

Annex M

Sulfur Dioxide Emissions

Sulfur dioxide (SO₂) emitted into the atmosphere through natural and anthropogenic processes affects the Earth's radiative budget through photochemical transformation into sulfate aerosols that can (1) scatter sunlight back to space, thereby reducing the radiation reaching the Earth's surface; (2) affect cloud formation; and (3) affect atmospheric chemical composition (e.g., stratospheric ozone, by providing surfaces for heterogeneous chemical reactions). The overall effect of SO₂ derived aerosols on radiative forcing is believed to be negative (IPCC 1996). However, because SO₂ is short-lived and unevenly distributed through the atmosphere, its radiative forcing impacts are highly uncertain. Sulfur dioxide emissions have been provided below in Table M-1.

The major source of SO₂ emissions in the United States was the burning of sulfur containing fuels, mainly coal. Metal smelting and other industrial processes also released significant quantities of SO₂. As a result, the largest contributors to overall U.S. emissions of SO₂ were electric utilities, accounting for 58 percent in 1998 (see Table M-2). Coal combustion accounted for approximately 94 percent of SO₂ emissions from electric utilities in the same year. The second largest source was industrial fuel combustion, which produced 20 percent of 1998 SO₂ emissions. Overall, SO₂ emissions in the United States decreased by 9 percent from 1990 to 1998. The majority of this decline came from reductions from electric utilities, primarily due to increased consumption of low sulfur coal from surface mines in western states.

Sulfur dioxide is important for reasons other than its effect on radiative forcing. It is a major contributor to the formation of urban smog and acid rain. As a contributor to urban smog, high concentrations of SO₂ can cause significant increases in acute and chronic respiratory diseases. In addition, once SO₂ is emitted, it is chemically transformed in the atmosphere and returns to earth as the primary contributor to acid deposition, or acid rain. Acid rain has been found to accelerate the decay of building materials and paints, and to cause the acidification of lakes and streams and damage trees. As a result of these harmful effects, the United States has regulated the emissions of SO₂ under the Clean Air Act. The EPA has also developed a strategy to control these emissions via four programs: (1) the National Ambient Air Quality Standards program,¹ (2) New Source Performance Standards,² (3) the New Source Review/Prevention of Significant Deterioration Program,³ and (4) the sulfur dioxide allowance program.⁴

References

EPA (1999) *National Air Pollutant Emissions Trends Report, 1900-1998*, U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC.

¹[42 U.S.C 7409, CAA 109]

²[42 U.S.C 7411, CAA 111]

³[42 U.S.C 7473, CAA 163]

⁴[42 U.S.C 7651, CAA 401]

Table M-1: SO₂ Emissions (Gg)

Sector/Source	1990	1991	1992	1993	1994	1995	1996	1997	1998
Energy	20,120	19,675	19,463	19,157	18,650	16,241	17,490	17,994	18,199
Stationary Combustion	18,407	17,959	17,684	17,459	17,134	14,724	15,981	16,458	16,635
Mobile Combustion	1,322	1,373	1,402	1,351	1,172	1,183	1,208	1,235	1,261
Oil and Gas Activities	390	343	377	347	344	334	300	301	303
Industrial Processes	1,306	1,187	1,186	1,159	1,135	1,117	1,167	1,184	1,204
Chemical Manufacturing	269	254	252	244	249	260	445	451	457
Metals Processing	658	555	558	547	510	481	387	395	402
Storage and Transport	6	9	8	4	1	2	2	2	3
Other Industrial Processes	362	360	360	355	361	365	316	321	327
Miscellaneous*	11	10	9	9	14	9	17	14	15
Solvent Use	+	+	+	1	1	1	+	1	1
Degreasing	+	+	+	+	+	+	+	+	+
Graphic Arts	+	+	+	+	+	+	+	+	+
Dry Cleaning	NA	NA	+	NA	+	+	+	+	+
Surface Coating	+	+	+	+	+	+	+	+	+
Other Industrial	+	+	+	+	+	+	+	+	+
Non-industrial	NA								
Agriculture	NA								
Agricultural Burning	NA								
Waste	38	40	40	65	54	43	37	37	38
Waste Combustion	38	39	39	56	48	42	36	36	37
Landfills	+	+	+	+	+	+	+	+	+
Wastewater Treatment	+	+	+	+	+	1	+	+	+
Miscellaneous Waste	+	1	1	8	5	+	+	+	+
Total	21,465	20,903	20,689	20,381	19,840	17,401	18,695	19,216	19,441

Source: (EPA 1999)

* Miscellaneous includes other combustion and fugitive dust categories.

+ Does not exceed 0.5 Gg

NA (Not Available)

Note: Totals may not sum due to independent rounding.

Table M-2: SO₂ Emissions from Electric Utilities (Gg)

Fuel Type	1990	1991	1992	1993	1994	1995	1996	1997	1998
Coal	13,807	13,687	13,448	13,179	12,985	10,526	11,010	11,378	11,272
Petroleum	580	591	495	555	474	375	395	443	662
Natural Gas	1	1	1	1	1	8	2	1	1
Misc. Internal Combustion	45	41	42	45	48	50	51	53	54
Total	14,432	14,320	13,986	13,779	13,507	10,959	11,459	11,875	11,990

Source: (EPA 1999)

Note: Totals may not sum due to independent rounding.