U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Regulatory Impact Analysis for Fossil Fuel Reduction Rule

Prepared for the U.S. Department of Energy
Federal Energy Management Program

By Pacific Northwest National Laboratory

July 2014

FEMP
Federal Energy Management Program

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Richland, Washington 99352

Summary

Section 433 of the *Energy Independence and Security Act of 2007* (Pub. L. 110-140) (EISA) directed the U.S. Department of Energy (DOE) to establish fossil fuel-generated energy consumption limits for new Federal buildings and Federal buildings undergoing major renovation (42 U.S.C. 6834(a)(3)(D)(i)).[1] The statute requires fossil fuel-generated energy[2] consumption reductions starting at 55% in fiscal year (FY) 2010 and increasing to 100% in FY 2030 and beyond. These reduction targets are measured relative to "typical" building energy use, as measured by DOE's Commercial Building Energy Consumption Survey (CBECS) and Residential Energy Consumption Survey (RECS). These targets only apply to new construction or major renovations with a total cost of $2.5 million (in 2007 dollars) or more and "public buildings" (as defined at 40 U.S.C. 3301) for which a prospectus to Congress is required under 40 U.S.C. 3307. The proposed rule is estimated to save 1.9 million metric tons of carbon dioxide emissions in 2030.

DOE has determined that the standards for Federal buildings outlined in the fossil fuel reduction rule constitute an "economically significant regulatory action" under Executive Order (E.O.) 12866, *Regulatory Planning and Review*. DOE has therefore committed to comparing regulatory alternatives to the rule by performing a Regulatory Impact Analysis (RIA). This RIA, which DOE has prepared pursuant to E.O. 12866, examines the economic impact of the Fossil Fuel-Reduction Rule on the construction cost and total life-cycle construction and operating costs of Federal construction. DOE notes that the $2.5 million construction cost threshold for this fossil fuel-reduction rule almost certainly rules out application of this rule to Federal low-rise residential buildings as does the "public building" requiring a prospectus threshold because the definition at 40 U.S.C. 3301 specifically excludes residential buildings. Thus, the remainder of this RIA will focus on Federal commercial and multifamily high-rise residential buildings.

In addition to analyzing the impacts on Federal buildings of the provisions in the proposed rule, DOE also performed analyses for the impacts for two alternatives to the rule: (1) a "no-action" alternative that assumes this rule is not published, but that existing energy efficiency requirements for new Federal construction remain in effect; and, (2) a more stringent "zero fossil fuel" alternative that requires Federal buildings to go immediately to the level of performance required in the rule as of FY 2030, i.e., a 100%

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[1] The proposed Fossil Fuel-Reduction Rule includes the following definition of a New Federal Building: "New Federal building means any new building (including a complete replacement of an existing building from the foundation up) to be constructed by, or for the use of, any Federal agency. Such term shall include buildings built for the purpose of being leased by a Federal agency, and privatized military housing." The same document also includes the definition of Major Renovation: "Major renovation means changes to a building that provide significant opportunities for substantial improvement in energy efficiency. This may include, but is not limited to, replacement of the HVAC system, the lighting system, the building envelope, and other components of the building that have a major impact on energy usage. Major renovation also includes a renovation of any kind that provides significant opportunities for compliance with other applicable requirements in this part."

[2] Fossil fuel-generated energy consumption is the sum of fossil fuel used directly on site and the fossil fuel used to generate electricity that is used on site. For this rule, the fossil fuel used on site is the source fossil fuel energy, including transmission and distribution losses. The fossil fuel used to generate electricity on site is defined as 71% of the source energy (as generated at the power plant and including transmission and distribution losses). See the rule itself for a detailed discussion of these definitions.

reduction of a typical building's fossil fuel-generated energy consumption, or zero fossil fuel usage. The outputs of these analyses are shown in Tables S-1 and S-2.

Table S-1. Annualized Benefits and Costs to Federal Government for New and Existing Construction under the Fossil Fuel-Reduction Rule[a]

	Discount Rate	Primary Estimate[b]	Low Estimate[b]	High Estimate[b]
		Monetized (2012 $million/year)		
Benefits				
Operating (Energy) Cost Savings	7%	349.2	336.1	468.9
	3%	606.7	580.1	841.4
CO_2 Reduction at $12.9/t[c]	5%	46.0	46.0	46.0
CO_2 Reduction at $40.8/t[c]	3%	178.6	178.6	178.6
CO_2 Reduction at $62.2/t[c]	2.50%	270.6	270.6	270.6
CO_2 Reduction at $117.0/t[c]	3%	550.9	550.9	550.9
NO_X Reduction at $2,639/t[c]	7%	2.9	2.9	2.9
	3%	4.9	4.9	4.9
Total (Operating Cost Savings, CO_2 Reduction and NO_X Reduction)[d]	7% plus CO_2 range	398 to 903	385 to 890	518 to 1023
	7%	530.7	517.6	650.4
	3%	790.2	763.6	1024.9
	3% plus CO_2 range	658 to 1163	631 to 1136	892 to 1397
Costs				
Incremental Purchase Price Increase	7%	479.4	572.6	386.3
	3%	574.6	695.6	453.5
Net Benefits/Costs				
Total (Operating Cost Savings, CO_2 Reduction and NO_X Reduction, Minus Incremental Cost Increase to Buildings)	7% plus CO_2 range	-28 to 477	-188 to 317	132 to 636
	7%	104.6	-55.0	264.2
	3%	215.7	68.0	571.4
	3% plus CO_2 range	187 to 692	-65 to 440	439 to 944

[a] Incremental costs are calculated for buildings constructed or renovated in 2015-2044; total benefits extend through 2074.

