

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-AD39)
(DOE/EA-2001)**

**Prepared by the
U.S. Department of Energy
Office of Energy Efficiency and Renewable Energy**



September 2015

**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-AD39)
(DOE/EA-2001)**

SUMMARY

The U.S. Department of Energy (DOE) prepared this environmental assessment (EA) to examine the potential environmental effects of DOE’s proposed action to update, by rule, energy efficiency performance standards (“baseline standard”) for new Federal commercial and multi-family high rise residential buildings. The proposed action updates the baseline standard, 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.

The model industry code for commercial buildings is 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, hereafter “ASHRAE Standard 90.1”. DOE determined that ASHRAE Standard 90.1-2013 is more energy efficient than the previous version 2010 (79 FR 57800; September 26, 2014). DOE also found that Federal adoption of ASHRAE Standard 90.1-2013 for would be cost effective for new Federal construction and multi-family high-rise residential buildings. Since the amended ASHRAE Standard 90.1-2013 meets the statutory criteria for DOE to adopt it for application to Federal buildings, DOE is considering issuing a rule to adopt the 2013 version of ASHRAE Standard 90.1.

DOE’s adoption of ASHRAE Standard 90.1-2013 would require that agencies design new Federal commercial and multi-family high-rise residential buildings to achieve energy efficiency performance that minimally meets ASHRAE Standard 90.1-2013, and, where life cycle cost effective, exceeds it by up to 30%. The maximum life cycle cost effective building design may fall short of 30% better than ASHRAE Standard 90.1-2013 for a given building; however, agencies would be required to design buildings to the maximum energy efficiency that is life cycle cost effective, up to 30% better than ASHRAE 90.1-2013.

This EA examines the potential environmental impacts of the proposed action on building habitability and the outdoor environment. DOE identified the potential environmental impacts of the proposed action by comparing the proposed action with the “no-action alternative”. The no-action alternative is defined as a DOE decision not to update the requirement to ASHRAE Standard 90.1-2013; the no-action alternative would retain ASHRAE Standard 90.1-2010.

Building Habitability (Indoor Air) Impacts

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 90.1-2013 does not require specific mechanical ventilation rates, and the rule 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 increase under the proposed action.

Outdoor-Air Environmental Impacts

DOE cannot determine with precision the degree of emissions impacts that would result from DOE's replacing ASHRAE 90.1-2010 with ASHRAE Standard 90.1-2013 because the aggregate emissions volume will depend on the specific level of energy efficiency that is cost effective for discrete building designs, which themselves include numerous interdependent measures and building systems that vary within individual building designs. However, it is possible to establish a range of changes in emissions based on an analysis of potential design scenarios. Under all scenarios, implementation of the new rule would result in emissions reductions.

DOE estimates cumulative emissions reductions of up to 24,156,900 metric tons of carbon dioxide (CO₂), up to 24,564 metric tons of nitrogen oxides (NO_x), up to 0.3357 metric tons of mercury (Hg), and up to 214,466 metric tons of methane (CH₄) for 30 years of construction (2015 through 2044) and 30 years of energy reduction for each building built during that period.¹ Emissions reductions for sulphur dioxide (SO₂), nitrous oxide (N₂O), halocarbons, carbon monoxide (CO), particulate matter (PM), and lead are negligible. Under no scenario would emissions for any of the listed compounds increase.

¹ The proposed action would mandate that Federal agencies design new commercial and multi-family high rise residential buildings to achieve energy performance under ASHRAE Standard 90.1-2013, and to exceed it by at least 30%, if life cycle cost effective. Exact emissions reductions are difficult to determine because they depend on the cost effectiveness of energy conservation measures included in the design, which is highly variable. However, DOE can evaluate building design scenarios to derive a range of potential emissions impacts by comparing the no-action alternative to the proposed action. For example, under the no action alternative, agencies must design buildings to achieve energy performance of up to 30% more efficient than ASHRAE Standard 90.1-2010. Under the proposed action, agencies must design buildings to achieve energy performance of up to 30% more efficient than ASHRAE Standard 90.1-2013. A comparison of the no action alternative to the proposed action shows an estimated 30-year carbon dioxide reduction of 16,909,900 metric tons. Under all possible scenarios, the proposed action would result in emissions reductions.

