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Environmental Assessment for Final Rule, 10 CFR 433, "Energy Efficiency Standards for New Federal Commercial and High-Rise Multi-Family Residential Buildings" and 10 CFR 435, "Energy Efficiency Standards for New Federal Residential Low-Rise Residential Buildings"

(DOE/EA-1463)

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SUMMARY

The U.S. Department of Energy (DOE) has prepared this Environmental Assessment (EA) for DOE's Final Rule, 10 CFR 433, "Energy Efficiency Standards for New Federal Commercial and High-Rise Multi-Family Residential Buildings" and 10 CFR 435, "Energy Efficiency Standards for New Federal Residential Low-Rise Residential Buildings". This document is functionally identical to the Environmental Assessment released in support of the Interim Final Rules published on December 4, 2006 (71 FR 70275). No findings or results have been changed.

Section 305(a) of the Energy Conservation and Production Act (ECPA) (Pub. L. 94-385) requires that DOE establish by rule Federal building energy efficiency standards for all Federal commercial and high-rise multi-family residential buildings and low-rise residential buildings. (Residential buildings include apartment buildings.) Section 109 of the Energy Policy Act of 2005 (EPAct 2005) (Pub. L. 109-58) made several changes to section 305 of ECPA. Section 109 of EPAct 2005 replaced the minimum standards referenced in section 305(a)(2)(A) of ECPA with references to updated building codes that are widely used today. For residential buildings, Council of American Building

Officials Model Energy Code, 1992, was replaced with the International Code Council's 2004 International Energy Conservation Code (IECC). For commercial and multi-family high-rise buildings, the American National Standards Institute (ANSI)/American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE)/Illuminating Engineering Society of North America (IESNA) Standard 90.1-1989 (ASHRAE 1989) replaced with the current version of this standard, 90.1-2004. Both the IECC and ASHRAE Standard 90.1 define energy efficiency requirements for buildings.

Section 109 of EPAct 2005 also added a new section 305(a)(3)(A) that requires DOE to establish by rule revised Federal building energy efficiency performance standards. The revised standards must require that new Federal buildings be designed to achieve energy consumption levels that are at least 30 percent below the minimum standards referenced in section 305(a)(2), if life-cycle cost effective. In general, this means the savings associated with the improved efficiency are greater than the associated costs. See 10 CFR Part 436.

DOE has developed standards for all new Federal commercial and high-rise multi-family residential (over three stories in height above ground) buildings and all new low-rise residential buildings pursuant to the requirements of ECPA, as revised by EPAct 2005. The rule for commercial and high-rise multi-family residential buildings entitled, "Energy Efficiency Standards for New Federal Commercial and High-Rise Multi-Family Residential Buildings," replaces 10 CFR Part 434 with the more stringent ASHRAE Standard 90.1-2004, incorporated by reference. This rule will be in 10 CFR Part 433.

With regard to low-rise residential buildings, 10 CFR 435 Subpart C, "Energy Efficiency Standards for New Federal Residential Low-Rise Residential Buildings," is replaced by the more stringent IECC 2004, incorporated by reference. This rule will be in 10 CFR Part 435 Subpart A.

The Final Rule is applicable to new Federal buildings, which are defined as any building to be constructed by, or for the use of, any Federal agency which is not legally subject to State or local building codes or similar requirements. The Final Rule does not apply to buildings that have already been constructed or for which design for which construction has begun prior to the effective date.

The EA examines the potential environmental impacts of the Final Rule on building habitability and the outdoor environment. To identify the potential environmental impacts that may result from implementing the Final Rule for new Federal commercial and residential buildings, DOE compared the Final Rule with the "no-action alternative" of using the current Federal standards – 10 CFR Part 434 and 10 CFR Part 435 Subpart C (referred to as the "no-action alternative"). DOE also compared the Final Rule to the prevailing national voluntary building energy codes, which also happen to be the minimum requirements for the Final Rule. For commercial and high-rise multi-family residential buildings, the alternative is the ASHRAE Standard 90.1-2004. For low-rise residential buildings, the alternative is the IECC 2004 Supplement Edition (2004 IECC). For the purposes of this EA, DOE also investigated the impact of buildings

achieving energy consumption below Standard 90.1-2004 or the 2004 IECC in increments of 10 percent, up to 50 percent.

Building Habitability (Indoor Air) Impacts

The rule does not change mechanical ventilation rates from the no-action alternative. For commercial and high-rise multi-family residential buildings, ASHRAE Standard 90.1-2004 does not require specific mechanical ventilation rates and the rule does not require any changes in mechanical ventilation rates. DOE assumes that agencies will continue to specify the same mechanical ventilation rates they are currently using. For residential buildings, the 2004 IECC does not contain any ventilation requirements and therefore the residential portion of the rule does not affect ventilation. In addition, natural ventilation through leaks and cracks in the building envelope (known as infiltration) is not expected to increase or decrease. The rule contains essentially the same requirements for sealing of the building envelope that have been in all previous versions of ASHRAE Standard 90 and the IECC and in all previous Federal energy efficiency standards. Indoor air pollutant levels are not expected to increase under the Final Rule. This expectation does not imply that the potential for health-related problems in new Federal buildings does not exist. All buildings, regardless of energy efficiency codes, have some potential for indoor air quality-related health problems, such as "sick-building syndrome." Sick-building syndrome can result from insufficient building air exchange. For example, if the ventilation system that brings in fresh outside air breaks down, the air will become stale and occupants in the building may get sick.

