

Annex L

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 L-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 66 percent in 1996 (see Table L-2). Coal combustion accounted for approximately 96 percent of SO₂ emissions from electric utilities in the same year. The second largest source was industrial fuel combustion, which produced 18 percent of 1996 SO₂ emissions. Overall, sulfur dioxide emissions in the United States decreased by 19 percent from 1990 to 1996. Eighty-two percent 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, as well as 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,¹¹ (2) New Source Performance Standards,¹² (3) the New Source Review/Prevention of Significant Deterioration Program,¹³ and (4) the sulfur dioxide allowance program.¹⁴

¹¹ [42 U.S.C § 7409, CAA § 109]

¹² [42 U.S.C § 7411, CAA § 111]

¹³ [42 U.S.C § 7473, CAA § 163]

¹⁴ [42 U.S.C § 7651, CAA § 401]

Table L-1: Emissions of SO₂ (Gg)

Sector/Source	1990	1991	1992	1993	1994	1995	1996
Energy	20,034	19,524	19,327	18,973	18,444	16,006	16,174
Stationary Sources	18,407	17,959	17,684	17,459	17,134	14,724	15,228
Mobile Sources	1,237	1,222	1,267	1,166	965	947	612
Oil and Gas Activities	390	343	377	347	344	334	334
Industrial Processes	1,306	1,187	1,186	1,159	1,135	1,116	1,122
Chemical Manufacturing	269	254	252	244	249	260	260
Metals Processing	658	555	558	547	510	481	481
Storage and Transport	6	9	8	4	1	2	2
Other Industrial Processes	362	360	360	355	361	365	371
Miscellaneous*	11	10	9	8	13	8	8
Solvent Use	+	+	+	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	43
Waste Combustion	38	39	39	56	48	42	42
Landfills	+	+	+	+	+	+	+
Wastewater Treatment	+	+	+	+	+	1	1
Miscellaneous Waste	+	1	1	8	5	+	+
Total	21,379	20,752	20,554	20,196	19,633	17,165	17,339

Source: (EPA 1997)

* 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 L-2: Emissions of SO₂ from Electric Utilities (Gg)

Fuel Type	1990	1991	1992	1993	1994	1995	1996
Coal	13,807	13,687	13,448	13,179	12,985	10,526	10,990
Oil	580	591	495	555	474	375	373
Gas	1	1	1	1	1	8	19
Misc. Internal Combustion	45	41	42	45	48	50	52
Total	14,432	14,320	13,986	13,779	13,507	10,959	11,434

Source: (EPA 1997)

Note: Totals may not sum due to independent rounding.