ABBREVIATIONS AND ACRONYMS

ANSI	American National Standards Institute
ASHRAE	American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc.
CAIR	Clean Air Interstate Rule
CAP	Climate Action Plan
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/ft ² -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 ₂ O	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

SUMMARY	2
ABBREVIATIONS AND ACRONYMS	4
1 PURPOSE AND NEED FOR AGENCY ACTION	6
2 PROPOSED ACTION AND ALTERNATIVES	6
2.1 Proposed Action Commercial and Multi-Family High-Rise Residential Buildings	6
2.1.1 No-Action Alternative– ASHRAE Standard 90.1-2010	7
2.2 Public Participation	7
3 DESCRIPTION OF THE AFFECTED ENVIRONMENT	8
3.2 Outdoor Air	11
3.2.1 Air Emissions Descriptions and Regulation	11
3.2.2 Global Climate Change	15
4 CALCULATING ENERGY SAVINGS BY BUILDING TYPE.....	18
4.1 Commercial and Multi-Family High-Rise Residential Buildings.....	18
4.1.1 Commercial Building Types Used to Estimate Energy Savings	18
5 ENVIRONMENTAL IMPACTS.....	20
5.1 Commercial and Multi-Family High-Rise Residential.....	20
5.1.1 Building Habitability (Indoor-Air) Impacts.....	20
5.1.2 Outdoor Air	20
5.2 Environmental Justice and Other Resource Areas	22
6 AGENCIES AND PERSON CONSULTED DURING THIS RULEMAKING.....	23
7 REFERENCES	24

TABLES

Table 1 Indoor-Air Emissions.....	9
Table 2 Estimated Floor Area Fraction of New Federal Commercial Building Construction	18

1 PURPOSE AND NEED FOR AGENCY ACTION

This environmental assessment (EA) complies with the National Environmental Policy Act of 1969 (NEPA) (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 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, 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) and (2)).

Section 305 of ECPA also requires that “[n]ot 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 proposed action is the result of DOE's determination that the revised standards should be updated to reflect the amendments made in the ASHRAE Standard 90.1-2013 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 90.1-2013 as required by Title III of ECPA, which establishes requirements for the Building Energy Efficiency Standards Program (42 U.S.C. 6831 et seq.). The preliminary determination for Standard 90.1-2013 was published in the Federal Register on May 15, 2014 (see 79 FR 27778). The final determination for Standard 90.1-2013 was published September 26, 2014 (see 79 FR 57900).

2 PROPOSED ACTION AND ALTERNATIVES

Section 2.1 describes the proposed action and the no-action alternative for commercial and multi-family high-rise residential buildings, and public participation.

2.1 Proposed Action Commercial and Multi-Family High-Rise Residential Buildings

DOE proposes to revise its building energy efficiency baseline standard for all new Federal commercial and multi-family high-rise residential buildings. DOE's proposed revision would update 10 CFR 433, “Energy Efficiency Standards for New Federal Commercial and Multi-Family High-Rise Residential Buildings,” by replacing ASHRAE Standard 90.1-2010 with the more energy efficient ASHRAE Standard 90.1-2013. The proposed action would make no other changes to the Federal Building Energy Efficiency Standards.

DOE examined the potential environmental impacts of the proposed action by comparing the proposed action 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 90.1-2010.

2.1.1 No-Action Alternative– ASHRAE Standard 90.1-2010

The no-action alternative is defined as a DOE decision not to adopt ASHRAE Standard 90.1-2013 as the energy efficiency baseline standard for new Federal commercial and multi-family high-rise residential buildings. Instead, DOE would retain ASHRAE Standard 90.1-2010, which is the current requirement in 10 CFR 433.

The 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.

2.2 Public Participation

Public involvement is an important requirement of the NEPA process. On August 10, 2015 DOE published a draft Environmental Assessment and Notice of Availability on the DOE NEPA website at <http://energy.gov/nepa/downloads/ea-2001-draft-environmental-assessment>. Comments on the draft EA were encouraged and accepted for a period of 15 days. The comment period expired on August 25, 2015. DOE received no comments on the draft EA.

3 DESCRIPTION OF THE AFFECTED ENVIRONMENT

The proposed action would establish requirements for new Federal buildings that may impact building habitability (indoor environment), and the outdoor environment. Section 3.1 below 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 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 PM, CO, CO₂, nitrogen dioxide (NO₂), radon, formaldehyde, volatile organic compounds (VOCs), 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 could reduce or increase indoor-generated pollutant concentration levels, respectively. The proposed action would not change ventilation or infiltration relative to the no-action alternatives for commercial and high-rise multi-family residential buildings.