[b] The primary, low, and high estimates utilize forecasts of energy prices from the Annual Energy Outlook 2013 reference case (DOE 2012b). The low and high cases were based upon the percentage price deviations from the Annual Energy Outlook 2013 reference case as provided in the Low Economic Growth case and High Economic Growth case, respectively.

[c] These values represent global values (in 2012$) of the social cost of CO_2 (SCC) emissions in 2013 under several scenarios developed by the Interagency Working Group on Social Cost of Carbon (SCC) (OMB 2013). The values of $12.9, $40.8, and $62.2 per metric ton are the averages of SCC distributions calculated using 5%, 3%, and 2.5% discount rates, respectively. The value of $117.0 per ton represents the 95th percentile of the SCC distribution calculated using a 3% discount rate. For NO_x, values were extracted from OMB guidance (OMB 2006) and updated to 2012$. An average value ($2,639) of the low ($468) and high ($4,809) values was used.

[d] Total monetary benefits for both the 3% and 7% cases utilize the central estimate of social cost of NO_x and CO_2 emissions calculated at a 3% discount rate (averaged across three integrated assessment models (IAMs)), which is equal to $40.8/metric ton (in 2012$).

Table S-2 Annualized Benefits and Costs to the Federal Government for New and Existing Construction under the "Zero Fossil Fuel" Alternative[a]

	Discount Rate	Primary Estimate[b]	Low Estimate[b]	High Estimate[b]
		Monetized (2012 $million/year)		
Benefits				
Operating (Energy) Cost Savings	7%	601.4	583.1	781.2
	3%	1076.6	893.6	1259.6
CO_2 Reduction at $12.9/t(c)	5%	68.6	68.6	68.6
CO_2 Reduction at $40.8/t(c)	3%	257.9	257.9	257.9
CO_2 Reduction at $62.2/t(c)	2.50%	388.0	388.0	388.0
CO_2 Reduction at $117.0/t(c)	3%	793.2	793.2	793.2
NO_X Reduction at $2,639/t[c]	7%	4.8	4.8	4.8
	3%	7.1	7.1	7.1
Total (Operating Cost Savings, CO_2 Reduction and NO_X Reduction)[d]	7% plus CO_2 range	675 to 1399	657 to 1381	855 to 1579
	7%	864.1	845.8	1043.8
	3%	1341.6	1158.6	1524.7
	3% plus CO_2 range	1152 to 1877	969 to 1694	1335 to 2060
Costs				
Incremental Purchase Price Increase	7%	1043.8	1167.0	920.6
	3%	1021.6	1161.1	882.2
Net Benefits/Costs				
Total (Operating Cost Savings, CO_2 Reduction and NO_X Reduction, Minus Incremental Cost Increase to Buildings)	7% plus CO_2 range	-288 to 436	-510 to 214	-66 to 659
	7%	-99.0	-321.2	123.2
	3%	320.0	-2.5	642.5
	3% plus CO_2 range	131 to 855	-192 to 533	453 to 1178

(a) Incremental costs are calculated for buildings constructed or renovated in 2014-2044; total benefits extend through 2074.

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DOE also considered non-regulatory policy alternatives (e.g., tax credits, rebates, labeling programs) to the rule, but was unable to identify any non-regulatory policy alternatives that would be viable for Federal buildings.

Based upon the primary estimates from Table S-1 and Table S-2, a summary of the annualized net benefits estimated for the regulatory policy options considered in this RIA are presented in Table S-3. To reiterate, future incremental costs include both measures to improve the energy efficiency of Federal facilities as well as incorporating renewable energy [solar photovoltaic (PV)] technologies when necessary. Future benefits incorporate both reductions in annual energy expenditures and monetized benefits of emissions reductions. The analysis shows that applying a 3% or 7% discount rate to future

costs and benefits of the proposed rule yields a net economic savings to the nation. For the "Zero Fossil Fuel" alternative, which would require installation of solar PV systems on many new Federal facilities in the near term, the net economic benefits are negative using the 7% discount rate, but positive using the 3% discount rate assumption.

Table S-3. Annualized Net Benefits of Regulatory Policy Options (primary estimate)

	7% Discount Rate (2012 $millions/year)	3% Discount Rate (2012 $millions/year)
Proposed Rule	104.6	215.7
"Zero Fossil Fuel" Alternative	-99.0	320.0

Contents

Tables

1.0 Introduction

Section 433 of the *Energy Independence and Security Act of 2007* (Pub. L. 110-140) (EISA) directed the U.S. Department of Energy (DOE) to establish fossil fuel-generated energy consumption limits for new Federal buildings and Federal buildings undergoing major renovation (42 U.S.C. 6834(a)(3)(D)(i)).[1] The statute requires fossil fuel-generated energy[2] consumption reductions starting at 55% in fiscal year (FY) 2010 and increasing to 100% in FY 2030 and beyond. These reduction targets are measured relative to "typical" building energy use, as measured by DOE's Commercial Building Energy Consumption Survey (CBECS) and Residential Energy Consumption Survey (RECS). These targets only apply to new construction or major renovations with a total cost of $2.5 million (in 2007 dollars) or more and "public buildings" (as defined at 40 U.S.C. 3301) for which a prospectus to Congress is required under 40 U.S.C. 3307. The proposed rule is estimated to save 1.9 million metric tons of carbon emissions in 2030.