Outdoor Air Environmental Impacts

For all Federal buildings, the rule is expected to reduce outdoor emissions primarily by reducing consumption of fossil fuels. The Federal Government constructs an estimated 28 million square feet of Federal commercial buildings annually. (See Section 5.1.2 for derivation of this number.) In contrast, the government rarely constructs Federal high-rise residential buildings. The reduction in the amount of energy that would otherwise be consumed by these buildings under the Final Rule depends on the cost-effective level of energy efficiency achieved by the agencies. For purposes of this EA, DOE considers energy savings of 10 percent, 20 percent, 30 percent, 40 percent, and 50 percent below the energy consumption level of ASHRAE Standard 90.1-2004. DOE then compares the energy savings of these five levels to the "no-action alternative" of continued use of the existing 10 CFR Part 434 as the Federal standard. Emissions avoided are directly proportional to energy savings achieved. Assuming a 30 percent reduction in energy use compared to the energy used for a building meeting 90.1-2004, carbon dioxide emissions avoided (relative to a building meeting the existing 10 CFR Part 434 requirements) would be 35,800 metric tons. This emission reduction is for the first year the Final Rule is in effect, with the savings compounding in future years as more Federal construction occurs. Nitrogen oxide emissions avoided would be 317 tons in the first year the rule is in effect, while the sulfur dioxide emissions avoided would be 625 tons.

For low-rise residential buildings, the Federal government is estimated to construct about 2000 housing units annually where this rule applies. (See Section 5.2.2 for derivation of this number.) Similar to the commercial rule, energy savings of 10 percent, 20 percent, 30 percent, 40 percent, and 50 percent below the energy consumption level of the relevant baseline code (the 2004 IECC) are examined here. Carbon dioxide emissions avoided would be 763 metric tons per year if 30 percent savings over the 2004 IECC are achieved in 2000 housing units. Nitrogen oxide and sulfur dioxide emissions avoided would each be 4 tons in the first year the rule is in effect.

Other Impacts

The Final Rule would not cause any adverse health effects, and thus would have no environmental justice impacts affecting low-income or minority populations. The Final Rule would not have any adverse impacts on sensitive environmental resources, such as wetlands, endangered species, or historic or archaeological sites, and would not be affected by a terrorist act.

ABBREVIATIONS AND ACRONYMS

Act or ECPA	Energy Conservation and Production Act (42 U.S.C. 6831 et seq.)
ANSI	American National Standards Institute
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.
BTU	British thermal unit
CFC	chlorofluorocarbon
CFR	Code of Federal Regulations
CO_2	carbon dioxide
CO	carbon monoxide
DOE	Department of Energy
EPA	Environmental Protection Agency
EUI	Energy use intensity, kBtu/ft2-yr
FR	Federal Register
HVAC	Heating, ventilation, and air conditioning
HFC	hydrofluorocarbon
ICC	International Code Council
IECC	International Energy Conservation Code
IESNA	Illuminating Engineering Society of North America
kWh	kilowatt-hour
LCC	life-cycle cost
MBtu	Million British Thermal Units
NEPA	National Environmental Policy Act of 1969

New building	a building that has never been in service
NO_2	nitrogen dioxide
PFC	perfluorocarbon
SF_6	sulfur hexafluoride
SO_2	sulfur dioxide
TSD	Technical support document
U.S.C.	United States Code
VOC	Volatile organic compounds

CONTENTS

TABLES

1 PURPOSE AND NEED FOR AGENCY ACTION

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

Section 305(a) of the Energy Conservation and Production Act (ECPA) (Pub. L. 94-385) requires that DOE establish by rule Federal building energy efficiency standards for all Federal commercial and high-rise multi-family residential buildings and low-rise residential buildings. The standard Established for new Federal commercial and high-rise multi-family residential buildings is found at 10 CFR Part 434. The standard established for new Federal low-rise residential buildings is found at 10 CFR Part 435 Subpart C.

Section 109 of the Energy Policy Act of 2005 (EPAct) made several changes to section 305 of ECPA. Section 109 replaced the minimum standards referenced in section 305(a)(2)(A) with references to updated building codes that are widely used today. For commercial and multi-family high-rise residential buildings, ASHRAE Standard 90.1-1989 was replaced with ASHRAE Standard 90.1-2004. For low-rise residential buildings, the Council of American Building Officials (CABO) Model Energy Code, 1992, was replaced with the 2004 International Energy Conservation Code. Section 109 also added a new section 305(a)(3)(A) that requires DOE to establish by rule revised Federal building energy efficiency performance standards. For new Federal buildings,

the revised standards must require that buildings be designed to achieve energy consumption levels that are at least 30 percent below the minimum standards referenced in section 305(a)(2), if life-cycle cost effective. In general, this means the savings associated with the improved efficiency are greater than the associated costs, as per 10 CFR Part 436.

DOE has developed standards for all new Federal commercial and high-rise multi-family residential (over three stories in height above ground) buildings and all new low-rise residential buildings pursuant to the requirements of ECPA. The new rule for commercial and high-rise multi-family residential buildings (10 CFR Part 433) entitled, "Energy Efficiency Standards for New Federal Commercial and High-Rise Multi-Family Residential Buildings," replaces the current 10 CFR Part 434. The new rule for low-rise residential buildings (10 CFR Part 435 Subpart A) entitled "Energy Efficiency Standards for New Federal Residential Low-Rise Residential Buildings", replaces the current 10 CFR Part 435 Subpart C.

The Final Rule applies to buildings constructed for and to be occupied by Federal agencies. The low-rise residential rule does not apply to housing built under the Department of Defense (DOD) privatization initiative, or to Department of Housing and Urban Development (HUD)-financed housing not for Federal use. The rule does not apply in locations that have applicable local or state energy efficiency codes. The rule covers new buildings only. This environmental assessment identifies possible

incremental environmental effects of the Final Rule on new buildings constructed for the Federal sector.

