

CHAPTER 9. EMISSIONS MONETIZATION

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CHAPTER 9. EMISSIONS MONETIZATION

9.1 INTRODUCTION

This chapter describes potential economic benefits that may result from reductions in environmental emissions due to amended energy conservation standards for commercial packaged boilers.

All of the potential standard levels analyzed are expected to result in reductions in environmental emissions in comparison to a baseline. (For the purposes of this EA, the baseline is defined as a scenario where DOE does not adopt any standard for commercial boilers). The changes in the demand for fossil fuel (including fuel oil and natural gas) and the costs of achieving these savings are the primary drivers for the reduction of environmental emissions. These emission reductions are then monetized using calculated values for the economic impacts to the nation of per-unit reductions in SO₂, NO_x and CO₂. Cumulative monetary benefits were determined using discount rates of 3 and 7 percent.

9.2 ECONOMIC VALUATION OF EMISSIONS REDUCTIONS

In addition to the estimation of reductions in physical emissions from an energy conservation standard, the analysis also considered the monetary benefits associated with these reductions.

Carbon Dioxide (CO₂)

During the preparation of its most recent review of the state of climate science, the Intergovernmental Panel on Climate Change (IPCC) identified various estimates of the present value of reducing carbon dioxide emissions by one ton over the life that these emissions would remain in the atmosphere. The estimates reviewed by the IPCC spanned a range of values. In the absence of a consensus on any single estimate of the monetary value of CO₂ emissions, DOE used an estimate identified by the study cited in Summary for Policymakers prepared by Working Group II of the IPCC's Fourth Assessment Report to calculate the potential monetary value of the CO₂ reductions likely to result from the standards under consideration in this rulemaking.

To put the potential monetary benefits from reduced CO₂ emissions into a form that is likely to be most useful to decision makers and interested parties, the estimated year-by-year reductions in CO₂ emissions were converted into monetary values and these resulting annual values were then discounted over the life of the affected equipment to the present using both 3 percent and 7 percent discount rates. DOE applied an annual growth rate of 2.4 percent to the value of the Social Cost of Carbon (SCC), as suggested by the IPCC Working Group II (2007, p. 822), based on estimated increases in damages from future emissions reported in published studies. As a result, DOE assigned a range for the SCC of \$0 to \$20 (2007\$) per ton of CO₂ emissions. These estimates were based on an assumption of no benefit to an average benefit value reported by the IPCC as the SCC.^a

^a According to IPCC, the mean social cost of carbon (SCC) reported in studies published in peer-reviewed journals was \$43 per ton of carbon. This translates into about \$12 per ton of carbon dioxide. The literature review (Tol

The IPCC estimate used as the upper bound value was derived from an estimate of the mean value of worldwide impacts from potential climate impacts caused by CO₂ emissions, and not just the effects likely to occur within the United States. In previous rulemakings, DOE considered that in estimating a monetary value for CO₂ emission reductions, the values should be restricted to a representation of those costs/benefits likely to be experienced in the United States and further expected that such values would be lower than comparable global values. DOE, in cooperation with other Federal agencies, is now reviewing whether this previous approach should be modified. Regardless, there currently are no consensus estimates for the U.S. benefits likely to result from CO₂ emission reductions. Because U.S.-specific estimates are unavailable and because DOE has not received any additional information that would help narrow the range of domestic benefits, DOE used the global mean value as an upper bound U.S. value.^b

The Department of Energy, together with other Federal agencies, is reviewing various methodologies for estimating the monetary value of reductions in CO₂ and other greenhouse gas emissions. This review will consider the comments on this subject that are part of the public record for this and other rulemakings, as well as other methodological assumptions and issues, such as whether the appropriate values should represent domestic U.S. or global benefits (and costs). Given the complexity of the many issues involved, this review is ongoing. However, consistent with DOE's legal obligations, and taking into account the uncertainty involved with this particular issue, DOE has included in the proposed rulemaking the values and analyses previously conducted.