DOE has determined that the standards for Federal buildings outlined in the Fossil Fuel-Reduction Rule constitute an "economically significant regulatory action" under Executive Order (E.O.) 12866, *Regulatory Planning and Review*. DOE has therefore committed to comparing regulatory alternatives to the rule by performing a Regulatory Impact Analysis (RIA). This RIA, which DOE has prepared pursuant to E.O. 12866, examines the economic impact of the fossil fuel-reduction rule on the construction cost and total life-cycle construction and operating costs of Federal construction. DOE notes that the $2.5 million construction cost threshold for this Fossil Fuel-Reduction Rule almost certainly rules out application of this rule to Federal low-rise residential buildings as does the "public building" requiring a prospectus threshold because the definition at 40 U.S.C. 3301 specifically excludes residential buildings. Thus, the remainder of this RIA will focus on Federal commercial and multifamily high-rise residential buildings. DOE performed analyses for the impacts on Federal buildings for two alternatives to the rule: (1) a "no-action" alternative that assumes this rule is not published, but that existing energy efficiency requirements for new Federal construction remain in effect; and, (2) a more stringent "zero fossil fuel" alternative that requires Federal buildings to go immediately to the level of performance required in the rule as of FY 2030, i.e., a 100% reduction of a typical building's fossil fuel-generated energy consumption, or zero fossil fuel usage. Costs and benefits of each alternative to the rule are compared in this RIA. DOE also considered non-regulatory policy alternatives (e.g., tax credits, rebates, labeling programs) to the rule, but was unable to identify any non-regulatory policy alternatives that would be viable for Federal buildings.

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[1] The proposed Fossil Fuel-Reduction Rule includes the following definition of a New Federal Building: "New Federal building means any new building (including a complete replacement of an existing building from the foundation up) to be constructed by, or for the use of, any Federal agency. Such term shall include buildings built for the purpose of being leased by a Federal agency, and privatized military housing." The same document also includes the definition of Major Renovation: "Major renovation means changes to a building that provide significant opportunities for substantial improvement in energy efficiency. This may include, but is not limited to, replacement of the HVAC system, the lighting system, the building envelope, and other components of the building that have a major impact on energy usage. Major renovation also includes a renovation of any kind that provides significant opportunities for compliance with other applicable requirements in this part."

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2.0 Regulatory Options

DOE considered several alternatives in developing the fossil fuel-reduction rule consistent with its statutory mandate to base the fossil fuel-generated energy consumption limits on the FY 2003 version of CBECS and RECS. Specifically, as the baseline for this analysis DOE considered a "no-action" alternative of not issuing the rule, i.e., leaving new Federal construction subject to energy efficiency performance requirements found in 10 CFR Part 433, "Energy Efficiency Standards for New Federal Commercial and Multi-Family High-Rise Residential Buildings", which requires that new Federal buildings be built with energy consumption of at least 30% below the levels established in ANSI/ASHRAE/IES Standard 90.1-2010, *Energy Standard for Buildings Except Low-Rise Residential Buildings*, if life-cycle cost-effective.[1]

DOE also considered a "zero fossil fuel" alternative of immediately requiring the lowest fossil fuel-generated energy consumption limits specified in the rule of zero fossil fuel usage. The impact on construction costs over a 30-year period from 2015-2044 of adopting the rule, and going immediately to "zero fossil fuel usage" alternative, compared to the baseline "no-action" alternative is presented in Table 1. The first costs of construction are greatly dependent on the assumed cost of solar photovoltaic (PV) power in the future[2]. Columns labeled "High PV-Cost Scenario" (second and fourth columns in the table) assume only a modest decline in the cost of PV-generated electricity in the future in contrast to more significant cost reductions in the "Low PV-Cost Scenario" columns (third and fifth columns in the table). The specific key assumptions in the analysis are described in Section 4.1, while the origins of the cost estimates are described in Section 4.2.

Table 1. Construction Cost Increases under the Fossil Fuel-Reduction Rule and "Zero Fossil Fuel" Alternative (relative to baseline "no-action" alternative)

Calendar Year	Fossil Fuel-Reduction Rule - High PV Cost Scenario (2012 $million)	Fossil Fuel-Reduction Rule - Low PV Cost Scenario (2012 $million)	"Zero Fossil Fuel" Alternative - High PV Cost Scenario (2012 $million)	"Zero Fossil Fuel" Alternative - Low PV Cost Scenario (2012 $million)
2015	$30	$30	$1,194	$1,136
2016	$30	$30	$1,189	$1,103
2017	$30	$30	$1,183	$1,071
2018	$30	$30	$1,178	$1,040
2019	$30	$30	$1,173	$1,010
2020	$536	$447	$1,191	$1,005
2021	$534	$435	$1,186	$976
2022	$532	$424	$1,181	$949
2023	$530	$413	$1,175	$922
2024	$528	$402	$1,170	$896

[1] 10 CFR 433 currently requires that new Federal buildings be built with energy consumption at least 30% below the levels established in Standard 90.1-2007, if life-cycle cost-effective.

[2] Solar PV systems are assumed to be used to meet the targets of the Fossil Fuel-Reduction Rule once conservation measures alone can no longer meet the targets. Solar PV systems were chosen as commonly used on-site renewable energy systems. On-site renewable energy systems were chosen over use of renewable energy certificates (RECs) or power purchase agreements (PPAs) because REC and PPA usage is limited in the Fossil Fuel-Reduction Rule.