2 THE FINAL RULE AND ALTERNATIVES

Section 2.1 describes the Final Rule, the no-action alternatives (the current 10 CFR Part 434 and ASHRAE Standard 90.1-2004) for commercial and high-rise multi-family residential buildings. Section 2.2 describes the Final Rule, the no-action alternatives (the current 10 CFR Part 435 and the 2004 IECC) for low-rise residential buildings.

2.1 Commercial and High-Rise Multi-Family Residential Buildings

The potential environmental impacts that would result from implementing the Final Rule for new Federal commercial and high-rise multi-family residential (over three stories in height above ground) buildings were examined by comparing the Final Rule with 10 CFR Part 434 and with the minimum that Federal agencies must achieve under the new rule, ASHRAE Standard 90.1-2004.

2.1.1 The Proposed Action - The Final Rule (Commercial and High-Rise Residential Buildings)

The proposed action is the Final Rule, which would set energy performance requirements for new Federal commercial and high-rise multi-family residential buildings constructed for the Federal agencies. It requires that commercial and multi-family high-rise buildings must be designed to achieve energy consumption levels that are at least 30

percent below the minimum standard - ASHRAE Standard 90.1-2004, if life-cycle cost effective. For purposes of alternative impact analysis, this EA considers the impacts of achieving 10 percent, 20 percent, 30 percent, 40 percent and 50 percent energy consumption reduction below the minimum standard.

2.1.2 "No-Action" Alternative One – 10 CFR Part 434

This no-action alternative, defined as the continued use of 10 CFR Part 434, represents a considerably less stringent alternative than the standard proposed in the Final Rule in terms of energy efficiency. 10 CFR Part 434 is based on the format of ASHRAE Standard 90.1 which, in turn, is a codified version of ASHRAE/IESNA Standard 90.1-1989. The requirements in 10 CFR Part 434 are similar to those in Standard 90.1-1989 (ASHRAE 1989a), including some Addenda to the Standard that had been published by ASHRAE as of October 1993.

2.1.3 "No-action" Alternative Two – Standard 90.1-2004 (as published)

The second no-action alternative is defined as the use of Standard 90.1-2004, as required by Section 109 of EPAct 2005. This standard sets the minimum level of energy savings that Federal agencies should achieve under the new Federal commercial standard. It provides the latest set of design and 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 Low-Rise Residential Buildings

The potential environmental impacts that would result from implementing the Final Rule for new Federal low-rise residential buildings (three stories or less in height above ground) were examined by comparing the Final Rule with the current 10 CFR Part 435 and with the 2004 IECC. Because the 2004 IECC is clearly stated as the minimum standard in Section 109 of EPAct 2005, the 2004 IECC represents the minimum that Federal agencies must achieve under the new rule.

2.2.1 The Proposed Action - The Final Rule (Low-Rise Residential Buildings)

The proposed action is the Final Rule, which would set energy performance requirements for new Federal low-rise buildings (constructed for the Federal agencies). It requires that low-rise residential buildings must be designed to achieve energy consumption levels that are at least 30 percent below the minimum standard – the 2004 IECC, if life-cycle cost effective. For purposes of alternatives impact analysis, this EA considers the impacts of achieving 10 percent, 20 percent, 30 percent, 40 percent and 50 percent energy consumption reduction below the minimum standard.

2.2.2 "No-Action" Alternative One – 10 CFR Part 435 Subpart C

This no-action alternative represents a less-stringent alternative than the standard proposed in the Final Rule in terms of energy efficiency. 10 CFR Part 435 Subpart C relies on the "COSTSAFR" software program to perform a life-cycle cost (LCC) analysis using energy costs, construction costs, climate, and other data to establish energy efficiency requirements (Lucas et al. 1991). If fuel costs are high, COSTSAFR sets more-stringent requirements; if fuel costs are low, COSTSAFR sets less-stringent requirements. The LCC analysis establishes minimum requirements on a project-specific basis. The software produces "point system" forms that the building designer completes to determine if the design complies. These forms do not have specific building envelope requirements but rather have an overall level of performance that must be achieved. The designer uses these forms to select a set of insulation levels, window characteristics, space heating and cooling equipment, and water heating equipment that obtain sufficient points to comply with the standards.

2.2.3 "No-action"Alternative Two – The 2004 IECC

The second no-action alternative is defined as the use of the 2004 IECC, as required by Section 109 of EPAct 2005. This standard sets the minimum level of energy savings that Federal agencies must achieve under the new Federal low-rise residential building standard. It sets energy efficiency requirements for building envelope; heating, ventilation, and air-conditioning (HVAC) systems; and domestic water-heating systems.

3 DESCRIPTION OF THE AFFECTED ENVIRONMENT

The Final Rule contains requirements that could have some impact on building habitability (indoor environment), the outdoor environment, the nation's economy, and the Federal agencies that procure commercial and residential buildings. Section 4.1 touches on air emissions that can affect indoor air quality and related human health effects. Section 4.2 addresses air emissions in the outdoor environment.

3.1 Indoor Habitability

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

Building energy code requirements could influence the concentration levels of indoor air emissions in several ways. First, they could increase or decrease the ventilation and/or infiltration of fresh air from outdoors, which generally reduces indoor-generated pollutant concentration levels. The air exchange rate of buildings built to the Final Rules will not change relative to those built to the no-action alternative. The Final Rules will not place any additional restrictions or requirements on ventilation.

