.3.2.1 Affected Environment

An air pollutant is any substance in the air that can cause discomfort or 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.[2]

Improving the efficiency of U.S. buildings by implementing efficient building codes and standards can play a role in reducing the amount of greenhouse gases (GHG) generated by buildings. "Greenhouse gases absorb infrared radiation, thereby trapping heat and making the planet warmer. The most important greenhouse gases directly emitted by humans include carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), and several other fluorine-containing halogenated substances. Although CO2, CH4, and N2O occur naturally in the atmosphere, human activities have changed their atmospheric concentrations" (EPA 2019, Section ES-1).

The combustion of fossil fuels for electrical generation was the second largest source of U.S. GHG emission in 2017, generating an estimated 26.8% of total U.S. emissions expressed in MMT CO2e[3] (EPA 2019, Table ES-2). In addition, combustion of fossil fuels for residential and commercial usage (for heating, cooking, and hot water) generated another 4.6% and 3.6%, respectively, of total U.S. emissions[4] (EPA 2019, Table ES-2). Because not all electricity generated in the U.S. is consumed in buildings (for example, some is used for electric vehicles or aluminum smelters), EPA also attributes electricity-related emissions to the residential and commercial building sectors. EPA's analysis (EPA 2019, Table ES-7) indicates that residential buildings account for 14.9% of total U.S. emission and commercial buildings account for 16.1% of total U.S. emissions when emissions associated with electricity generation are attributed

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[2] More information on air pollution characteristics and regulations is available on EPA's website at www.epa.gov.
[3] Percentages based on total emissions.
[4] Percentages based on total emissions.

properly.[5] This table also indicates that U.S. buildings as a whole account for a higher percentage of U.S. emissions (31%) than the industry, transportation, or agricultural sectors.

According to the EPA, total U.S. GHG emissions rose from 1990 to 2005 and have since declined to levels slightly higher than those found in 1990, with the 2017 level being 1.3% higher than the 1990 level (EPA 2019, Table ES-7). During the same time period, total GHG emission associated with buildings followed a similar trend, with residential and commercial buildings in 2017 being 0.9% and 5.8% higher than the 1990 levels, respectively.

The major outdoor air pollutants considered in this EA are described in more detail in the following section.

Carbon Dioxide. CO_2 is of interest because of its classification as a GHG. GHGs, which trap the sun's radiation inside the Earth's atmosphere, either occur naturally in the atmosphere or result from human activities. Naturally occurring GHGs include water vapor, CO_2, CH_4, 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 2017, 90.2 percent of anthropogenic (i.e., human-made) CO_2 equivalent emissions resulted from burning fossil fuels (Table 2.1 of EPA 2019d).

Numerous processes, collectively known as the "carbon cycle", naturally regulate concentrations of CO2 in the atmosphere. Natural processes, such as plant photosynthesis, dominate the movement of carbon between the atmosphere and the land and oceans. 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, CO_2 emissions from electricity generation and fossil fuels burned in commercial and residential buildings accounted for nearly 17.1 percent of total U.S. GHG emissions in 2017 (Table 2-5 of EPA 2019d).

Nitrogen Oxides. Nitrogen oxides 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. Quoting from EPA 2019, "The primary climate change effects of nitrogen oxides (i.e., NO and NO2) are indirect. Warming effects can occur due to reactions leading to the formation of ozone in the troposphere, but cooling effects can occur due to the role of NOx as a precursor to nitrate particles (i.e., aerosols) and due to destruction of stratospheric ozone when emitted from very high-altitude aircraft. Additionally, NOx emissions are also likely to decrease CH4 concentrations, thus having a negative radiative forcing effect (IPCC 2013). Nitrogen oxides are created from lightning, soil microbial activity, biomass burning (both natural and anthropogenic fires), fossil fuel combustion, and, in the stratosphere, from the photo-degradation of N2O" (EPA 2019).

"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. There are also natural sources of NO_x such as lightning and microbial processes ion soils. Stationary combustion

[5] Percentages based on total emissions.

sources, including electric utilities and combustion of fossil fuels in buildings, account for about 30.3 percent of NO_x emissions in the United States (Table 2-15 of EPA 2019).

Mercury. Coal-fired power plants emit 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 Mercury Website). 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.

Methylmercury exposures in the U.S. primarily occur through eating fish and shellfish. Women of childbearing age are regarded as the population of greatest concern because the developing fetus is the most sensitive to the toxic effects of methylmercury. 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. SO_2 belongs to the family of sulfur oxide gases (SO_x). These gases dissolve easily in water. Sulfur is prevalent in 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 $S0_2$ website).