Table 1. (continued)

Calendar Year	Fossil Fuel-Reduction Rule - High PV Cost Scenario (2012 $million)	Fossil Fuel-Reduction Rule - Low PV Cost Scenario (2012 $million)	"Zero Fossil Fuel" Alternative - High PV Cost Scenario (2012 $million)	"Zero Fossil Fuel" Alternative - Low PV Cost Scenario (2012 $million)
2025	$841	$618	$1,165	$871
2026	$837	$601	$1,160	$847
2027	$834	$585	$1,155	$824
2028	$830	$569	$1,150	$801
2029	$827	$554	$1,145	$778
2030	$1,135	$736	$1,140	$757
2031	$1,130	$716	$1,140	$757
2032	$1,125	$696	$1,140	$757
2033	$1,120	$677	$1,140	$757
2034	$1,115	$658	$1,140	$757
2035	$1,110	$640	$1,140	$757
2036	$1,110	$640	$1,140	$757
2037	$1,110	$640	$1,140	$757
2038	$1,110	$640	$1,140	$757
2039	$1,110	$640	$1,140	$757
2040	$1,110	$640	$1,140	$757
2041	$1,110	$640	$1,140	$757
2042	$1,110	$640	$1,140	$757
2043	$1,110	$640	$1,140	$757
2044	$1,110	$640	$1,140	$757

PV = photovoltaic

As shown in Table 1, both the Fossil Fuel-Reduction Rule and the "zero fossil fuel" alternative would increase the cost of new construction and renovations to existing buildings relative to the "no-action" alternative. One item to note in Table 1 is the relatively low cost associated with the first 2 years of the analysis period under the Fossil Fuel-Reduction Rule. The estimated cost increase for these 2 years is associated entirely with existing buildings because the cost to design new buildings to the "no-action" alternative is higher than the cost estimated under the rule. This increase in cost is balanced by reducing the environmental impact of energy generation-related emissions. Therefore, the net present value of the estimated future stream of yearly benefits and costs to the Federal government (calculated using two different discount rates of 3% and 7%) is the difference between the increased purchase price and the decreased costs associated with annual energy use and emissions.

The results of expressing the net present value as annualized benefits (over the period 2015-2044) for the Fossil Fuel-Reduction Rule and the "zero fossil fuel" alternative are presented in Table 2 and Table 3, respectively, for both new construction and existing buildings. The present value of incremental costs is computed over the 30-year period extending from 2015 through 2044. The present value of operating cost savings and environmental benefits is computed over a longer period, 2015-2074, to capture all of the benefits accruing to buildings built through the year 2044. Thus, for analytical purposes, the benefits

were assumed to extend for a period of 30 years beyond the year of construction. However, the actual figures shown in Table 2 and Table 3 are expressed as annualized values over the 30-year period.[3]

Primary, low, and high estimates of the benefits and costs were developed to indicate the possible range of these metrics. The future energy prices used to compute operating cost savings for the primary estimate were taken from the *Annual Energy Outlook 2013* reference case. The low estimate combines slightly *lower* energy prices as compared to the high economic growth scenario reference case in the AEO 2013 case, along with the construction cost developed as part of the *high*-cost PV case (used for incremental construction cost). Alternatively, the high estimate combines *higher* energy prices relative to the low economic growth scenario reference case in the AEO 2013 case, along with the construction cost developed as part of the *low*-cost PV case. The average incremental construction cost based upon the high-cost PV case and the low-cost PV case was used as the primary estimate of incremental construction cost.

The net benefit in 2012 dollars to the Federal government using the primary estimate for PV system costs is $104.6 million/year using the 7% discount rate, while it is $215.7 million/year using the 3% discount rate for the Fossil Fuel-Reduction Rule (Table 2), while the corresponding values are -$99.0 million/year using the 7% discount rate and $320.0 million per year using the 3% discount rate for the "zero fossil fuel" alternative to the rule (Table 3).

[3] The purpose of extending the period out 60 years is to capture the life-cycle economic benefits of the buildings built in the last year of the analysis period (2044). This is the standard methodology used by DOE in its analysis of equipment energy-efficiency standards.

Table 2. Annualized Benefits and Costs to Federal Government for New and Existing Construction under the Fossil Fuel-Reduction Rule[a]

	Discount Rate	Primary Estimate[b]	Low Estimate[b]	High Estimate[b]
		Monetized (2012 $million/year)		
Benefits				
Operating (Energy) Cost Savings	7%	349.2	336.1	468.9
	3%	606.7	580.1	841.4
CO_2 Reduction at $12.9/t[c]	5%	46.0	46.0	46.0
CO_2 Reduction at $40.8/t[c]	3%	178.6	178.6	178.6
CO_2 Reduction at $62.2/t[c]	2.50%	270.6	270.6	270.6
CO_2 Reduction at $117.0/t[c]	3%	550.9	550.9	550.9
NO_X Reduction at $2,639/t[c]	7%	2.9	2.9	2.9
	3%	4.9	4.9	4.9
Total (Operating Cost Savings, CO_2 Reduction and NO_X Reduction)[d]	7% plus CO_2 range	398 to 903	385 to 890	518 to 1023
	7%	530.7	517.6	650.4
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[d] Total monetary benefits for both the 3% and 7% cases utilize the central estimate of social cost of NO_x and CO_2 emissions calculated at a 3% discount rate (averaged across three integrated assessment models (IAMs)), which is equal to $40.8/metric ton (in 2012$).

Table 3. Annualized Benefits and Costs to the Federal Government for New and Existing Construction under the "Zero Fossil Fuel" Alternative[a]

	Discount Rate	Primary Estimate[b]	Low Estimate[b]	High Estimate[b]
		Monetized (2012 $million/year)		
Benefits				
Operating (Energy) Cost Savings	7%	601.4	583.1	781.2
	3%	1076.6	893.6	1259.6
CO_2 Reduction at $12.9/t(c)	5%	68.6	68.6	68.6
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(b) The primary, low, and high estimates utilize forecasts of energy prices from the *Annual Energy Outlook 2013* reference case. The low and high cases were based upon the percentage price deviations from the *Annual Energy Outlook 2013* reference case as provided in the Low Economic Growth case and High Economic Growth case, respectively.