Second, requirements in energy efficiency codes can impact internally generated indoor emissions by mandating particular 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, CO₂, NO_x, and SO₂. Fossil-fuel-burning (including gas stoves/ovens) equipment and, if allowed, tobacco smoke, are the main sources of combustion products.

Third, 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 naturally occurring gas that seeps out of rocks and soil. Radon flows from the soil into buildings from the movement of gases in the soil beneath them. Outside air tends to contain very low levels of radon, but it builds up to higher concentrations indoors where it cannot disperse. Radon is radioactive—its airborne atoms can spontaneously decay; the resulting atoms are electrically charged and can attach themselves to tiny dust particles, and adhere to the lining of the lungs when inhaled. The deposited atoms emit radiation that can damage cells in the lungs and disrupt DNA of these lung cells, becoming one step in a chain of events that can lead to cancer.

Table 1 Continued

Pollutant	Health Impacts	Sources
Formaldehyde	The National Toxicology Program has classified formaldehyde as a human carcinogen (NTP 2014). In low concentration levels, formaldehyde 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 (CPSC 2013).	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 2013). Cigarette smoke also produces formaldehyde.
Volatile organic compounds	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 2015f).	VOCs contain carbon and exist as vapors at room temperatures. For indoor air quality, all organic chemical compounds whose compositions give them the potential to evaporate under normal atmospheric conditions are considered VOCs. (EPA 2015f) Building materials, finishes and furnishings are key sources of indoor VOC contaminants. A single material can emit an extremely large number of diverse compounds. Individual materials can be highly variable in terms of emissions composition, complexity and duration. (ASHRAE 2009.)
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

A primary focus of this environmental analysis is the impact on outdoor air emissions resulting from the proposed energy efficiency standards. The proposed action would reduce energy consumption in Federal buildings, and therefore would affect outdoor pollutant emissions associated with energy generation.

3.2.1 Air Emissions Descriptions and Regulation

U.S. buildings account for nearly 40% of the nation's man-made CO₂ emissions, 18% of the NO_x emissions, and 55% of the SO₂ emissions. These emissions—primarily from electricity generation—in turn contribute to smog, acid rain, haze, and global climate change. Improving the efficiency of the nation's buildings can play a significant role in reducing air pollution.

This analysis first considers three air pollutants that impact air quality: SO₂, NO_x, and 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 PM), liquid droplets, or gases.² DOE's analysis also considers CO₂, which is of interest because of its classification as a greenhouse gas (GHG). Seven additional pollutants—CH₄, NO_x, halocarbons, CO, PM, and lead—are also analyzed.

Carbon Dioxide. CO₂ 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, CO₂, CH₄, N₂O, and ozone (O₃). Human activities, however, add to the levels of most of these naturally occurring gases. For example, CO₂ is emitted to the atmosphere when solid waste, fossil fuels (oil, natural gas, and coal), wood, and wood products are burned. In 2013, 93.7 percent of anthropogenic (i.e., human-made) CO₂ emissions resulted from burning fossil fuels (EPA 2015d).

Concentrations of CO₂ 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 CO₂ emissions produced each year, billions of metric tons are added to the atmosphere annually. In the United States, in 2013, CO₂ emissions from electricity generation accounted for nearly 40 percent of total U.S. GHG emissions (EPA 2015d).

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. However, one common pollutant, NO₂, along with particles in the air, can

² More information on air pollution characteristics and regulations is available on EPA's website at www.epa.gov.

often be seen as a reddish-brown layer over many urban areas. NO_2 is the specific form of NO_x reported in this document. NO_x is one of the main ingredients involved in the formation of ground-level ozone, which can trigger serious respiratory problems. It can contribute to the formation of acid rain, and can impair visibility in areas such as national parks. NO_x also contributes to the formation of fine particles that can impair human health (EPA 2015b).

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 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 2015c). 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. 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 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 2015a).

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 60 percent of the energy source emissions (or 25 percent of all CH_4 emissions) (DOE 2011).

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. 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 2011).

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 (SF₆). 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. SF₆ is used as an insulator for electric equipment. Energy used in buildings contributes a negligible amount of emissions of these greenhouse gases (DOE 2011).

Carbon Monoxide. The main source of CO is the incomplete burning of fossil fuels such as gasoline. Exhaust from 'highway vehicles' contributes about 52 percent of all CO emissions. The CO produced from energy use related to buildings is 3.5 percent of all emissions, but most of this is from wood burning in residential buildings, which should not be impacted by these rules. One percent of CO emissions come from fuel combustion for electrical generation by utilities (EPA 2015e).