Second, requirements in energy efficiency codes have the potential to impact internally generated indoor emissions by changing the materials or equipment used within the buildings. Various emissions can be continuously or intermittently released within commercial and residential buildings. These emissions can originate from furnishings within a building (e.g., carpet, furniture), from building materials (e.g., insulation material, particle board), from the ground (e.g., radon), from the building occupants' indoor activities (e.g., tobacco smoking, painting), or from the mechanical equipment (e.g., fossil-fuel appliances). Potential combustion emissions include CO, CO_2, nitrogen oxides, and sulfur dioxide (SO_2). Fossil-fuel-burning (including gas stoves/ovens) equipment and, if allowed, tobacco smoke, are the main sources of combustion products. In addition, sources from outside the building (particularly vehicle exhaust) can be drawn into the building. The Final Rules are not expected to change pollutant rates from indoor sources of air pollution compared to the no-action alternative. (DOE will be issuing a subsequent rulemaking that addresses the requirement for use of sustainable design principles in siting, design, and construction of new Federal buildings and this rule may reasonably be assumed to address pollutant rates from indoor sources.)

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 to 8 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.

Table 1. (cont'd)		
Pollutant	**Health Impacts**	**Sources**
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 as these buildings usually have mechanical ventilation and occupants are typically not in the buildings as many hours a week as they are in their homes.	Radon is a radioactive gas that occurs in nature. The greatest single source of radon is from the soil. It can be found in soils and rocks containing uranium, granite, shale, phosphate, and pitchblende (Moffat 1997).

Table 1. (cont'd)		
Pollutant	**Health Impacts**	**Sources**
Formaldehyde	The EPA has classified formaldehyde as a "probable human carcinogen" (EPA 1989). In low concentration levels, formaldehyde irritates the eyes and mucous membranes of the nose and throat (NRC 1981). Formaldehyde can cause watery eyes; burning sensations in the eyes, nose, and throat; nausea; coughing; chest tightness; wheezing; skin rashes; and allergic reactions (CPSC 1997).	Various pressed-wood products can emit formaldehyde, including particle board, plywood, pressed wood, paneling, some carpeting and backing, some furniture and dyed materials, urea-formaldehyde insulating foam, and pressed textiles (CPSC 1997). Cigarette smoke also produces formaldehyde.
Volatile organic compounds (VOCs)	VOCs can cause a wide variety of health problems. Some examples of potential heath effects include increased cancer risks, depression of the central nervous system, irritation to the eyes and respiratory tract, and liver and kidney damage. Some evidence exists that VOCs can provoke some of the symptoms typical of sick-building syndrome and cause severe reactions for individuals who appear to demonstrate multiple chemical sensitivities (EPA 1991).	VOCs contain carbon and exist as vapors at room temperatures. Over 900 VOCs have been identified in indoor air (EPA 1991). Formaldehyde is one type of VOC. Many products give off VOCs as they dry, cure, set, or otherwise age (Moffat 1997).

Table 1. (cont'd)		
Pollutant	**Health Impacts**	**Sources**
Biological Contaminants	Biological agents in indoor air are known to cause three types of human disease: infections, where pathogens invade human tissue; hypersensitivity diseases, where specific activation of the immune system causes diseases; and toxicosis, where biologically produced chemical toxins cause direct toxic effects (EPA 1994). Evidence is available showing that some episodes of sick-building syndrome may be related to microbial contamination of buildings (EPA 1994).	Sources include outdoor air and human occupants who shed viruses and bacteria, animal occupants (insects and other arthropods, mammals) that shed allergens, and indoor surfaces and water reservoirs such as humidifiers where fungi and bacteria can grow (EPA 1994).

3.2 Outdoor Air

The Final Rule impacts energy consumption and therefore impacts pollutant emissions and greenhouse gas emissions associated with energy consumption. The emissions addressed in this report are split into two groups, namely, greenhouse gases and gases other than greenhouse gases.

3.2.1 Greenhouse Gases

All the information on greenhouse gases presented below is from the DOE report entitled, “Emissions of Greenhouse Gases in the United States” (DOE 2001). The gases in the earth's atmosphere that help trap the Sun's heat are referred to as "greenhouse gases." Most greenhouse gases occur naturally, with the most important being water vapor and carbon dioxide. Scientists have discovered that the concentration of greenhouse gases, including carbon dioxide, methane, and nitrous oxide, is increasing—more of these gases are being emitted than absorbed. Anthropogenic (human-made) emissions occur in addition to natural emissions. The U.S. government has agreed to (but not ratified) the Kyoto Protocol goal to reduce carbon emissions in the year 2010 to levels below 1990 emissions. The Final Rule will help reduce greenhouse gas emissions by saving energy.

The impacts presented in Section 5.0 are focused on human-made emissions and specifically those in the United States. Eighty-two percent of U.S. greenhouse gas

emissions result from the combustion of fossil fuels such as coal, petroleum, and natural gas. Consequently, U.S. emissions are strongly tied to fossil energy consumption. Other greenhouse gas emissions include methane, nitrous oxide, and other gases.

Carbon Dioxide

CO_2 is by far the most common greenhouse gas emitted. More than 98 percent of U.S. CO_2 emissions can be traced to the combustion of fossil fuels. The commercial sector (as defined by DOE [2001], including all commercial buildings, not just Federal buildings) contributes a 17 percent share of U.S. CO_2 emissions. Seventy-five percent of the commercial-sector CO_2 emissions are associated with the production of electric power used in the sector. Eighteen percent of the commercial-sector CO_2 emissions are from natural gas (used directly in buildings), with the remaining 7 percent mainly from petroleum products. The residential sector contributes a 20 percent share of U.S. CO_2 emissions. Twenty-three percent of the residential-sector CO_2 emissions are from natural gas (used directly in buildings), with 9 percent from petroleum products. Coal by far produces the largest share of the carbon emissions from electricity generation. Coal produces about 78 percent more carbon emissions than natural gas per unit of energy produced.