Given the uncertainty surrounding estimates of the SCC, relying on any single study may be inadvisable since its estimate of the SCC will depend on many assumptions made by its authors. The Working Group II's contribution to the Fourth Assessment Report of the IPCC notes that:

The large ranges of SCC are due in the large part to differences in assumptions regarding climate sensitivity, response lags, the treatment of risk and equity, economic and non-economic impacts, the inclusion of potentially catastrophic losses, and discount rates.¹

Because of this uncertainty, DOE previously used the SCC value from Tol (2005), which was presented in the IPCC's "Fourth Assessment Report" and provided a comprehensive meta-analysis of estimates for the value of SCC. Tol released an update of his 2005 meta-analysis in September 2007 that reported an increase in the mean estimate of SCC from \$43 to \$71 per ton carbon. Although the Tol study was updated in 2007, the IPCC has not adopted the update. As a result, DOE previously decided to continue to rely on the study cited by the IPCC. DOE notes that the conclusions of Tol in 2007 are similar to the conclusions of Tol in 2005. In 2007, Tol continues to indicate that there is no consensus regarding the monetary value of reducing CO₂ emissions by 1 ton. The broad range of values in both Tol studies are the result of significant differences in the methodologies used in the studies Tol summarized. According to Tol, all of

2005) from which this mean was derived did not report the year in which these dollars were denominated. However, we understand this estimate was denominated in 1995 dollars.

^b In contrast, most of the estimates of costs and benefits of increasing the efficiency of commercial packaged boilers include only economic values of impacts that would be experienced in the U.S. DOE generally does not consider impacts on manufacturers that occur solely outside of the United States.

the studies have shortcomings, largely because the subject is inherently complex and uncertain and requires broad multidisciplinary knowledge. Thus, it was not certain that the values reported in Tol in 2007 are more accurate or representative than the values reported in Tol in 2005. For the ASHRAE NOPR, DOE used the range of values based on the values presented in Tol (2005) as proposed. Additionally, DOE applied an annual growth rate of 2.4 percent to the value of SCC, as suggested by the IPCC Working Group II (2007, p. 822). This growth rate is based on estimated increases in damage from future emissions that published studies have reported. Because the values in Tol (2005) were presented in 1995\$, DOE calculated more current values, assigning a range for SCC of \$0 to \$20 (2007\$) per ton of CO₂ emissions.

DOE believes that the most appropriate monetary values for consideration in the development of efficiency standards are those drawn from studies that attempt to estimate the present value of the marginal economic benefits likely to result from reducing greenhouse gas emissions, rather than estimates that are based on the market value of emission allowances under existing cap and trade programs or estimates that are based on the cost of reducing emissions—both of which are largely determined by policy decisions that set the timing and extent of emission reductions and do not necessarily reflect the benefit of reductions. The marginal social cost of carbon is an estimate of the monetary value to society of the environmental damage of CO₂ emissions. DOE also believes that the studies it relies upon generally should be studies that were the subject of a peer review process and were published in reputable journals.

The upper bound of the range used by DOE is based on Tol (2005)², which reviewed 103 estimates of the SCC from 28 published studies, and concluded that when only peer-reviewed studies published in recognized journals are considered, “that climate change impacts may be very uncertain but [it] is unlikely that the marginal damage costs of carbon dioxide emissions exceed \$50 per ton carbon [comparable to a value of \$20 per ton carbon dioxide when expressed in 2007\$ with a 2.4 percent growth rate.]”

In setting a lower bound of \$0, DOE agrees with the IPCC Working Group II (2007) report that “significant warming across the globe and the locations of significant observed changes in many systems consistent with warming is very unlikely to be due solely to natural variability of temperatures or natural variability of the systems” (pp. 9), and, thus, tentatively concludes that a global value of zero for reducing emissions cannot be justified. However, DOE also believes that it is reasonable to allow for the possibility that the U.S. portion of the global cost of carbon dioxide emissions may be quite low. In fact, some of the studies looked at in Tol (2005) reported negative values for the SCC. DOE is using U.S. benefit values, and not world benefit values, in its analysis and, further, DOE believes that U.S. domestic values will be lower than the global values. Additionally, the statutory criteria in EPCA do not require consideration of global effects. Therefore, DOE is using a lower bound of \$0 per ton of CO₂ emissions in estimating the potential benefits.