(c) These values represent global values (in 2012$) of the social cost of CO_2 (SCC) emissions in 2012 under several scenarios developed by the Interagency Working Group on Social Cost of Carbon (SCC) (OMB 2013). The values of $12.9, $40.8, and $62.2 per metric ton are the averages of SCC distributions calculated using 5%, 3%, and 2.5% discount rates, respectively. The value of $117.0 per ton represents the 95th percentile of the SCC distribution calculated using a 3% discount rate. For NOx, values were extracted from OMB guidance (OMB 2006) and updated to 2012$. An average value ($2,639) of the low ($468) and high ($4,809) values was used.

(d) Total monetary benefits for both the 3% and 7% cases utilize the central estimate of social cost of NO_x and CO_2 emissions calculated at a 3% discount rate (averaged across three integrated assessment models (IAMs)), which is equal to $40.8/metric ton (in 2012$).

3.0 Non-Regulatory Options

DOE also considered certain non-regulatory policy alternatives such as tax credits, rebates, and labeling programs, and was unable to identify any non-regulatory policy alternatives that would be viable for Federal buildings.

Federal agencies constructing new Federal buildings are not subject to Federal or state taxes and thus a tax credit program is not expected to be a viable option. DOE acknowledges that the current Federal tax incentive program[8] can be utilized by Federal agencies, but only to the extent that agencies can assign the tax incentives to private sector design firms who work on Federal buildings. The Fossil Fuel-Reduction Rule imposes much more efficient requirements on the design of new Federal buildings than are called for in the current Federal tax incentives and the issue is not that designers cannot envision buildings that meet those requirements, but simply that constructing a building that meets those requirements is costly. Without a way of directly subsidizing agencies for the added cost, no non-regulatory option is likely to be useful. Additionally, using a tax credit or incentive for Federal construction would simply be transferring money from one Federal source of funding to another, with no net benefit to the Federal government.

DOE also considered rebates and decided that any Federal rebate alternative suffers from the same problem as tax incentives – a rebate merely transfers money from one Federal source of funding to another, with no net benefit to the Federal government.

DOE also consider labeling programs as an alternative to the Fossil Fuel-Reduction Rule. However, Federal agencies are already encouraged to voluntarily participate in green building rating programs[9] and are required to use the Energy Star Portfolio Manager software by other legislation and rules. In that sense, many Federal buildings are already part of a labeling program so adding another label for fossil fuel usage was not judged a viable alternative.

[8] See http://www1.eere.energy.gov/buildings/tax_commercial.html for detailed description of Federal tax incentives for commercial buildings.

[9] Such as the US Green Building Council (USGBC) Leadership in Energy and Environmental Design (LEED) program (www.usgbc.org/LEED) and the Green Building Initiative (GBI) Green Globes program (www.thegbi.org).

4.0 Analysis Methodology

In DOE's previous rulemaking activities associated with efficiency standards for appliances and manufactured housing, the Energy Information Administration's (EIA) National Energy Modeling System (NEMS)[10] model has been used to generate estimates of the change in environmental emissions that, in turn, drive the monetary benefits shown in Tables 2 and 3 above. In these analyses, the use of NEMS is necessary because both appliance efficiency standards and the manufactured housing rule have dealt with only single (or at most several) end uses. Because different end use energy reductions have different implications for environmental emission reductions (primarily because of their differential impact on various types of electricity generation), NEMS has been judged the best available tool for evaluating these impacts. The Fossil Fuel-Reduction Rule differs from these previous rules in that it covers *all* end uses in future Federal building construction, including major renovations. Accordingly, a more straightforward approach that is deemed to provide a comparable degree of accuracy is to assume that percentage reductions in overall commercial building energy use can be translated into comparable reductions in environmental emissions associated with the entire commercial building sector.[11]

This approach, which may be termed a proportional impacts approach, assumes that because the Fossil Fuel-Reduction Rule applies to all end uses, the overall impacts of the rule applied to Federal buildings is approximately proportional to an overall reduction in all commercial building energy consumption. The proportional reduction in energy use is applied to the carbon emissions shown in the *Annual Energy Outlook* (NEMS) table entitled, "Table 18. Carbon Dioxide Emissions by Sector and Source." A comparable methodology is applied for NO_x emissions.

The actual calculations undertaken in this analysis are found in two linked spreadsheet workbooks available from Pacific Northwest National Laboratory: (1) "FF RIA Input_0430 v3.xlsx;" and (2) "National Benefits_FF_Rule_0430 v7.xlsx." Each spreadsheet includes brief how-to instructions in worksheets titled "Background."[12]

4.1 Key Assumptions in Analysis Methodology

The following assumptions were made in the Fossil Fuel-Reduction Rule RIA.

4.1.1 New Federal Commercial Building Construction Volume per Year

Assumption: 42 million square feet per year of new commercial and high-rise multifamily residential building construction.

Basis: This assumption is based on the analysis of 3 years of Federal construction data purchased by PNNL as part of a commercial building construction dataset. The data is

[10] See http://www.eia.gov/oiaf/aeo/overview/ for more information on NEMS.

[11] The decision to use an alternative approach to NEMS should not be taken as a criticism of NEMS. While NEMs is no longer used to analyze individual rules by DOE, it is used to evaluate generic cases and the results of those analyses are collapsed into "rules of thumb" results.

[12] For copies of these spreadsheets, contact Mark Halverson at mark.halverson@pnnl.gov.

described in "Weighting Factors for the Commercial Building Prototypes Used in the Development of ANSI/ASHRAE/IESNA Standard 90.1-2010", (Jarnagin and Bandyopadhyay, 2010). Data from the years 2007, 2008, and 2009 were used. The total Federal construction volume plus the construction volume associated with projects greater than $2 million based on the assumption that 20% of the construction cost would be related to design of the building and not the actual cost of the building materials and components. The results of this evaluation are as follows:

Year	Federal Construction Volume (million ft^2)	Federal Construction Volume for Projects Costing More than $2 million (million ft^2)
2007	30.64	29.38
2008	43.71	42.29
2009	51.72	50.45
Average	**42.02**	**40.71**

4.1.2 New Federal Commercial Construction Building Type Distribution

Assumption: 63% office building, 15% warehouse, 4% hospital, 8% education and training, 9% barracks and dormitory.