Methane

Methane emissions are primarily from human-related sources, not natural sources. U.S. methane emissions are from three categories of sources, each accounting for about one-third of total emissions: (1) decomposition of solid waste in landfills, (2) energy

sources, and (3) emissions from domestic livestock. The methane emitted from energy sources occurs primarily during the production and processing of natural gas, coal, and oil; not in the actual use (combustion) of these fuels. Methane is the primary ingredient in natural gas, and production, processing, storage, and transmission of natural gas account for 58 percent of the energy source emissions (or 23 percent of all methane emissions).

Nitrous Oxide

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

Halocarbons and Other Gases

The final group of human-made greenhouse gases consists of halocarbons and other engineered gases not usually found in nature. Three of these gases are discussed below:

1. Hydrofluorocarbons (HFC),
2. Perfluorocarbons (PFC), and
3. Sulfur hexafluoride (SF_6).

HFCs are compounds containing carbon, hydrogen, and fluorine. HFCs do not reach the stratosphere to destroy ozone so are, therefore, considered more environmentally benign than ozone-depleting substances such as chlorofluoro-carbons (CFCs), even though HFCs are greenhouse gases. HFCs are used as refrigerants and are becoming more common as ozone-depleting refrigerants are phased out. PFCs are compounds containing carbon and fluorine. PFC emissions result as a byproduct of aluminum smelting and semiconductor manufacturing. SF_6 is used an insulator for electric equipment.

3.2.2 Other Outdoor Air Emissions

Several outdoor air emissions other than the greenhouse gases having detrimental effects on human health and/or the environment are discussed below. National air quality standards have been set for six principal air emissions (also referred to as "criteria pollutants"): ozone, NO_2, CO, particulate matter, SO_2, and lead. More information on these emissions is presented below. All of the following information on air emissions is from 2002 EPA data (EPA 2005).

Ozone

Ozone occurring high in the atmosphere is beneficial, providing a protective layer from ultraviolet radiation. Closer to ground level, however, ozone is the prime ingredient

of smog. Ozone can cause respiratory problems, damage plants and trees, while fine particles in smog reduce visibility. Ozone is formed in the atmosphere by the reaction of VOCs and nitrogen oxides. Various consumer products, for example, fuel, solvents, paints and glues emit VOCs. VOCs in outdoor air come primarily from industrial processes and transportation.

Nitrogen Oxides

NO_2 is a precursor to acid rain as well as to ozone. The major source of human-made NO_2 emissions is high-temperature combustion of fossil fuels. About 22 percent of emissions come from fuel combustion to produce electricity and 3 percent of emissions come from fuel consumption in buildings; the remainder is mainly from the transportation and industrial sectors.

Carbon Monoxide

The main source of CO is the incomplete burning of fossil fuels such as gasoline. Exhaust from 'highway vehicles' contributes about 55 percent of all CO emissions. The CO produced from energy use related to buildings is 2 percent of all emissions, but most of this is from wood burning in residential buildings, which should not be impacted by these rules.

Particulate Matter

Particulate matter is a general term used for a mixture of solid particles and liquid droplets found in air. Particulate matter can cause or exacerbate respiratory problems and

reduce visibility. These particles come in a wide range of sizes and originate from many human-made and natural sources. Particles less than 2.5 micrometers are known as "fine" particles. Those larger than 2.5 micrometers are known as "coarse" particles. Fuel combustion generates "fine" particles. Most particulate matter comes from roads (particularly unpaved roads), agriculture, and fires. The particulate matter emitted from energy use related to buildings is only about 2 percent for course particles and 6 percent for fine particles of all U.S. emissions. Most of this is from wood burning in residential buildings.

Sulfur Dioxide

As with most of the other emissions, SO_2 can cause respiratory problems, including breathing problems and damage to the lungs. SO_2, along with nitrogen oxides, causes acid rain. SO_2 is formed when fuel containing sulfur is burned. Coal is the primary fuel that produces SO_2. Coal burned by electric utilities produces 63 percent of all SO_2 emissions. About 4 percent of SO_2 emissions come from direct use of coal and oil in buildings.

Lead

Exposure to lead can cause a variety of health problems. Lead can adversely affect the brain, kidneys, liver, nervous system, and other organs. Today, metals processing is the major source of lead emissions to the atmosphere. Combustion from electric utilities is less than 2 percent of all lead emissions, with most of the combustion

emissions are from coal, not natural gas or oil. Lead emissions directly from buildings are a negligible share of national total emissions.

4 CALCULATING ENERGY SAVINGS BY BUILDING TYPE

4.1 Commercial and High-Rise Multi-Family Residential Buildings

To compare estimated outdoor emissions from the Final Rule and the no-action alternatives, it is necessary to determine differences in building energy use by fuel type for these three alternatives. In addition, five potential savings levels associated with the Final Rule were evaluated. The Final Rule was compared with 10 CFR 434 for two common buildings types in 11 cities, representing 11 climate regions within the United States. Energy savings from the Final Rule were estimated using the Building Load and System Thermodynamics (BLAST) building simulation software (BLAST 1991). Assumptions used in this analysis are described below.