The Department is well aware that scientific and economic knowledge about the contribution of CO₂ and other green house gas (GHG) emissions to changes in the future global climate and the potential resulting damages to the world economy continues to evolve rapidly. Thus, any value placed in this rulemaking on reducing CO₂ emissions is subject to likely change. DOE recognizes the importance of continuing to monitor current research on the potential economic damages resulting from climate change, and of periodically updating estimates of the

value of reducing CO₂ emissions to reflect continuing advances in scientific and economic knowledge about the nature and extent of climate change and the threat it poses to world economic development. Further, DOE recognizes the interest and expertise of other Federal agencies, particularly the Environmental Protection Agency and the Department of Transportation, in terms of the issue of valuing the reductions in climate damages that are likely to result from those agencies' own efforts to reduce GHG emissions. DOE will continue to work closely with those and other Federal agencies in the development and review of the economic values of reducing GHG emissions.

Nitrogen Oxides (NO_x)

NO_x emissions from 28 eastern States and the District of Columbia (D.C.) are limited under the Clean Air Interstate Rule, published in the Federal Register on May 12, 2005. Although the rule has been remanded to EPA by the D.C. Circuit, it will remain in effect until it is replaced by a rule consistent with the Court's opinion in *North Carolina v. EPA* (see TSD Chapter 8 for more complete discussion). All States covered by CAIR opted to reduce NO_x emissions through participation in cap-and-trade programs for electric generating units; emissions from these sources are capped across the CAIR region. However, these emission caps do not address more disparate sources of NO_x, including sources such as commercial packaged boilers. As such, NO_x emissions from commercial packaged boilers for which DOE is setting efficiency standards are largely unregulated. Accordingly, DOE estimated the national monetized benefits of NO_x reductions associated with this rulemaking, based on environmental damage estimates from the literature. Available estimates suggest a very wide range of monetary values for NO_x emissions, ranging from \$370 per metric ton to \$3,800 per metric ton of NO_x from stationary sources, measured in 2001\$,³ or a range of \$432 per metric ton to \$4,441 per metric ton in 2007\$.

Sulfur Dioxide (SO₂)

As with NO_x, although regulations on SO₂ emissions for power plants currently exist, there are no national regulations limiting SO₂ emissions from relatively small and disparate sources such as oil-fired commercial packaged boilers.

SO₂ causes a wide variety of health and environmental impacts because of the way it reacts with other substances in the air. Direct human health effects, including respiratory effects, can be caused by SO₂ or by sulfate particles derived from the presence of SO₂ in the atmosphere. Damage to vegetation and water resources can result from acid rain and subsequent acidification of the terrestrial and aquatic environments. Aesthetic damages to building materials and visibility impairment can also result. All of these result in damages to the environment that have a monetary impact. Environmental damage from SO₂ emissions is dependent on the location of the emission and subsequent location of the environmental impact.

DOE conducted research to provide an estimate of the ranges of monetized benefits that could be attributed to the reduction of SO₂ emissions from commercial packaged boilers based on a range of estimates. At one end, DOE used the annual estimates of an SO₂ trading price as developed in the National Energy Modeling System (NEMS) electricity market model for the western and eastern U.S. This model estimates a trading price for SO₂ in the utility markets, and

while not directly applicable to commercial packaged boilers, does reflect a market value for the cost of reducing SO₂ emissions into the atmosphere. As DOE is interested in a national estimate, it used a simple average of the trading prices from the eastern and western electricity market models for the period from 2012-2030, and extrapolated the prices out through 2042.

These range in SO₂ costs from this source varied both by year and region from \$86 to \$1,012 (2007\$). At the higher end, DOE used an estimate of environmental damage costs of \$7,300 per metric ton of SO₂ from stationary sources, measured in 2001\$^{e,4} or \$8,542 per metric ton in 2007\$. These low and high values were in turn multiplied by the emission of SO₂ estimated for the period from 2012-2042.