Particulate Matter. PM, also known as particle pollution, is a complex mixture of extremely small particles and liquid droplets. PM 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 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 SO₂ and NO_x. The quantity of the secondary sulfates produced is determined by a very complex set of factors including the atmospheric quantities of SO₂ 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 SO₂, 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 (CDC 2007). Today, mobile sources, primarily aircraft, are the major source of lead emissions to the atmosphere, followed by industrial processes. Combustion from electric utilities represents 10 percent of all lead emissions.

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 SO₂ 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 SO₂ and NO_x. Title IV of the 1990 amendments established a cap-and-trade program for SO₂, in all 50 states and the District of Columbia (D.C.), intended to help control acid rain. This cap-and-trade program serves as a model for more recent programs with similar features.

In 2005, EPA issued the Clean Air Interstate Rule (CAIR) under sections 110 and 111 of the Clean Air Act (40 CFR Parts 51, 96, and 97),³ (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 (CSAPR), or the Transport Rule (76 FR 48208 (Aug. 8, 2011))⁴. CSAPR took effect January 1, 2015 for SO₂ and annual NO_x, and May 1, 2015 for ozone season NO_x.

On February 16, 2012, EPA issued national emissions standards for hazardous air pollutants (NESHAPs) for Hg and certain other pollutants emitted from coal and oil-fired electric generating units (EGUs) (77 FR 9304).

³ See <http://www.epa.gov/cleanairinterstaterule/>.

⁴ See also <http://www.epa.gov/crossstaterule/>.

3.2.2 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 CO₂, as major contributors to climate change. Because this rule will likely decrease CO₂ 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 (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 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).⁵

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; increased drought; 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 emissions scenarios for CO₂, other GHGs, and aerosols. After that period, the rate of increase is less certain. The IPCC Report describes increases in average global temperatures of about 1.1°C to 6.4°C at the end of the century relative to today. These increases vary depending on the model and emissions scenarios (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. Projections also indicate that there are likely to be some beneficial impacts on crop yields in temperate regions.

⁵ Note that a fifth IPCC Assessment Report is now available at <http://www.ipcc.ch/pdf/assessment-report/ar4/wg3/ar4-wg3-ts.pdf>.

Causes of Climate Change. The IPCC Report states that the world has warmed by about 0.74°C in the last 100 years. Additionally, 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 CO₂ and other long-lived greenhouse gases such as CH₄ and N₂O in the atmosphere, rather than from natural causes.

Increasing the CO₂ 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, CO₂ makes up about 77 percent of the total CO₂-equivalent⁶ global warming potential in GHGs emitted from human activities, with the vast majority (74 percent) of the CO₂ 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, CO₂ would continue to comprise more than 70 percent of the total global warming potential (IPCC 2000).

Stabilization of CO₂ Concentrations. Unlike many traditional air pollutants, CO₂ mixes thoroughly in the entire atmosphere and is long-lived. The residence time of CO₂ in the atmosphere is long compared to the emissions processes. Therefore, the global cumulative emissions of CO₂ over long periods determine CO₂ concentrations because it takes hundreds of years for natural processes to remove the CO₂. Globally, 49 billion metric tons of CO₂ – equivalent of anthropogenic (man-made) greenhouse gases are emitted every year.⁷ Of this annual total, fossil fuels contribute about 29 billion metric tons of CO₂ (IPCC 2000).

Researchers have focused on considering atmospheric CO₂ 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 CO₂ concentrations with temperature increases that plateau in a defined range. For example, at the low end, the IPCC Report scenarios target CO₂ 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 levels⁸ (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 emissions 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

⁶ 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 CO₂, i.e., CO₂-equivalent. CO₂ equivalent emission is the amount of CO₂ 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.

⁷ Other non-fossil fuel contributors include CO₂ emissions from deforestation and decay from agriculture biomass; agricultural and industrial emissions of CH₄; and emissions of nitrous oxide and fluorocarbons.

⁸ IPCC Working Group 3, Table TS 2.

scenarios describe some warming and some climate change is projected because of already accumulated CO₂ and GHGs in the atmosphere (IPCC 2007c).

It is difficult to correlate specific emissions rates with atmospheric concentrations of CO₂ and specific atmospheric concentrations with future temperatures because the IPCC Report describes a clear lag in the climate system between any given concentration of CO₂ (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 providing 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 CO₂ mitigation scenarios that aim to meet specific temperature levels.