SO_2 is primarily emitted from coal combustion for electric power generation and the metals industry. Sulfur-containing compounds emitted into the atmosphere tend to exert a negative radiative forcing (i.e., cooling) and therefore are discussed separately (EPA 2019). Stationary combustion sources, including electric utilities and combustion of fossil fuels in buildings, account for about 72.3 percent of SO_2 emissions in the United States (Table 2-15 of EPA 2019).

The indirect effect of sulfur-derived aerosols on radiative forcing can be considered in two parts. The first indirect effect is the aerosols' tendency to decrease water droplet size and increase water droplet concentration in the atmosphere. The second indirect effect is the tendency of the reduction in cloud droplet size to affect precipitation by increasing cloud lifetime and thickness. Although still highly uncertain, the radiative forcing estimates from both the first and the second indirect effect are believed to be negative, as is the combined radiative forcing of the two (IPCC 2013).

Sulfur dioxide is also a major contributor to the formation of regional haze, which can cause significant increases in acute and chronic respiratory diseases. Once SO_2 is emitted, it is chemically transformed in the atmosphere and returns to the earth as the primary source of acid rain. Because of these harmful effects, the United States has regulated SO_2 emissions in the Clean Air Act.

Electric power is the largest anthropogenic source of SO_2 emissions in the United States, accounting for 49.2 percent in 2017. Coal combustion contributes nearly all of those emissions (approximately 92 percent). Sulfur dioxide emissions have decreased in recent years, primarily as a result of electric power generators switching from high-sulfur to low-sulfur coal and installing flue gas desulfurization equipment.

Methane. CH_4 emissions are primarily from human-related sources, not natural sources. U.S. CH_4 emissions come 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 CH_4 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. CH_4 is the primary ingredient in natural gas, and production, processing, storage, and transmission of natural gas account for 58.4 percent of the energy-related CH_4 emissions (Table 3.2 of EPA 2019). Natural gas distribution systems also account for 25.2 percent of all CH_4 emissions) (Table 2-2 of EPA 2019).

Nitrous Oxide. N_2O emission rates are more uncertain than those for CO_2 and CH_4, with nitrogen fertilization of agricultural soils being the primary human-related source. In 2017, N_2O emissions from stationary combustion accounted for 62.3 percent of N_2O emissions (Table 3.1 of EPA 2019). Table 3-7 of the same reference shows that electric power generation accounted for 54.5 percent of N2O emissions in 2017, with residential and commercial buildings accounting for 1.8 percent and 0.7 percent, respectively (Table 3-7 of EPA 2019).

Halocarbons and Other Gases. Halocarbons and other engineered gases not usually found in nature are another group of human-made greenhouse gases. 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 chlorofluorocarbons (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 contributed a negligible amount of emissions of these greenhouse gases in 2009(DOE 2011). Data from 2017 in the EPA National Greenhouse Emission Inventory indicate that the majority of these emissions are associated with refrigerants and semiconductor manufacturing. (EPA 2019)

Carbon Monoxide. The main source of CO is the incomplete burning of fossil fuels such as gasoline. Exhaust from mobile combustion sources contributed about 56 percent of all CO emissions in 2014, with on road vehicles accounting for 62% of mobile emission (Figure 3 of EPA 2014 (NEI)). Stationary combustion sources accounted for 13.5% of CO emissions in 2014 (Figure 3 of EPA 2014 (NEI)). The CO produced from energy use related to residential, commercial, and institutional buildings is about 28 percent of stationary combustion emissions, accounting for about 3.8 percent of all emissions, with most coming from wood burning in residential buildings (Figure 3 of EPA 2014 (NEI)). Eight percent of stationary combustion CO emissions, or about one percent came from fuel combustion for electrical generation by utilities in 2014 (Figure 3 of EPA 2014 (NEI)).

Particulate Matter. PM, also known as particle pollution, is a complex mixture of extremely small particles and liquid droplets. PM pollution consists of a number of components, including acids (such as nitrates and sulfates), organic chemicals, metals, and soil or dust particles (EPA 2019 (PM)).

PM impacts are a concern because human exposures can adversely affect respiratory and cardiac 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, for example, increased respiratory symptoms, such as irritation of the airways, coughing, or difficulty breathing; 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 leave the smoke stack in the form of particulates. 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.