4.1.1 Commercial Building Types Used to Estimate Energy Savings

Two types of commercial buildings were modeled in estimating energy savings from the Final Rule. The first building was a three-story, 48,000-ft^2 office building with 15 single-zone electric air-conditioning systems, each using gas furnaces for space-heating. The second building was a one-story, 7,000-ft^2 warehouse with no air conditioning and gas unit heaters. Federal buildings were assumed to have the following distribution:

- office (conditioned buildings) 76 percent
- warehouse (semi-heated) 9 percent
- other 15 percent

Office and warehouse energy usage results were averaged using this distribution to obtain the national average energy usage. The remaining building types include industrial buildings, prisons, utilities, and others that add up to about 15 percent of the total Federal building floor space. Space-heating, space-cooling, water heating and lighting energy are included in the energy use simulations.

Table 2 shows the national average energy savings in terms of energy use intensity (EUI) from the Final Rule by building and fuel type. EUI is the energy consumed by a building per square foot per year. Site energy includes energy used only at the building site.

Source energy includes energy used at the building site and energy lost in producing and delivering the energy to the site (for electricity). The total source EUIs for the combined average building indicates the total energy averaged across the two building types using the percent distribution given above.

Table 2 Comparison of Simulated EUIs by Fuel Type (Commercial)

Code or Standard	Site Energy Breakdown		Total	
	Gas EUI (kBtu/ft^2-yr)	Electric EUI (kBtu/ft^2-yr)	Site EUI (kBtu/ft^2-yr)	Source EUI (kBtu/ft^2-yr)
Combined Average Building				
Current 10 CFR 434	5.1	48.3	53.4	159.4
Standard 90.1-2004	5.7	34.2	39.9	115.3
Final Rule – 10%	5.1	30.8	35.9	103.8
Final Rule – 20%	4.6	27.4	32.	92.2
Final Rule – 30%	4.0	23.9	27.9	80.7
Final Rule – 40%	3.4	20.5	23.9	69.2
Final Rule – 50%	2.9	17.1	20.0	57.7
Note: Lower EUIs indicates lower energy usage				

4.2 Low-Rise Residential Buildings

Energy savings for the Final Rule were estimated using the DOE-2 (Version 2.1E) energy simulation software to determine the energy savings from the changes in the envelope requirements in the IECC. DOE-2.1E is the Department of Energy's sophisticated building energy simulation program (Lawrence Berkeley National Laboratory 1981).

4.2.1 Residential Building Used to Estimate Energy Savings

The prototype building used in the energy simulations is intended to approximate a typical new house. Four foundation types were examined: crawl space, slab-on-grade, heated basement with wall insulation, and unheated basement with floor insulation. The prototype characteristics used here are:

- A rectangular two-story house, 25 ft. by 40 ft., with 2000 ft^2 of conditioned floor area.
- 1000 ft^2 roof/ceiling area. 300 ft^2 cathedral, 700 ft^2 with attic.
- 1000 ft^2 floor area above unconditioned basements or crawl spaces. 130 ft^2 foundation perimeter. 1040 ft^2 basement wall area for the heated basement scenario.
- 2210 ft^2 of gross exterior wall area (this is the above-ground area, excluding any basement wall area).
- 56 ft^2 of exterior doors.
- Window area of 15 percent of the conditioned floor.
- The heating system consisted of a gas furnace and cooling that is via central air conditioning with an air ducted system. Domestic water heating is assumed to be from natural gas.

This analysis included simulations of the 239 locations encompassing all regions and climates in the U.S. These results are combined into a weighted national average.

Table 3 shows the national average annual energy savings from the rule compared to the 2004 IECC baseline. The no-action alternative (10 CFR Part 435 Subpart C) increases

energy use compared to the 2004 IECC and therefore has negative savings. Source energy includes energy used at the building site and energy lost in producing and delivering the energy to the site for electricity (DOE 2006c). The source energy impacts are used to estimate emission reductions.

Table 3 Annual Energy Savings (MBtu per house) of Improvement over 2004 IECC

Improvement over IECC	Site Energy		Source Energy	
	Natural Gas	Electricity	Natural Gas	Electricity
Current 10 CFR 435	-15.9	-1.1	-15.9	-3.3
2004 IECC	0	0	0	0
Final Rule - 10%	6.6	0.6	6.6	2
Final Rule - 20%	13.1	1.2	13.1	4
Final Rule - 30%	19.6	1.9	19.6	6
Final Rule - 40%	26.2	2.5	26.2	7.9
Final Rule - 50%	32.8	3.1	32.8	9.9

5 ENVIRONMENTAL IMPACTS

5.1 Commercial and High-Rise Multi-Family Residential

This section provides the potential environmental impacts that may result from implementing the Final Rule, which is evaluated in increments of 10 percent increase in energy efficiency, up to 50 percent better than the alternative of using ASHRAE Standard 90.1-2004. Air emissions are shown for all the increments including the "30 percent better than the ASHRAE Standard 90.1-2004" target level specified in the EPAct 2005. These values are then compared to the no-action alternatives. The improved energy efficiency of the Final Rule would reduce the use of fossil fuels, and therefore would reduce air emissions.

5.1.1 Building Habitability (Indoor Air) Impacts

The Final Rule is not expected to have any impact on indoor air quality relative to the no-action alternatives, as the changes between the codes do not alter ventilation rates or sources of indoor emissions. This does not imply that a potential for health-related problems does not or will not exist in new Federal commercial buildings. The Final Rule does not address the potential for indoor air quality-related health problems, such as "sick-building syndrome." Sick-building syndrome can result from insufficient building air exchange. For example, if the ventilation system that brings in fresh outside air breaks down, the air will get stale and occupants in the building may get sick. The Final

Rule does not impact exactly how a building is operated (e.g., how a ventilation system is controlled) nor does it impact materials (e.g., type of paint used, or if occupants are exposed to fumes from painting) used in the buildings. The Final Rule and the no-action alternatives do not have any requirements specifically for radon control or control of other indoor air emissions. As noted in Table 1, " radon is much less of a concern in commercial buildings than in residential buildings, as 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." DOE has previously consulted with the U.S. Environmental Protection Agency (EPA) on the issue of radon in commercial buildings and determined that radon standards are not applicable to commercial and high-rise multi-family residential buildings.