In response to global climate change concerns, the President issued a Climate Action Plan in June 2013, where he affirmed that the Federal government must position itself as a leader in clean energy and energy efficiency. He pledged that Federal agencies must surpass previous greenhouse gas reduction achievements, through a combination of consuming 20 percent of Federal electricity from renewable sources by 2020, and by pursuing greater energy efficiency in Federal buildings. Additionally, the President directed that efficiency standards for appliances and federal buildings set in the first and second terms combined would reduce carbon pollution by at least 3 billion metric tons cumulatively by 2030 – equivalent to nearly one-half of the carbon pollution from the entire U.S. energy sector for one year.

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 proposed action. Energy use is evaluated at the ASHRAE Standard 90.1-2013 level, then compared to the no-action alternative, which is ASHRAE Standard 90.1-2010. The proposed action energy savings were assessed for five common 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 2010). Assumptions used in this analysis are described below.

4.1.1 Commercial Building Types Used to Estimate Energy Savings

GSA data were used to find the distribution of existing Federal building types (GSA 2008, GSA 2009, GSA 2010, GSA 2011, GSA 2012, GSA 2013, and GSA 2014). 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. A total of 39.4 million square feet of new Federal buildings are assumed to be constructed each year. This assumption is based on a combination of data from the 2015 Annual Energy Outlook (AEO) (DOE 2015a) and the 2012 Commercial Building Energy Consumption Survey (CBECS) (DOE 2015b). Data from the 2015 AEO Reference Case was used to estimate the growth in total commercial sector floor space over the time period 2015 through 2040. This data was then extrapolated to 2044 to get the total increase over the period 2015 to 2044. The 2012 CBECS was then used to estimate the fraction of total commercial floor space owned by the Federal government. In 2012, that fraction was 1.81%. This fraction was

assumed constant over the period 2015 to 2044. Over the period 2015 to 2044, the average Federal commercial new construction floor space was calculated to be 39.2 million square feet.

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 2. 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.

DOE cannot determine precisely the degree of energy use impact associated with updating the Federal energy efficiency baseline standard to ASHRAE Standard 90.1-2013 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 2.7 EUI (kBtu/ ft²-yr), and annual source energy use reductions can be estimated to reach up to 8.9 EUI (kBtu/ ft²-yr). Under no scenario would annual site or annual source energy use increase.

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 proposed action. Environmental impacts are evaluated at the ASHRAE Standard 90.1-2013 level then compared to the no-action alternative, which is the ASHRAE Standard 90.1-2010.

5.1.1 Building Habitability (Indoor-Air) Impacts

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 90.1-2013 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.

5.1.2 Outdoor Air

Under the proposed action, CO₂, 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 2015c) was used to provide the total electric generation in the U.S. in 2013. Data for CO₂ emission coefficients was taken from EPA's Greenhouse Gas Emission Inventory (EPA 2015d) for the year 2013. Data for SO₂ and NO_x emissions was taken from EPA's Emissions and Generation Resource Integrated Database (eGrid) (EPA 2014) using the 2010 data from version 9. Data for Hg emissions was taken from DOE's 2015 Annual Energy Outlook (AEO) (DOE 2015a), Table A8. Data for CH₄ emissions was taken from four sources. The CH₄ sources include the Intergovernmental Panel for Climate Change (IPCC) Fifth Assessment Report (IPCC 2013) for the conversion factor for CH₄ to CO₂ equivalents, DOE's 2015 Electric Power Annual (DOE 2015c) for coal and natural gas consumption associated with electric power generation in 2013, Table 1 of DOE's 2015 Natural Gas Annual (DOE 2015d) for total natural gas consumption in 2013, and DOE's Emissions of Greenhouse Gases Report (DOE 2008) for emissions of CH₄ from energy sources.

DOE cannot provide an exact determination of emissions impacts associated with updating the Federal energy efficiency baseline standard to ASHRAE Standard 90.1-2013 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 51,950 metric tons of CO₂, up to 53 tons of NO_x, up to 0.00072 tons of Hg, and up to 461 metric tons of CH₄⁹. Emissions reductions for N₂O, 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 (2015 through 2044) and 30 years of energy reduction¹⁰ for each building built during that period can be estimated at up to 24,156,900 metric tons of CO₂, up to 24,564 metric tons of NO_x, up to 0.3357 metric tons of Hg, and up to 214,466 metric tons of CH₄¹¹. Emission reductions for SO₂, N₂O, halocarbons, CO, PM, and lead are negligible. Under no scenario of future construction would emissions of any of the listed compounds increase.