The resulting estimates of the potential range of the present value of monetary benefits associated with the national reduction of CO₂, NO_x and SO₂ emissions resulting from adoption of standards for commercial packaged boilers at the ASHRAE 90.1-2007 efficiency levels are shown by equipment class in Table 9.2.1 (7 percent discount rate) and Table 9.2.2 (3 percent discount rate). As with the energy emission benefits discussed previously, these are benefits calculated against the market baseline.

Table 9.2.1 Cumulative Present Value for Emissions Reductions from Commercial Boilers from 2012 to 2042 for Adopting ASHRAE Standard 90.1-2007 over the Market Baseline, Seven Percent Discount Rate

Equipment Class	Cumulative National Emissions Impact from 2012 to 2042					
	CO ₂ (Thousand 2007\$)		NO _x (Thousands 2007\$)		SO ₂ (Thousands 2007\$)	
	Low	High	Low	High	Low	High
Small, Gas-fired, Hot Water	\$0	\$4,716	\$95	\$983	\$0	\$0
Small, Gas-fired, Steam, All Except natural Draft	\$0	\$215	\$4	\$45	\$0	\$0
Small, Gas-fired, Steam, Natural Draft	\$0	\$12,153	\$230	\$2,366	\$0	\$0
Small, Oil-fired, Hot Water	\$0	\$4,735	\$68	\$699	\$254	\$4,651
Small, Oil-fired, Steam	\$0	\$2,284	\$33	\$337	\$122	\$2,243
Large, Gas-fired, Hot Water	\$0	\$2,068	\$42	\$431	\$0	\$0
Large, Gas-fired, Steam, All Except Natural Draft	\$0	\$1,235	\$25	\$257	\$0	\$0
Large, Gas-fired, Steam, Natural Draft	\$0	\$8,716	\$157	\$1,615	\$0	\$0
Large, Oil-fired, Hot Water	\$0	\$0	\$0	\$0	\$0	\$0
Large, Oil-fired, Steam	\$0	\$0	\$0	\$0	\$0	\$0

Table 9.2.2 Cumulative Present Value for Emissions Reductions from Commercial Boilers from 2012 to 2042 for Adopting ASHRAE Standard 90.1-2007 over the Market Baseline, Three Percent Discount Rate

Equipment Class	Cumulative National Emissions Impact from 2012 to 2042					
	CO ₂ (Thousand 2007\$)		NO _x (Thousands 2007\$)		SO ₂ (Thousands 2007\$)	
	Low	High	Low	High	Low	High
Small, Gas-fired, Hot Water	\$0	\$11,368	\$218	\$2,242	\$0	\$0
Small, Gas-fired, Steam, All Except natural Draft	\$0	\$518	\$10	\$102	\$0	\$0
Small, Gas-fired, Steam, Natural Draft	\$0	\$32,087	\$582	\$5,995	\$0	\$0
Small, Oil-fired, Hot Water	\$0	\$11,415	\$155	\$1,594	\$549	\$10,609
Small, Oil-fired, Steam	\$0	\$5,505	\$75	\$769	\$265	\$5,116
Large, Gas-fired, Hot Water	\$0	\$4,985	\$95	\$983	\$0	\$0
Large, Gas-fired, Steam, All Except Natural Draft	\$0	\$2,978	\$57	\$587	\$0	\$0
Large, Gas-fired, Steam, Natural Draft	\$0	\$24,399	\$428	\$4,408	\$0	\$0
Large, Oil-fired, Hot Water	\$0	\$0	\$0	\$0	\$0	\$0
Large, Oil-fired, Steam	\$0	\$0	\$0	\$0	\$0	\$0

In addition, DOE developed estimates of the potential range of the present value of monetary benefits associated with the national reduction of CO₂, NO_x, and SO₂ emissions resulting from adoption of standards higher than the ASHRAE Standard 90.1-2007 efficiency levels. These estimates are shown by equipment class in Table 9.2.3 (7 percent discount rate) and Table 9.2.4 (3 percent discount rate).