5.1.2 Outdoor Air

In general, under all the alternatives examined in this EA, greenhouse gas emissions (carbon dioxide, methane, nitrous oxides, and halocarbons) are reduced because more energy efficient buildings consume less fossil fuels that create greenhouse gases. Table 4 shows the estimated reductions of greenhouse gas emissions resulting from the Final Rule. This is the estimated annual energy savings from one year of Federal building construction under the 10%, 20%, 30%, 40%, and 50% savings over Standard 90.1-2004.

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. This distribution was obtained from the Monthly Energy Review (DOE 2006c). Reductions in CO_2 emissions are based on multiplying the total fuel (coal, natural gas, and oil) savings from the Final Rule by emission coefficients by fuel type given in Table B.1 of DOE's report on emissions of greenhouse gases (DOE 2001). Reduction in the release of methane was obtained by scaling the total national emissions by the percentage savings in total national energy use (by fuel type) resulting from the Final Rule.

Total annual Federal construction was estimated from U.S. General Services Administration (GSA) data on total construction of buildings owned by the Federal Government (GSA 1998). The government owns about 2.25 billion square feet of buildings (excluding residential buildings). Detailed data on the square footage of new Federal buildings built in recent years proved difficult to obtain. Examination of DOE's Annual Energy Outlook indicates that approximately 2 billion square feet per year of commercial buildings are constructed. (DOE 2006a). Examination of DOE's Commercial Building Energy Consumption Survey (CBECS) data (DOE 1994, DOE 1997, DOE 2002, and DOE 2006b) indicates that for the building age categories considered, Federal buildings may account for about 1.4 percent of the total commercial construction volume. Therefore, 28 million square feet are assumed to be built each year (2 billion times 1.4 percent = 28 million square feet). Hard data is not available on the amount of Federal high-rise residential construction, but DOE believes this Federal

building type is rare. Reductions in CO_2 and methane are in metric tons of carbon and methane, respectively.

Because the energy used in Federal building sector is not a substantial source of nitrous oxide or halocarbons, the impacts of the Final Rule for these two gases are negligible. The reductions in greenhouse gas emissions will accumulate in the future as more and more Federal commercial buildings are built.

Table 4 Savings in Annual Greenhouse Gas Emissions in Metric Tons (Year One of Commercial Construction)

		Carbon Dioxide	Methane	Nitrous Oxide or Halocarbons
Savings of Final Rule (10%, 20%, 30%, 40%, 50% Targets) vs. 10 CFR Part 434 (no-action one)	10%	11,900	51.7	Negligible
	20%	23,900	103	
	30%	35,800	155	
	40%	47,700	207	
	50%	59,700	258	
Savings of Final Rule (10%, 20%, 30%, 40%, 50% Targets vs. ASHRAE Standard 90.1-2004 (no-action two)	10%	5,200	27.7	Negligible
	20%	10,500	51.3	
	30%	15,700	77	
	40%	20,900	103	
	50%	26,200	128	

For example, a 30% improvement in energy efficiency over the no-action alternative will save an estimated 35,800 metric tons of carbon dioxide per year for 28 million ft^2 of construction. This compares to 1582 million metric tons of total emissions for the U.S. in 2004 (DOE 2006d), or only two-thousandths of one percent of the national total.

Estimated savings in criteria emissions as a result of the Final Rule are shown in Table 5. The savings represent the annual savings from only one year of Federal commercial building construction (28 million ft^2); these savings will accumulate in the future as more and more Federal buildings are built. Total pollutant emissions in the United States were obtained from the National Emissions Inventory (EPA 2002). The improved energy efficiency of the Final Rule will reduce the use of coal and other fossil fuels to produce energy and therefore will reduce emissions of nitrogen oxides and sulfur dioxide. The Final Rule is assumed to have a negligible effect on emissions other than nitrogen oxides and sulfur dioxide because the energy use associated with buildings contributes only a small fraction of the emissions. The savings in air pollutant emissions will accumulate in the future as more Federal commercial buildings are built.

Table 5 Savings in Annual Outdoor Pollutant Emissions in Metric Tons (Year One of Commercial Construction)

		Nitrogen Oxides	Sulfur Dioxide	Carbon Monoxide, Particulate Matter, Sulfur Dioxide, or Lead
Savings of Final Rule (10%, 20%, 30%, 40%, 50% Targets) vs. 10 CFR Part 434 (no-action one)	10%	106	208	Negligible
	20%	211	417	
	30%	317	625	
	40%	423	833	
	50%	528	1042	
Savings of Final Rule (10%, 20%, 30%, 40%, 50% Targets vs. ASHRAE Standard 90.1-2004 (no-action two)	10%	45.7	88	Negligible
	20%	91.3	177	
	30%	137	265	
	40%	183	353	
	50%	228	442	

5.2 Low-Rise Residential

This section provides the potential environmental impacts that may result from implementing the Final Rule. The Final Rule is evaluated in increments of 10 percent increase in energy efficiency, up to 50 percent better than the alternative of using the 2004 IECC. Emissions are shown for all the increments including the "30 percent better than the 2004 IECC" level specified in the Energy Policy Act of 2005. These values are then compared with the no-action alternative. The improved energy efficiency of the Final Rule will reduce the use of coal and other fossil fuels to produce energy as compared to the no-action alternatives, and therefore will reduce emissions of outdoor emissions.