SO₂ emissions were also considered in this analysis. SO₂ 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 SO₂ 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 SO₂ emissions allowances resulting from the lower electricity demand caused by the imposition of an efficiency standard could be used to permit offsetting increases in SO₂

⁹ 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 90.1-2010, if life cycle cost effective. Under the proposed action, agencies would be required to design buildings that are 30% more efficient than ASHRAE Standard 90.1-2013, if life cycle cost effective. A comparison of the no-action alternative to the proposed action yields an estimated first year emissions reduction for CO₂ of 36,365 metric tons.

¹⁰ 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.

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 90.1-2010, if life cycle cost effective. Under the proposed action, agencies would be required to design buildings that are 30% more efficient than ASHRAE Standard 90.1-2013, 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 16,473,500 metric tons.

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 SO₂ emissions from the standards. While there remains some uncertainty about the ultimate effects of efficiency standards on SO₂ emissions covered by the existing cap and trade system, the 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 SO₂. Therefore, no reductions in SO₂ emissions are assumed for this analysis.

DOE estimates will avoid cumulative emissions of 6,234,000 metric tons of carbon dioxide through 2030. Today's rule directly supports the Administration's undertaking to make energy efficiency in Federal buildings an essential stratagem in the government's enduring achievement of the greenhouse gas reduction goals set out in the CAP.¹²

5.2 Environmental Justice and Other Resource Areas

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. DOE analyzed the potential impacts of the proposed action on low-income and minority populations and determined that it, 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.

DOE analyzed the potential impacts of the proposed action on sensitive environmental resources and determined that it would not impact any sensitive environmental resources such as wetlands, endangered species, or historic or archaeological sites. Further, sensitive resource impacts of Federal building construction will be evaluated by individual agencies through their NEPA process.

DOE analyzed the potential impacts of a terrorist act on the proposed action and determined that there are no aspects of the proposed action that would be affected by a terrorist act.

¹² Emission reductions associated with the CAP are calculated using the same process as used for the 30 year emission calculations, with the exception that the CAP is for savings through 2030 – a 15 year period – instead of the 30 year period. See footnote 10 for explanation of the calculation methodology. The multiplier used for the CAP savings is 120 (the sum of the numbers 1 through 15).

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 – Sarah Jensen, Kavita Vaidyanathan, Ami Grace-Tardy, Roak Parker, Lisa Jorgensen, Julie Anderson
Pacific Northwest National Laboratory (DOE contractor) - Mark Halverson

7 REFERENCES

10 CFR 433. 2010. U.S. Department of Energy, "Energy Efficiency Standards for New Federal Commercial and Multi-Family High Rise Residential Buildings." U.S. Code of Federal Regulations.

10 CFR 1021. 2000. U.S. Department of Energy, "National Environmental Policy Act Implementing Procedures." U.S. Code of Federal Regulations.

40 CFR 1500-1508. July 1, 1986. Council on Environmental Quality, "Regulations for Implementing the Procedural Provisions of the National Environmental Policy Act." U.S. Code of Federal Regulations.

42 U.S.C. 4321 et seq. National Environmental Policy Act. Available at <http://energy.gov/nepa/downloads/national-environmental-policy-act-1969>,

42 USC 6831. Congressional Findings and Purpose. Available at <http://us-code.vlex.com/vid/congressional-findings-and-purpose-19247711>.

42 USC 6834. Federal Building Energy Efficiency Standards. Available at <http://us-code.vlex.com/vid/building-energy-efficiency-standards-19247704>.

70 FR 25162. Rule To Reduce Interstate Transport of Fine Particulate Matter and Ozone (Clean Air Interstate Rule); Revisions to Acid Rain Program; Revisions to the NOX. Available at <http://www.gpo.gov/fdsys/search/pagedetails.action?granuleId=05-5723&packageId=FR-2005-05-12&acCode=FR>.

76 FR 43299. Building Energy Standards Program: Preliminary Determination Regarding Energy Efficiency Improvements in the Energy Standard for Buildings, Except Low-Rise Residential Buildings, ANSI/ASHRAE/IESNA Standard 90.1-2010. July 20, 2011. Available at <http://www.reginfo.gov/public/do/eAgendaViewRule?pubId=201110&RIN=1904-AC42>.

76 FR 64904. Building Energy Standards Program: Final Determination Regarding Energy Efficiency Improvements in the Energy Standard for Buildings, Except Low-Rise Residential Buildings, ANSI/ASHRAE/IESNA Standard 90.1-2010. October 19, 2011. Available at <http://www.reginfo.gov/public/do/eAgendaViewRule?pubId=201110&RIN=1904-AC42>.