Lead. Exposure to lead can cause a variety of health problems. Lead can adversely affect the brain, kidneys, liver, nervous system, and other organs (CDC 2007). Sources of lead emissions vary from one area to another. At the national level, major sources of lead in the air are ore and metals processing and piston-engine aircraft operating on leaded aviation fuel. Other sources are waste incinerators, utilities, and lead-acid battery manufacturers. The highest air concentrations of lead are usually found near lead smelters. As a result of EPA's regulatory efforts including the removal of lead from motor vehicle gasoline, levels of lead in the air decreased by 98 percent between 1980 and 2014 (EPA 2019; EPA Lead Website).

3.3.2.2 Outdoor Air Quality Regulation

As required by the Clean Air Act (CAA), EPA has set national air quality standards, known as the National Ambient Air Quality Standards (NAAQS), for six common pollutants (also referred to as "criteria" pollutants). 42 U.S.C. §7409. The standards are set to protect public health and welfare. Pollutants for which standards have been set include carbon monoxide (CO), nitrogen dioxide (NO2), particulate matter less than 10 or 2.5 microns in aerodynamic diameter (PM10 and PM2.5), ozone (O3), sulfur dioxide (SO2), and lead. Volatile organic compounds (VOCs) can cause or contribute to ozone levels that violate the NAAQS for ozone, so EPA has taken several actions to reduce VOC emissions. 40 CFR Part 59.

To reduce acid rain, the CAA requires emission reductions of SO2 and nitrogen oxides (NOx), the primary precursors of acid rain, from the power sector. 42 U.S.C. §7651 et seq. There is also an annual emissions cap on SO2 for affected electric generating units (EGUs) in the 48 contiguous States and the District of Columbia (D.C.). Additionally, emissions of NOx and SO2, which contribute to harmful levels of PM2.5 and ozone, from numerous States in the eastern half of the United States are limited under the Cross-State Air Pollution Rule (CSAPR). 76 FR 48208 (Aug. 8, 2011). CSAPR requires these States to reduce SO2, annual NOx, and ozone season NOx emissions from EGUs. Compliance with CSAPR is flexible among EGUs and is enforced through the use of state-level caps on emissions and an interstate tradable emissions program.

The CAA also requires EPA to control the emissions of hazardous air pollutants (HAPs). 42 U.S.C. §7412. EPA issued national emissions standards for hazardous air pollutants (NESHAPs) for mercury (Hg) and certain other pollutants emitted from EGUs, which are also known as the Mercury and Air Toxics Standards (MATS) for power plants. 77 FR 9304 (Feb. 16, 2012).

Additionally, greenhouse gases (GHGs) are regulated pollutants under the CAA because the buildup of heat-trapping GHGs in the atmosphere endangers public health and welfare. In 2015, EPA finalized the Clean Power Plan, a federal plan to implement emission guidelines for states to follow in developing implementation plans to reduce GHG emissions from EGUs. 80 FR 64662 (Oct. 23, 2015). The Clean Power Plan was stayed by the U.S. Supreme Court and has never gone into effect.[6] In 2017, EPA proposed to repeal of the Clean Power Plan. 82 FR 48035 (Oct. 16, 2017). In 2018, EPA issued the proposed Affordable Clean Energy (ACE) rule, which would replace the Clean Power Plan. 83 FR 44746 (Aug. 31, 2018). In 2019, EPA issued a final rule to repeal the Clean Power Plan, finalize the ACE rule, and finalize new regulations for the EPA and state implementation of the ACE rule. 84 FR 32520 (Jul. 8, 2019).[7]

3.3.2.3 Impacts of Proposed Action

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 proposed action. Energy use is evaluated at the ASHRAE Standard 90.1-2016 level, then compared to the no-action alternative, which is ASHRAE Standard 90.1-2013. The proposed action energy savings were assessed for five common

[6] The CPP was challenged in the United States Court of Appeals for the D.C. Circuit and was stayed by the Supreme Court pending disposition in the lower court. West Virginia, et al. v. Envtl. Prot. Agency, et al., No. 15-1363 (and consolidated cases) (D.C. Cir. 2015); West Virginia, et al. v. Envtl. Prot. Agency, et al., 136 S. Ct. 1000 (2016).