5.2.1 Building Habitability (Indoor Air) Impacts

The Final Rule is not expected to have any impact on indoor air quality relative to the no-action alternative as the changes between the codes do not alter ventilation rates or sources of indoor emissions. This does not imply that a potential for health-related problems does not or will not exist in new Federal residential buildings. The Final Rule does not address the potential for indoor air quality-related health problems. The Final Rule does not impact how a building is operated (e.g., how a ventilation system is controlled) nor does it impact materials (e.g., type of paint used, or if occupants are exposed to fumes from painting) used in the buildings. The Final Rule and the no-action

alternative do not have any requirements specifically for radon control or control of other indoor air emissions.

(DOE will be issuing a subsequent rulemaking that addresses the requirement in Section 109 of the Energy Policy Act of 2005 that, if life-cycle cost effective for new Federal buildings, agencies apply sustainable design principles to the siting, design, and construction of all new and replacement buildings.)

5.2.2 Outdoor Air

Under all the alternatives examined in this environmental assessment, greenhouse gas emissions (carbon dioxide, methane, nitrous oxides, and halocarbons) are reduced because more energy efficient buildings consume less fossil fuel and that creates less greenhouses gases. Table 6 shows the estimated reductions of greenhouse gas emissions resulting from the Final Rule. This is the annual energy savings from one year of Federal construction under the 10 percent, 20 percent, 30 percent, 40 percent, and 50 percent energy savings alternatives Electricity production ultimately used in Federal residential buildings is assumed to have the same distribution of fuel/energy sources (e.g., coal, nuclear) as overall national electricity production. This distribution was obtained from the Monthly Energy Review (DOE 2006c). Reductions for CO_2 are based on multiplying the total fuel (coal, natural gas, and oil) savings from the Final Rule by emission coefficients by fuel type given in Table B.1 of DOE's report on emissions of greenhouse gases (DOE 2001). Reduction in the release of methane was obtained by scaling the total

national emissions by the percentage savings in total national energy use (by fuel type) resulting from the Final Rule. The amount of Federal residential construction that must comply with the requirements in the Final Rule is not known. Much of the expected construction by the Department of Defense is expected to be under the privatization initiative, where the Federal code (10 CFR 435) will often not apply because state and local codes supersede the Federal code. For the results shown in this report, DOE estimated Federal construction where the Final Rule will apply to be 2000 housing units per year with an estimated over 90 percent being built for the Department of Defense. This estimate is based on historical data obtained from the Department of Defense, which constructs the large majority of all Federal housing. Federal construction rates in the future are not known. Because the energy used in Federal buildings is not a substantial source of nitrous oxide or and halocarbons, the impacts of the Final Rule for these two gases are negligible. The reductions in greenhouse gas emissions will accumulate in the future as more and more Federal commercial buildings are built.

The reductions in greenhouse gas emissions would grow in the future as more Federal residential buildings are built.

Table 6 Savings in Annual Greenhouse Gas Emissions in Metric Tons (Year One of Residential Construction)

		Carbon Dioxide	Methane	Nitrous Oxide or Halocarbons
Savings of Final Rule (10%, 20%, 30%, 40%, 50% Targets) vs. 10 CFR Part 435 Subpart C (no-action one)	10%	407	6	Negligible
	20%	814	12	
	30%	1221	18	
	40%	1628	24	
	50%	2035	30	
Savings of Final Rule (10%, 20%, 30%, 40%, 50% Targets vs. 2004 IECC (no-action two)	10%	254	4	Negligible
	20%	509	8	
	30%	763	12	
	40%	1017	16	
	50%	1272	20	

For example, a 30% improvement in energy efficiency over the no-action alternative will save an estimated 1,221 metric tons of carbon dioxide per year for the estimated 2000 housing units per year. This compares to 1582 million metric tons of total emissions for the U.S. in 2004 (DOE 2001), or less than one-millionth of the national total.

Estimated annual savings in criteria emissions as a result of the Final Rule are shown in Table 7 for one year of construction (2000 units). Total pollutant emissions in the United States were obtained from the National Emissions Inventory (EPA 2002). The improved energy efficiency of the Final Rule will reduce the use of coal and other fossil fuels to produce energy and therefore will reduce emissions of nitrogen oxides and sulfur dioxide. The Final Rule is assumed to have a negligible effect on emissions other than nitrogen oxides and sulfur dioxide because the energy use associated with buildings contributes only a small fraction of the emissions.

Table 7 Savings in Annual Outdoor Pollutant Emissions in Metric Tons (Year One of Residential Construction)

		Nitrogen Oxides	Sulfur Dioxide	Carbon Monoxide, Particulate Matter, Sulfur Dioxide, or Lead
Savings of Final Rule (10%, 20%, 30%, 40%, 50% Targets) vs. 10 CFR Part 435 (no-action one)	10%	2	2	Negligible
	20%	4	4	
	30%	6	6	
	40%	8	8	
	50%	10	10	
Savings of Final Rule (10%, 20%, 30%, 40%, 50% Targets vs. 2004 IECC (no-action two)	10%	1	1	Negligible
	20%	3	3	
	30%	4	4	
	40%	5	5	
	50%	7	7	

5.3 Environmental Justice and Other Impacts

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

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

6 AGENCIES AND PERSON CONSULTED DURING THIS RULEMAKING

In accordance with 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 DOE Federal Energy Management Program - Cyrus Nasseri, and Stephen Walder,

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

The rulemaking was also presented to a variety of Federal agency representatives at the following forums:

2006 Federal Environmental Symposium, May 2, 2006; Interagency Working Group on Sustainability, May 17, 2006

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