77 FR 9304. National Emission Standards for Hazardous Air Pollutants From Coal- and Oil-Fired Electric Utility Steam Generating Units and Standards of Performance for Fossil-Fuel-Fired Electric Utility, Industrial-Commercial-Institutional, and Small Industrial-Commercial-Institutional Steam Generating Units; Final Rule. Available at <http://www.gpo.gov/fdsys/pkg/FR-2012-02-16/html/2012-806.htm>.

American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE). 2009. "Indoor Air Quality Guide: Best Practices for Design, Construction and Commissioning." Atlanta, Georgia.

American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE). 2010. ANSI/ASHRAE/IESNA Standard 90.1-2010, "Energy Standard for Buildings Except Low-Rise Residential Buildings." Atlanta, Georgia.

American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE). 2013. ANSI/ASHRAE/IESNA Standard 90.1-2013, "Energy Standard for Buildings Except Low-Rise Residential Buildings." Atlanta, Georgia.

Center for Disease Control (CDC). 2007. Agency for Toxic Substances and Disease Registry, Public Health Statement, Lead, CAS# 7439-92-1, 2007.
<http://www.atsdr.cdc.gov/ToxProfiles/tp13-c1-b.pdf>

Consumer Product Safety Commission (CPSC). 2013. An Update on Formaldehyde—2013 Revision. Washington, D.C.

Energy Conservation and Production Act (ECPA). 42 U.S.C. 6834 et seq., as amended.

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

Intergovernmental Panel on Climate Change (IPCC). 2013. *Climate Change 2013 – The Physical Science Basis*. IPCC Fifth Assessment Report. Geneva, Switzerland. Available at
<http://www.ipcc.ch/report/ar5/wg1/> .

Intergovernmental Panel On Climate Change. 2014. *Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. Geneva, Switzerland, 151 pp. Available at
https://www.ipcc.ch/pdf/assessment-report/ar5/syr/SYR_AR5_FINAL_full.pdf

Intergovernmental Panel On Climate Change. 2015a. *IPCC WGI Fourth Assessment Report: Climate Change 2007: The Physical Science Basis*. Geneva, Switzerland. http://ipcc-wg1.ucar.edu/wg1/docs/WG1AR4_SPM_PlenaryApproved.pdf

Intergovernmental Panel On Climate Change. 2015b. *Climate Change 2007 – Impacts, Adaptation and Vulnerability*. Geneva, Switzerland. <http://www.ipcc-wg2.gov>

Intergovernmental Panel On Climate Change. 2015c. *IPCC Fourth Assessment Report Climate Change 2007: Working Group III Report "Mitigation of Climate Change"*. Geneva, Switzerland. Available at <http://www.ipcc.ch/pdf/assessment-report/ar4/wg3/ar4-wg3-ts.pdf>

Jarnagin RE, and GK Bandyopadhyay. 2010. *Weighting Factors for the Commercial Building Prototypes Used in the Development of ANSI/ASHRAE/IESNA Standard 90.1-2010*. PNNL-

19116, Pacific Northwest National Laboratory, Richland, WA. Also available at http://www.pnl.gov/main/publications/external/technical_reports/PNNL-19116.pdf .

National Energy Modeling System (NEMS). 2009. For more information on NEMS, a useful summary is National Energy Modeling System: An Overview 2003, DOE/EIA-0581(2009). Available at <http://www.eia.gov/oiaf/aeo/overview/overview.html>.

National Academy of Sciences (NAS). 1999. Biological Effects of Ionizing Radiation (BEIR) VI Report: The Health Effects of Exposure to Radon. National Academy Press, Washington, D.C.

National Toxicology Program. 2014. Report on Carcinogens, Thirteenth Edition. Research Triangle Park, NC: U.S. Department of Health and Human Services, Public Health Service. Available at <http://ntp.niehs.nih.gov/pubhealth/roc/roc13/>.

National Research Council (NRC). 1981. Indoor Pollutants. National Academy Press, Washington, D.C. Available at http://www.nap.edu/openbook.php?record_id=1711.

Trasande L, C Schechter, KA Haynes, and PJ Landrigan. 2006. Applying Cost Analyses to Drive Policy That Protects Children: Mercury as a Case Study. *Annals of the New York Academy of Sciences*.

U.S. Department of Energy (DOE). 2008. Emissions of Greenhouse Gases Report. DOE/EIA-0573(2008). Available at <http://www.eia.gov/oiaf/1605/ggrpt/methane.html#energyuse>.