Basis: This assumption was originally derived from the Federal Real Property Council's FY2008 and FY2009 Federal Real Property Reports (GSA 2008, GSA 2009). Subsequent analysis of the FY2010, FY2011, and FY2012 Federal Real Property Council's reports (GSA 2010, GSA 2011, and GSA 2012) confirmed this distribution. The values assumed above were also used in the *Environmental Assessment for Final Rule, 10 CFR 433, "Energy Efficiency Standards for New Federal Commercial and Multi-Family High-Rise Residential Buildings"* (DOE 2011).

4.1.3 New Federal Commercial Fraction over $2.5 Million in Cost or For Which a Prospectus to Congress is Required

The $2.5 million threshold is a key parameter in deciding if a building falls under EISA Section 433 requirements. The threshold is more formally stated in the Fossil Fuel-Reduction Rule as follows:

> Those Federal buildings covered by EISA 2007 include new Federal buildings, or major renovations to Federal buildings, that are also: (1) public buildings, as defined in 40 U.S.C. 3301 for which a transmittal of a prospectus to Congress is required under 40 U.S.C. 3307; or (2) Federal buildings for which the construction cost or major renovation cost is at least $2,500,000 (2007 dollars, adjusted for inflation).

The assumed fraction (of total new floor space) includes both buildings that exceed this $2.5 million cost threshold as well as "public buildings" that meet the requirement for a prospectus to Congress. The U.S. General Services Administration (GSA) maintains an annual cost threshold for their buildings that was approximately $2.5 million in 2007 when EISA was signed.[13] The analysis in Section 4.1.1 uses a

[13] See http://www.gsa.gov/portal/content/101522 for current GSA cost thresholds.

threshold of $2 million dollars for projects under the assumption that 20% of the project cost would be in design costs and other costs that are not included in the database of Federal project costs[14].

Assumption: 97% of the Federal building stock falls under this requirement.

Basis: This value was chosen based on the analysis conducted for Section 4.1.1. The database shows that for the years 2007, 2008, and 2009, the fraction of Federal commercial construction projects greater than $2 million averages 0.97.

4.1.4 New Federal Construction Building Energy Usage

Assumption: New Federal construction building energy usage is assumed to meet the energy-efficiency performance standards currently found in 10 CFR Part 433. These standards call for the energy consumption by new Federal buildings to be at least 30% below the levels established by Standard 90.1-2010, if life-cycle cost-effective.[15]

Basis: Data taken from DOE's determination of energy savings for Standard 90.1-2010[16] were used for the typical value of energy use intensity for buildings that meet this requirement. This data was also used in DOE's *Environmental Assessment for Final Rule, 10 CFR 433, "Energy Efficiency Standards for New Federal Commercial and Multi-Family High-Rise Residential Buildings"* (DOE 2011).

4.1.5 Federal Commercial Renovation Volume per Year

Assumption: 14.6 million square feet per year of commercial and multifamily high-rise residential building construction.

Basis: This assumption is based on the analysis of 3 years of Federal construction data purchased by PNNL as part of a commercial building construction dataset. The data is described in "Weighting Factors for the Commercial Building Prototypes Used in the Development of ANSI/ASHRAE/IESNA Standard 90.1-2010", (Jarnagin and Bandyopadhyay, 2010). Data from the years 2007, 2008, and 2009 were used. The total Federal renovation cost plus the renovation cost associated with projects greater than $2.25 million based on the assumption that 10% of the construction cost would be related

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[14] The 20% design cost estimate was derived from an analysis of "value put in place" (VPIP) data from the Census Bureau (http://www.census.gov/construction/c30/methodology.html), data from the F.W. Dodge group of McGraw-Hill Construction (http://construction.com/dodge/), and data from R.S. Means (www.rsmeans.reedconstructiondata.com). There is a wide range of design cost estimates for new construction and 20% was chosen as a value in the middle of the range of estimates.

[15] The current 10 CFR Part 433 requires the use of ASHRAE Standard 90.1-2007 as a baseline for covered buildings for which design for construction began on or after August 10, 2012, but before July 9, 2014. (10 CFR 433.5)However, on July 9, 2013, DOE published a final rule updating the baseline standard for 10 CFR Part 433 to Standard 90.1-2010 for covered buildings for which design for construction began on or after July 9, 2014. Because the analysis period for this RIA starts in 2015, the baseline will be Standard 90.1-2010.

[16] See http://www.energycodes.gov/status/determinations_com.stm for all material on DOE's determination on Standard 90.1-2010.

to design of the building and not the actual cost of the building materials and components was used. Construction costs for renovations were converted to square footage by calculating the total cost of new Federal construction for the years 2007 to 2009, dividing that number by the total new construction square footage for the same years, and calculating a new Federal construction cost per square foot. This new Federal construction cost was then multiplied by 75% to generate a Federal renovation square foot cost[17]. The total cost of Federal renovations in each year was then divided by the Federal renovation square foot cost to give a Federal renovation square footage.

One important note on this data source is that it only considers major renovations in the sense that multiple systems of a building are changed. A less extensive renovation (such as an equipment replacement or system upgrade) is not included in this data source even though the cost of the equipment or system may exceed the $2.5 million threshold for the proposed rule. DOE has no good source of information on the frequency or magnitude of less extensive renovations that may also be considered "major" renovations.

