

ENVIRONMENTAL FOOTPRINT COMPARISON TOOL

A tool for understanding environmental decisions related to the pulp and paper industry

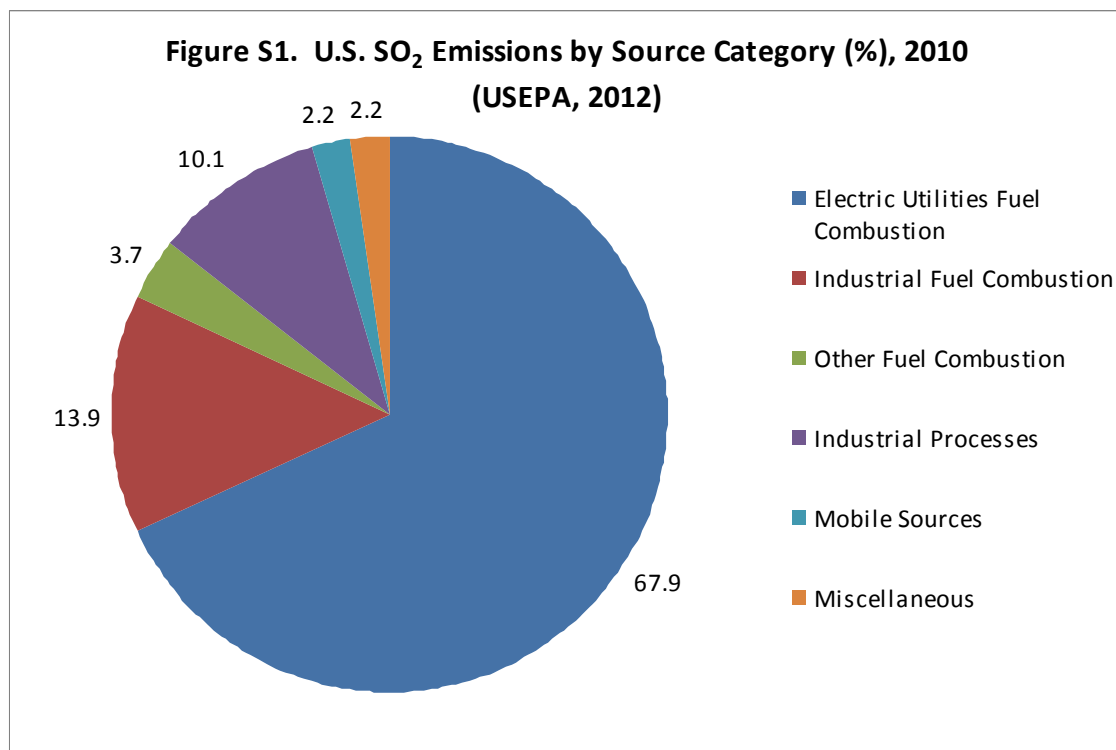
OVERVIEW OF EFFECTS OF DECREASED SO_x AND NO_x EMISSIONS