U.S. Department of Energy (DOE). 2010. EnergyPlus Energy Simulation Software. Version 6.0.0. Updated October 18, 2010. Available at <http://apps1.eere.energy.gov/buildings/energyplus/>

U.S. Department of Energy (DOE). 2011. Emissions of Greenhouse Gases in the United States 2009. DOE/EIA-0573 (2009), Washington, D.C. Available at http://www.eia.gov/environment/emissions/ghg_report/pdf/0573%282009%29.pdf

U.S. Department of Energy (DOE). 2015a. Annual Energy Outlook. DOE/EIA-0383(2015), Washington, D.C. Available at <http://www.eia.gov/forecasts/AEO>.

U.S. Department of Energy (DOE). 2015b. *2012 Commercial Building Energy Consumption Survey*. DOE/EIA-0246(2012), Washington, D.C. Available at <http://www.eia.gov/consumption/commercial/>.

U.S. Department of Energy (DOE). 2015c. *Electric Power Annual (with data for 2013)*. Available at <http://www.eia.gov/electricity/annual/>.

U.S. Department of Energy (DOE). 2015d. *Natural Gas Annual (with data for 2013)*. Available at http://www.eia.gov/naturalgas/annual/pdf/table_001.pdf.

U.S. Department of Energy (DOE). 2015e. Monthly Energy Review. DOE/EIA-0035(2015/03), Washington, D.C. Available at <http://www.eia.gov/totalenergy/data/monthly/#environment>.

U.S. Environmental Protection Agency (EPA). 1989. Report to Congress on Indoor Air Quality, Volume II: Assessment and Control of Indoor Air Pollution. EPA-400-I-89-001C, Washington, D.C.

U.S. Environmental Protection Agency (EPA). 1990. *Clean Air Act. 1990*. <http://www.epa.gov/air/caa/>

U.S. Environmental Protection Agency (EPA). 1994. Indoor Air Pollution--An Update for Health Professionals. Washington, D.C.

U.S. Environmental Protection Agency (EPA). 2007. National Emissions Inventory. Washington D.C. Available at: <http://www.epa.gov/ttn/chief/trends/index.html>

US Environmental Protection Agency, 2011. 2011 National Emissions Inventory (NEI). <http://www.epa.gov/ttn/chief/net/2011inventory.html>

U.S Environmental Protection Agency (EPA). 2014a. Emissions and Generation Resource Integrated Database (eGrid). Version 9, 2010 data. Available at <http://www.epa.gov/cleanenergy/energy-resources/egrid/index.html>.

U.S. Environmental Protection Agency (EPA). 2015a. *Sulfur dioxide*. Available at <http://www.epa.gov/airquality/sulfurdioxide/>.

U.S. Environmental Protection Agency (EPA). 2015b. *Nitrogen dioxide*. Available at <http://www.epa.gov/air/nitrogenoxides/>.

U.S. Environmental Protection Agency (EPA). 2015c. *Mercury*. Available at <http://www.epa.gov/mercury/>.

U.S. Environmental Protection Agency (EPA). 2015d. *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990 – 2013*. Available at <http://www.epa.gov/climatechange/Downloads/ghgemissions/US-GHG-Inventory-2015-Main-Text.pdf>.

U.S. Environmental Protection Agency (EPA). 2015e. The 2011 National Emissions Inventory. Available at <http://www.epa.gov/ttn/chief/net/2011inventory.html>.

U.S. Environmental Protection Agency (EPA). 2015f. Volatile Organic Compounds <http://www.epa.gov/iaq/voc.html>

U.S. General Services Administration (GSA). 2008. FY 2007 Federal Real Property Report. Washington, D.C.

U.S. General Services Administration (GSA). 2009. FY 2008 Federal Real Property Report. Washington, D.C.

U.S. General Services Administration (GSA). 2010. FY 2009 Federal Real Property Report. Washington, D.C.

U.S. General Services Administration (GSA). 2011. FY 2010 Federal Real Property Report. Washington, D.C.

U.S. General Services Administration (GSA). 2012. FY 2011 Federal Real Property Report. Washington, D.C.

U.S. General Services Administration (GSA) 2013. FRPC FY12 Summary Report (FRPP). Washington, D.C.

U.S. General Services Administration (GSA) 2014. FY13 FRPP Summary Data Set. Washington, D.C.

U.S. General Services Administration (GSA) 2015. FY14 FRPP Summary Data Set. Washington, D.C.