The results of this evaluation are as follows:

Year	Federal Construction Renovation Volume (million ft^2)	Federal Construction Renovation Volume for Projects Costing More than $2.25 million (million ft^2)
2007	9.5	8.3
2008	11.1	9.6
2009	23.2	20.4
Average	**14.6**	**12.8**

4.1.6 Federal Commercial Renovation Fraction over $2.5 million in Cost or for which a Prospectus to Congress is Required

This is a key parameter in deciding if a building falls under EISA Section 433 requirements. The threshold is more formally stated in the Fossil Fuel-Reduction Rule as follows:

> Those Federal buildings covered by EISA 2007 include new Federal buildings, or major renovations to Federal buildings, that are also: (1) public buildings, as defined in 40 U.S.C. 3301 for which a transmittal of a prospectus to Congress is required under 40 U.S.C. 3307; or (2) Federal buildings for which the construction cost or major renovation cost is at least $2,500,000 (2007 dollars, adjusted for inflation).

The assumed fraction (of total new floor space) includes both buildings that exceed this $2.5 million cost threshold as well as "public buildings" that meet the requirement for a prospectus to Congress. GSA maintains an annual cost threshold of their own for their buildings that cost approximately $2.5 million in 2007 when EISA was signed.[18] The analysis for Section 4.1.5 used a threshold of $2.25 million under the

[17] The 75% estimate was based on analysis data from F.W. Dodge Division of McGraw-Hill Construction ((http://construction.com/dodge/). The data relate only to the total cost of "major alterations.

[18] See http://www.gsa.gov/portal/content/101522?utm_source=PBS&utm_medium=print-radio&utm_term=annualprospectusthreshold&utm_campaign=shortcuts for the GSA prospectus threshold.

assumption that 10% of renovation project costs were design or other costs not included in the Federal construction cost data base.

Assumption: 87% of Federal building stock falls under this requirement.

Basis: This value was chosen based on the analysis conducted for Section 4.1.5. The database shows that for the years 2007, 2008, and 2009, the fraction of Federal commercial renovation projects greater than $2.25 million averages 0.87.

4.1.7 Federal Commercial Major Renovation Fraction

Just because a renovation costs over $2.5 million does not mean it is a "major renovation" for the purpose of the Fossil Fuel-Reduction Rule. A renovation must also be a significant opportunity to meet the requirements of the rule. Replacing the carpeting, painting the walls, and moving some interior walls in a large Federal building may cost over $2.5 million, but that renovation would not be an opportunity to meet the Fossil Fuel-Reduction Rule.

Assumption: 88% of Federal building stock falls under this requirement.

Basis: This value was chosen based on the analysis conducted for Section 4.1.5. There is a large amount of uncertainty associated with this assumption.

4.1.8 Federal Commercial Major Renovation Savings Fraction

The approximate savings for a "typical" renovation must be estimated to determine the total energy saved by major renovations.

Assumption: 38% and 50% (depending on year).

Basis: The most detailed studies DOE has on renovations are the Advanced Energy Retrofit Guide (AERG) for Office Buildings.[19] Of these, only the large office is really applicable to the Federal commercial building sector. The Advanced Energy Retrofit Guide large office result shows that savings of about 23% can be achieved by simply doing commissioning, 38% in a "standard" retrofit, and 50% in a "deep" retrofit. These values are used in the analysis, with all buildings being assumed to be able to achieve "standard" retrofits for the years 2015 to 2019 and "deep" retrofits thereafter.[20]

4.1.9 Typical Existing Federal Building Energy Usage

This assumption is used for estimating the current total energy use by existing buildings.

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[19] See http://apps1.eere.energy.gov/buildings/commercial_initiative/resource_database/detail.cfm?p=537 for documentation and links to the AERG for office buildings.

[20] Work supported by DOE's Federal Energy Management Program (FEMP) indicates that "deep" retrofits are possible now, but it is not believed that they are particularly common at this time. See for example, the General Services Administration's (GSA) deep retrofit challenge at http://www.gsa.gov/portal/content/129983. An arbitrary decision was made to assume that deep retrofits are common in 2020.

Assumption: 113.9 kBtu/ft^2 to 89.5 kBtu/ft^2 depending on the year, with the estimated value held constant from 2015 on at the 2015 value[21].

Basis: Table 4.1.3 of DOE's Building Energy Databook, available at http://buildingsdatabook.eere.energy.gov/TableView.aspx?table=4.1.3.

4.1.10 Typical Existing Federal Building Electricity Fraction

The typical existing Federal building electricity fraction value is needed to convert a site to source energy, and to convert source energy to fossil fuel energy.

Assumption: 0.494

Basis: Table 4.1.2 of DOE's Building Energy Databook (DOE 2012a), available at http://buildingsdatabook.eere.energy.gov/TableView.aspx?table=4.1.2.

4.2 Cost Estimates

Cost estimates were developed for the following five cases.

4.2.1 New Construction Baseline under 10 CFR Part 433 Energy Efficiency Performance Standards

New construction is assumed to be built to an energy consumption level of at least 30% below that established by Standard 90.1-2010 in accordance with the baseline standards update to 10 CFR 433 that is currently undergoing OMB review. Costs for this level of performance were taken from PNNL-19004 (Thornton et al. 2009), *Technical Support Document: 50% Energy Saving Design Technology Packages for Medium Office Buildings*.[22]

4.2.2 New Construction under Proposed Rule

New construction under the proposed rule was assumed to be built to the performance requirements of the Fossil Fuel-Reduction Rule. For the 55% and 65% fossil fuel-reduction targets, energy conservation was assumed to meet the requirements and the data from PNNL-19004 was extrapolated to the appropriate levels of savings to provide costs. Beyond 65% fossil fuel-reduction, on-site solar PV system use was assumed to provide the additional fossil fuel-reduction necessary[23]. PV system costs were estimated as follows.