[7] Litigation regarding the latest EPA-GHG regulations is pending before the United States Court of Appeals for the D.C. Circuit. American Lung Association v. EPA, No. 19-1140 (D.C. Cir. 2019).

buildings types in 15 cities, representing 15 climate regions within the United States. Energy savings from the proposed action were estimated using the EnergyPlus whole building energy simulation program (DOE 2011a). Assumptions used in this analysis are described below.

Energy Use

GSA data were used to find the distribution of existing Federal building types (GSA 2019).[8] A database query was run on the Federal Real Property Profile Management System (FRPPMS) in December 2019 to determine the characteristics of all new construction added to the database in the last 10 years and buildings were aggregated to the Federal building types used in the FRPPMS.[9] It was assumed that new Federal construction would have a similar distribution between building types.

A total of 28.75 million square feet of new Federal buildings are assumed to be constructed each year. This assumption is based on the GSA FRPPMS data and represents 10 percent of the square footage extracted during the search described above

Several less common buildings types, including those categorized as "Other" in the FRPP, 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 3 was used for new Federal construction.

Table 3 Estimated Floor Area Fraction of New Federal Commercial Building Construction

Facility Type	Percent
Office	21.6%
Dormitories and Barracks	17.1%
Service	13.8%
School	12.8%
Other Institutional Uses	5.8%
Warehouses	5.5%
Laboratories	5.1%
Hospital	4.9%
All Other	3.2%
Outpatient Healthcare Facility	3.1%
Industrial	1.7%
Child Care Center	1.3%
Prisons and Detention Centers	1.2%
Communications Systems	0.8%

[8] The current Federal Real Property Profile Management System (FRPPMS) data for the last ten years of Federal construction were used. The FRPPMS was accessed on November 26, 2019.

[9] See the FRPPMS Data Dictionary at https://www.gsa.gov/cdnstatic/FY%202018%20FRPP%20DATA%20DICTIONARY%20final.pdf for description of Federal building types used. This document refers to the FRPP and not the FRPPMS because the name of the system was changed to FRPPMS in 2019.

Navigation and Traffic Aids	0.5%
Land Port of Entry	0.5%
Facility Security	0.3%
Museum	0.2%
Data Centers	0.2%
Border/Inspection Station	0.1%
Comfort Station/Restrooms	0.1%
Public Facing Facility	0.0%
Post Office	0.0%
Aviation Security Related	0.0%
Grand Total	**100.0%**

Energy Use Intensity (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 3. Site energy includes energy used only at the building site, while source energy includes energy used at the building site and energy lost in producing and delivering the energy to the site. To determine the EUI of the Federal buildings listed in Table 3, FEMP mapped the EUIs determined various building prototypes used in DOE's Building Energy Codes Program (BECP) determination of energy savings for ANSI/ASHRAE/IES Standard 90.1-2016.[10] The mapping used for this EA is shown in Table 4.

Table 4 Mapping of Federal Building Types to BECP Prototypes

Federal Building Type	**Match to BECP Prototypes**
Office	Small office, medium office, large office (weighted by estimated percentages in FRPPMS data)
Dormitories and Barracks	Small office, small hotel, mid-rise apartment (average of 3)
Service	None
School	Primary school, secondary school (average of 2)
Other Institutional Uses	None
Warehouses	Warehouse
Laboratories	None
Hospital	Hospital
All Other	None
Outpatient Healthcare Facility	Outpatient healthcare
Industrial	None
Child Care Center	Primary School
Prisons and Detention Centers	None
Communications Systems	None

[10] See Technical Support Document (Energy Analysis) in the determination docket at https://www.regulations.gov/docket?D=EERE-2017-BT-DET-0046.

Navigation and Traffic Aids	None
Land Port of Entry	Small Office
Facility Security	Small Office
Museum	None
Data Centers	None
Border/Inspection Station	Small office
Comfort Station/Restrooms	None
Public Facing Facility	Small office
Post Office	Small office
Aviation Security Related	Small office

As can be seen in Table 4, a number of Federal building types have no specific match to BECP prototype buildings. These Federal building types, including Service, Other Institutional Uses, and Laboratories (to name the three largest by percentage) are assumed to have EUIs equal to the average of all mapped Federal building types. It also can be seen in Table 3 that a large number of Federal building types are mapped to the BECP Small Office, which is assumed to be the most plausible match.

It should also be noted that three Federal building types - Offices, Dormitories and Barracks, and Schools are mapped to multiple BECP prototypes. For Offices, FEMP utilized the Asset Height information in the FRPPMS to estimate the BECP category that each building would fall into and weighted the Federal Offices using that weight. For Dormitories and Barracks, FEMP determined that the Federal Dormitories and Barracks would be some combination of the BECP Small Office, Small Hotel and Mid-Rise Apartment and weighted the results by one-third each. For Federal Schools, FEMP assumed that the average of BECP Primary School and Secondary School would be the best match.