Table 9.2.3 Cumulative Present Value of National Emissions Reductions for Commercial Boilers from 2012 to 2042 for Adoption of Analyzed Higher Standards over ASHRAE 90.1-2007 Baseline, Seven Percent Discount Rate

Equipment Class	Cumulative Value of National Emissions Reductions from 2012 to 2042 (Thousand 2007\$)*,**											
	Efficiency Level 1			Efficiency Level 2			Efficiency Level 3			Efficiency Level 4		
	CO ₂	NO _x	SO ₂	CO ₂	NO _x	SO ₂	CO ₂	NO _x	SO ₂	CO ₂	NO _x	SO ₂
	Low - High \$	Low - High \$	Low - High \$	Low - High \$	Low - High \$	Low - High \$	Low - High \$	Low - High \$	Low - High \$	Low - High \$	Low - High \$	Low - High \$
Small, Gas-fired, Hot Water	0 - 8,091	157 - 1,618	0 - 0	0 - 27,056	157 - 1,618	0 - 0	0 - 52,820	1,039 - 10,710	0 - 0	0 - 79,945	1,574 - 16,223	0 - 0
Small, Gas-fired, Steam, All Except natural Draft	0 - (32)	(1) - (8)	0 - 0	0 - 5,371	(1) - (8)	0 - 0	0 - 11,226	221 - 2,280	0 - 0	0 - 17,128	338 - 3,480	0 - 0
Small, Gas-fired, Steam, Natural Draft	0 - (1,235)	(13) - (137)	0 - 0	0 - 6,933	(13) - (137)	0 - 0	0 - 16,885	344 - 3,546	0 - 0	na	na	na
Small, Oil-fired, Hot Water	0 - 7,713	106 - 1,091	384 - 7,263	0 - 17,324	106 - 1,091	877 - 16,470	0 - 29,099	405 - 4,169	1,480 - 27,750	na	na	na
Small, Oil-fired, Steam	0 - 4,658	64 - 661	233 - 4,401	0 - 13,580	64 - 661	691 - 12,948	0 - 34,913	487 - 5,015	1,785 - 33,384	na	na	na
Large, Gas-fired, Hot Water	0 - 5,312	104 - 1,068	0 - 0	0 - 13,962	104 - 1,068	0 - 0	0 - 23,023	453 - 4,668	0 - 0	0 - 66,462	1,310 - 13,497	0 - 0
Large, Gas-fired, Steam, All Except Natural Draft	0 - 8,161	160 - 1,652	0 - 0	0 - 23,784	160 - 1,652	0 - 0	0 - 39,671	782 - 8,056	0 - 0	0 - 55,804	1,100 - 11,336	0 - 0
Large, Gas-fired, Steam, Natural Draft	0 - (6,793)	(117) - (1,207)	0 - 0	0 - 2,074	(117) - (1,207)	0 - 0	0 - 13,520	285 - 2,938	0 - 0	0 - 27,058	553 - 5,701	0 - 0
Large, Oil-fired, Hot Water	0 - 6,962	97 - 1,002	357 - 6,669	0 - 12,279	97 - 1,002	630 - 11,762	0 - 17,472	244 - 2,514	896 - 16,737	na	na	na
Large, Oil-fired, Steam	0 - 20,280	283 - 2,919	1,040 - 19,427	0 - 54,700	283 - 2,919	2,805 - 52,400	0 - 102,301	1,429 - 14,723	5,246 - 97,999	0 - 211,478	2,953 - 30,435	10,844 - 202,583

*Negative values, shown in parentheses, indicate emissions savings over the base case

**na indicates that the equipment class did not have an Efficiency Level 4

Table 9.2.4 Cumulative Present Value of National Emissions Reductions for Commercial Boilers from 2012 to 2042 for Adoption of Analyzed Higher Standards over ASHRAE 90.1-2007 Baseline, Three Percent Discount Rate