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[21] This assumption is valid if one assumes that buildings that will undergo major renovations in the years 2015 to 2030 will be buildings that have energy usage of typical Federal buildings in 2015.

[22] See http://www.pnl.gov/main/publications/external/technical_reports/PNNL-19004.pdf for this report.

[23] Solar PV systems are assumed to be used to meet the targets of the Fossil Fuel-Reduction Rule once conservation measures alone can no longer meet the targets. Solar PV systems were chosen as commonly used on-site renewable energy systems. On-site renewable energy systems were chosen over use of renewable energy certificates (RECs) or power purchase agreements (PPAs) because REC and PPA usage is limited in the Fossil Fuel-Reduction Rule.

Assumption: Installed cost of $5,600 per kW (DC) in 2012. Low benefits case: cost decline of 10% by 2035. High benefits case: cost decline by 50% by 2035.

Basis: The modeling and reports produced by the EIA with regard to the commercial building module in NEMS form the basis of these assumptions. NEMS is used to generate the *Annual Energy Outlook*, published in the beginning of each calendar year. The PV costs in NEMS are based upon a report prepared by ICF International for EIA in August 2010, *Photovoltaic (PV) Cost and Performance Characteristics for Residential and Commercial Applications*. Using the estimates provided in this report together with the "learning" algorithm in the NEMS commercial module, the *Annual Energy Outlook 2012 Early Release Overview*[24] reference case indicated an installed cost in 2009 dollars of $5,558/kW (kW expressed as DC) for commercial PV electricity generation[25] (personal communication with Erin Boedecker of EIA, March 20, 2012). Converting to 2012 dollars, the 2012 cost is approximately $5,779/kW. This is a composite of costs for both crystalline and thin-film PV modules; the EIA cost estimates imply that a majority of installations in the commercial building sector employ the thin-film technology.

The ICF International report projected future costs and performance for PV systems. By 2035, costs were assumed to decline by roughly 40% (42% for thin-film and 35% for crystalline). System efficiencies (DC to AC power) were assumed to increase in the range of 10%. For the analysis here related to a "high-benefits" case, these two projections were combined to yield an effective cost decline of 50% by 2035. A conservative ("low-benefits") assumption is that there will be only a modest cost reduction from this point forward. In this case, a 10% improvement was assumed to occur over this period. In both cases, the cost reductions were assumed to occur along a declining exponential growth path, thus yielding absolute annual reductions that are higher in the early years of the projection period compared to years approaching 2035. Costs beyond 2035 were fixed at their 2035 projected values.

4.2.3 New Construction under Zero Fossil Fuel Alternative

For new construction under the "zero fossil fuel" alternative, energy conservation was assumed to immediately bring the design of buildings to 65% fossil fuel reduction and the remaining 35% fossil fuel reduction were to be provided by PV systems[26]. Costs for the energy conservation and PV systems were calculated in the same way as for the proposed rule.

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[24] See 2012 AEO Early Release at http://www.eia.gov/forecasts/aeo/er/.

[25] Email from Erin Boedecker (DOE Energy Information Administration) to David Belzer (Pacific Northwest National Laboratory) regarding solar PV costs for commercial buildings. March 20, 2012.

[26] Solar PV systems are assumed to be used to meet the targets of the Fossil Fuel-Reduction Rule once conservation measures alone can no longer meet the targets. Solar PV systems were chosen as commonly used on-site renewable energy systems. On-site renewable energy systems were chosen over use of renewable energy certificates (RECs) or power purchase agreements (PPAs) because REC and PPA usage is limited in the Fossil Fuel-Reduction Rule.

4.2.4 Existing Buildings Baseline under 10 CFR Part 433 Energy Efficiency Performance Standards

The current 10 CFR Part 433 energy performance standards are applicable only to new construction. Therefore, the baseline cost for existing buildings is $0 in all years.

4.2.5 Existing Buildings under Proposed Rule or Zero Fossil Fuel Alternative

Existing building renovations under the proposed rule or the "zero fossil fuel" alternative are assumed to achieve levels of performance found in the *Advanced Energy Retrofit Guide for Office Buildings*.[27] The costs to achieve these levels of performance are taken from the *Advanced Energy Retrofit Guide for Office Buildings* (PNNL and PECI 2011).

[27] See http://apps1.eere.energy.gov/buildings/commercial_initiative/resource_database/detail.cfm?p=537 for documentation and links to the Advanced Energy Retrofit Guide for Office Buildings.

5.0 Conclusion

Based upon the primary estimates from Table 2 and Table 3, a summary of the annualized net benefits estimated for the regulatory policy options considered in this RIA are presented in Table 4. To reiterate, future incremental costs include both measures to improve the energy efficiency of Federal facilities as well as incorporating renewable energy (solar PV) technologies when necessary. Future benefits incorporate both reductions in annual energy expenditures and monetized benefits of emissions reductions. The analysis shows that applying a 3% or 7% discount rate to future costs and benefits of the proposed rule yields a net economic savings to the nation. For the "zero fossil fuel" alternative, which would require installation of solar PV systems on many new Federal facilities in the near term, the net economic benefits are negative using the 7% discount rate, but positive using the 3% discount rate assumption.

Table 4. Annualized Net Benefits of Regulatory Policy Options (primary and alternative estimates)

	7% Discount Rate (2012 $millions/year)	**3% Discount Rate (2012 $millions/year)**
Proposed Rule (primary estimate)	104.6	215.7
"Zero Fossil Fuel" Alternative	-99.0	320.0

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