DOE cannot determine precisely the degree of energy use impact associated with updating the Federal energy efficiency baseline standard to ASHRAE Standard 90.1-2016 because exact energy use will depend on the specific level of energy efficiency that is cost effective for each future building design. However, it is possible to establish a range of changes in energy use.

Under the proposed action, annual site energy use reductions can be estimated to reach up to 2.9 EUI (kBtu/ ft^2-yr), and annual source energy use reductions can be estimated to reach up to 8.0 EUI (kBtu/ ft^2-yr). Under no scenario would annual site or annual source energy use increase.

Emission Reductions

Under the proposed action, CO_2, NO_x, and Hg emissions would be reduced because more energy efficient buildings consume less fossil fuel, either directly as fossil fuel consumed on site or indirectly as fossil fuel used to generate electricity that is consumed on site.

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 multiple sources. DOE’s Electric Power Annual (DOE 2018c) was used to provide the total electric generation in the U.S. in 2017. Data for CO_2 emission coefficients was taken from EPA's Greenhouse Gas Emission Inventory (EPA 2019a) for the year 2017. Data for SO_2 , NO_X, and methane emissions was taken from DOE's Electric Power Annual (DOE 2019b) and DOE's Monthly Energy Review (DOE 2019c). Data for Hg emissions was taken from DOE's 2019 Annual Energy Outlook (AEO) (DOE 2019a), Table A8.

DOE cannot provide an exact determination of emissions impacts associated with updating the Federal energy efficiency baseline standard to ASHRAE Standard 90.1-2016 because emissions will depend on the specific level of energy efficiency that is cost effective for each future building design. However, it is possible to determine the range of changes in emissions reductions.

Air emission reductions for the first year of construction for which the new rule is in effect can be estimated at up to 39,830 metric tons of CO_2, up to 31 tons of NO_x, up to 0.0010 tons of Hg, and up to 35.9 metric tons of CH_4[11]. Emissions reductions for N_2O, halocarbons, CO, PM, and lead are negligible. Under no scenario of future construction would emissions of any of the listed compounds increase.

Cumulative emission reductions for 30 years of construction (2020 through 2050) and 30 years of energy reduction[12] for each building built during that period can be estimated at up to 18,519,200 metric tons of CO_2, up to 14,300 metric tons of NO_x, up to 0.0457 metric tons of Hg, and up to 16,700 metric tons of CH_4[13]. Emission reductions for SO_2, N_2O, halocarbons, CO, PM, and lead are negligible. Under no scenario of future construction would emissions of any of the listed compounds increase.

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[11] Actual reductions would depend on the level of energy efficiency that is life cycle cost effective for each new building design. For example, under the no action alternative, agencies are required to design all new Federal commercial and multi-family high-rise residential buildings at 30% more efficient than ASHRAE Standard 90.1-2013, if life cycle cost effective. Under the proposed action, agencies would be required to design buildings that are 30% more efficient than ASHRAE Standard 90.1-2016, if life cycle cost effective. A comparison of the no-action alternative to the proposed action yields an estimated first year emissions reduction for CO_2 of 27,900 metric tons.

[12] Cumulative emissions for 30 years of construction are calculated by summing up the numbers 1 to 30 to get a multiplier of 465. This multiplier is applied to the first year emissions discussed in the previous paragraph. The reasoning behind this approach is that construction is assumed to be constant across years and therefore the cumulative impact will increase year by year. For the first year, we have one year of emission reductions for one year of new construction. For the second year, we have one year of emission reductions for the new construction that takes place in the second year plus continued emission reductions from the new construction in year 1. For the third year, we have one year of emission reductions from the new construction in year 3, plus continued emission reductions from new construction in years 1 and 2. The total emission reduction in year 2 is twice the first year emission reductions. The total emission reduction in year 3 is 3 times the first year emission reductions. The total cumulative emission reduction through year 2 is 3 (1+2). The total cumulative reduction through year 3 is 6 (1+2+3). This summation is continued to year 30 where the multiplier is 465.