Equipment Class	Cumulative Value of National Emissions Reductions from 2012 to 2042 (Thousand 2007\$)*, **											
	Efficiency Level 1			Efficiency Level 2			Efficiency Level 3			Efficiency Level 4		
	CO ₂	NO _x	SO ₂	CO ₂	NO _x	SO ₂	CO ₂	NO _x	SO ₂	CO ₂	NO _x	SO ₂
	Low - High \$	Low - High \$	Low - High \$	Low - High \$	Low - High \$	Low - High \$	Low - High \$	Low - High \$	Low - High \$	Low - High \$	Low - High \$	Low - High \$
Small, Gas-fired, Hot Water	0 - 20,503	381 - 3,928	0 - 0	0 - 67,647	1,267 - 13,060	0 - 0	0 - 131,692	2,471 - 25,466	0 - 0	0 - 199,119	3,738 - 38,527	0 - 0
Small, Gas-fired, Steam, All Except natural Draft	0 - (63)	(1) - (14)	0 - 0	0 - 13,368	251 - 2,588	0 - 0	0 - 27,923	525 - 5,407	0 - 0	0 - 42,596	800 - 8,249	0 - 0
Small, Gas-fired, Steam, Natural Draft	0 - (5,128)	(73) - (752)	0 - 0	0 - 15,176	309 - 3,181	0 - 0	0 - 39,916	774 - 7,973	0 - 0	na	na	na
Small, Oil-fired, Hot Water	0 - 19,563	257 - 2,652	890 - 17,654	0 - 43,455	575 - 5,929	2,002 - 39,465	0 - 72,727	965 - 9,944	3,363 - 66,189	na	na	na
Small, Oil-fired, Steam	0 - 11,767	155 - 1,599	538 - 10,643	0 - 33,945	450 - 4,641	1,570 - 30,891	0 - 86,976	1,156 - 11,914	4,037 - 79,305	na	na	na
Large, Gas-fired, Hot Water	0 - 13,374	250 - 2,572	0 - 0	0 - 34,878	654 - 6,737	0 - 0	0 - 57,403	1,077 - 11,100	0 - 0	0 - 165,385	3,107 - 32,017	0 - 0
Large, Gas-fired, Steam, All Except Natural Draft	0 - 20,390	382 - 3,938	0 - 0	0 - 59,225	1,112 - 11,461	0 - 0	0 - 98,717	1,854 - 19,111	0 - 0	0 - 138,822	2,608 - 26,879	0 - 0
Large, Gas-fired, Steam, Natural Draft	0 - (19,929)	(340) - (3,505)	0 - 0	0 - 1,964	73 - 753	0 - 0	0 - 30,225	607 - 6,251	0 - 0	0 - 63,653	1,237 - 12,754	0 - 0
Large, Oil-fired, Hot Water	0 - 17,306	230 - 2,374	805 - 15,799	0 - 30,522	406 - 4,186	1,420 - 27,865	0 - 43,432	578 - 5,957	2,020 - 39,651	na	na	na
Large, Oil-fired, Steam	0 - 50,414	671 - 6,914	2,345 - 46,024	0 - 135,977	1,810 - 18,650	6,326 - 124,138	0 - 254,305	3,384 - 34,879	11,830 - 232,164	0 - 525,699	6,996 - 72,102	24,456 - 479,930

*Negative values, shown in parentheses, indicate emissions savings over the base case

**na indicates that the equipment class did not have an Efficiency Level 4

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ABBREVIATIONS AND ACRONYMS

ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning
CAIR	Clean Air Interstate Rule
CFR	Code of Federal Regulations
CO ₂	Carbon Dioxide
DOE	U.S. Department of Energy
EIA	Energy Information Administration
EPA	Environmental Protection Agency
EPCA	Energy Policy and Conservation Act of 1975
GHG	Green House Gas
IPCC	Intergovernmental Panel on Climate Change
LCC	Life-Cycle Cost
N ₂	Nitrogen
NEMS	National Energy Modeling System
NEMS-BT	National Energy Modeling System-Building Technologies version
NEPA	National Environmental Policy Act
NO ₂	Nitrogen Dioxide
NO _x	Nitrous Oxides
NODA	Notice of Data Availability
NOPR	Notice of Proposed Rulemaking

NPV	Net Present Value
NSPS	New Source Performance Standards
OMB	Office of Management and Budget
O ₃	Ozone
SCC	Social Cost of Carbon
SO ₂	Sulfur Dioxide
TSD	Technical Support Document