[13] Actual reductions would depend on the level of energy efficiency that is life cycle cost effective for each new building design. For example, under the no action alternative, agencies are required to design all new Federal commercial and multi-family high-rise residential buildings at 30% more efficient than ASHRAE Standard 90.1-2013, if life cycle cost effective. Under the proposed action, agencies would be required to design buildings that are 30% more efficient than ASHRAE Standard 90.1-2016, if life cycle cost effective. A comparison of the no-action alternative to the proposed action yields an estimated 30-year emissions reduction for carbon dioxide of 12,963,500 metric tons.

It should be noted that certain emission reductions would remain uncertain for pollutants, such as SO_2 and NO_x that are regulated by cap and trade systems, as well as PM which forms, in part, from those pollutants. For example, SO_2 emissions from affected electric generating units (EGUs) are subject to nationwide and regional emissions cap and trade 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 existing EPA regulations, any excess SO_2 emissions allowances resulting from the lower electricity demand caused by the imposition of an efficiency standard could be used to permit offsetting increases in SO_2 emissions by any regulated EGU. However, if the standard resulted in a permanent increase in the quantity of unused emissions allowances, there would be an overall reduction in SO_2 emissions from the standards. While there remains some uncertainty about the ultimate effects of efficiency standards on SO_2 emissions covered by the existing cap and trade system, the National Energy Modeling System (NEMS) [NEMS 2009] 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.

3.3.3 Global Climate Change

Climate change has evolved into a matter of global concern because it is expected to have widespread, adverse effects on natural resources and systems. A growing body of evidence points to anthropogenic sources of greenhouse gases, such as CO_2, as major contributors to climate change. Climate change is a resource area with possible impacts from the Proposed Action and No Action Alternative.

3.3.3.1 Affected Environment

Climate is 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 (WMO) 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 series of IPCC Fifth Assessment Reports (IPCC Reports), published in 2013 and 2014[14], "The [Synthesis Report] SYR confirms that human influence on the climate system is clear and growing, with impacts observed across all continents and oceans. Many of the observed changes since the 1950s are unprecedented over decades to millennia. The IPCC is

[14] The 5th IPCC Assessment Report was published in four volumes over the course of 2013 and 2014. The complete set of reports may be found at https://www.ipcc.ch/report/ar5/. The first three volumes are the reports of Working Groups I, II, and III, while the fourth volume is the Synthesis Report for Policy Makers. This section of the EA focuses on results presented in the Synthesis Report.

now 95 percent certain that humans are the main cause of current global warming". (Foreword to IPCC Synthesis Report (SYR) 2014).[15]

The IPCC Report states that the world has warmed by about 0.85°C in the last 132 years.[16] Additionally, the IPCC Report finds that it is extremely likely 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 CH_4 and N_2O in the atmosphere, rather than from natural causes.[17] 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 72 percent of the total CO_2-equivalent global warming potential in GHGs emitted from human activities, with the vast majority (62 percent) of the CO_2 attributable to fossil fuel use.[18] Globally, 49 billion metric tons of CO_2 –equivalent of anthropogenic (man-made) greenhouse gases are emitted every year.[19] For the future, the IPCC Report describes a wide range of GHG emissions scenarios, but "cumulative emissions of CO2 largely determine global mean surface warming by the late 21st century and beyond".[20]

Researchers have focused on considering atmospheric CO_2 concentrations that likely will result in some level of global climate stabilization, and the emissions 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 that would *likely* keep projected temperature rises below. To achieve this goal, 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 40 to 71 percent below today's annual emissions rates by no later than 2050.[21]

3.3.3.2 Impacts of Proposed Action

It is difficult to correlate specific emissions 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

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15 https://www.ipcc.ch/report/ar5/syr/.

16 IPCC 5th AR SYR 2014, Summary for Policy Makers (SPM) 1.1.

17 IPCC 5th AR SYR 2014, SPM 1.2

18 IPCC 5th AR SYR 2014, Figure SPM 2. 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.

19 IPCC 5th AR SYR 2014, Figure SPM 2. Other non-fossil fuel contributors include CO2 emissions from deforestation and decay from agriculture biomass; agricultural and industrial emissions of CH_4; and emissions of nitrous oxide and fluorocarbons.

20 IPCC 5th AR SYR 2014, SPM 2.1.

21 IPCC 5th AR SRY, Table 3.1, Scenario RCP2.6

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 1.5°C to 4.5°C, with cloud feedback and vapor feedback providing the largest sources of uncertainty.[22] 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.

[22] IPCC AR SYR 2014, Box 1.1.

4 LIST OF PREPARERS

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.

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