Introduction

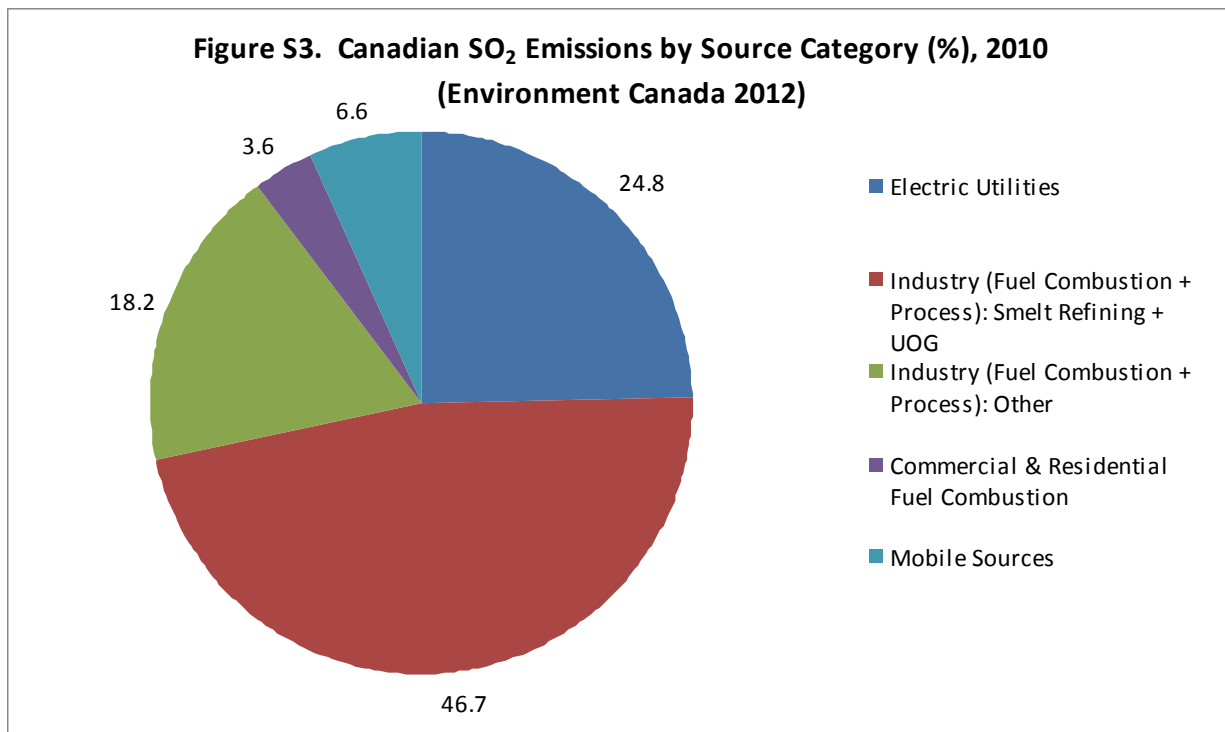
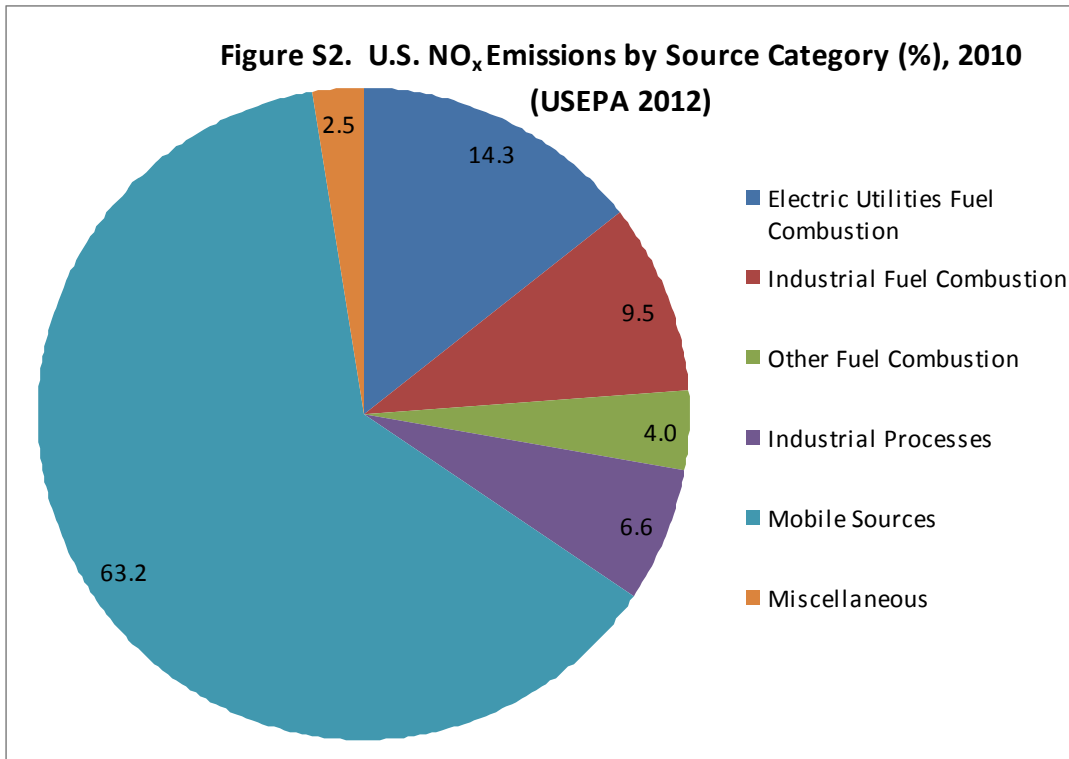
Lingering environmental concerns associated with sulfur oxides (SO_x) and nitrogen oxides (NO_x) emissions prompt continued pressure for further emissions reductions. Forest products manufacturing is one of many industrial sources of these emissions. They originate as products of combustion that accompany steam and power generation, processing of pulping chemicals, and wood drying. In the US, electric utilities are by far the dominant sector for SO_x and NO_x emissions. In Canada, smelting (for SO_x) and upstream oil and gas (for NO_x) sectors dominate these releases.

Since the 1980s, measures have been taken in North America to reduce atmospheric emissions of SO_x and NO_x where levels contributed to impaired environmental quality, as well as in response to government mandated performance standards. Considered together, these substances have been implicated in adverse respiratory effects where certain thresholds are exceeded, as well as acidic deposition thought to be of consequence to vegetation, soils, and surface waters. NO_x emissions are also known to contribute to ozone formation and deposition-related eutrophication of surface waters. Most recently, SO_x and NO_x emissions are being scrutinized because of their role in the formation of fine particulate matter, which is an emerging health concern and a contributor to visibility impairment in certain geographic settings (USEPA 2007).

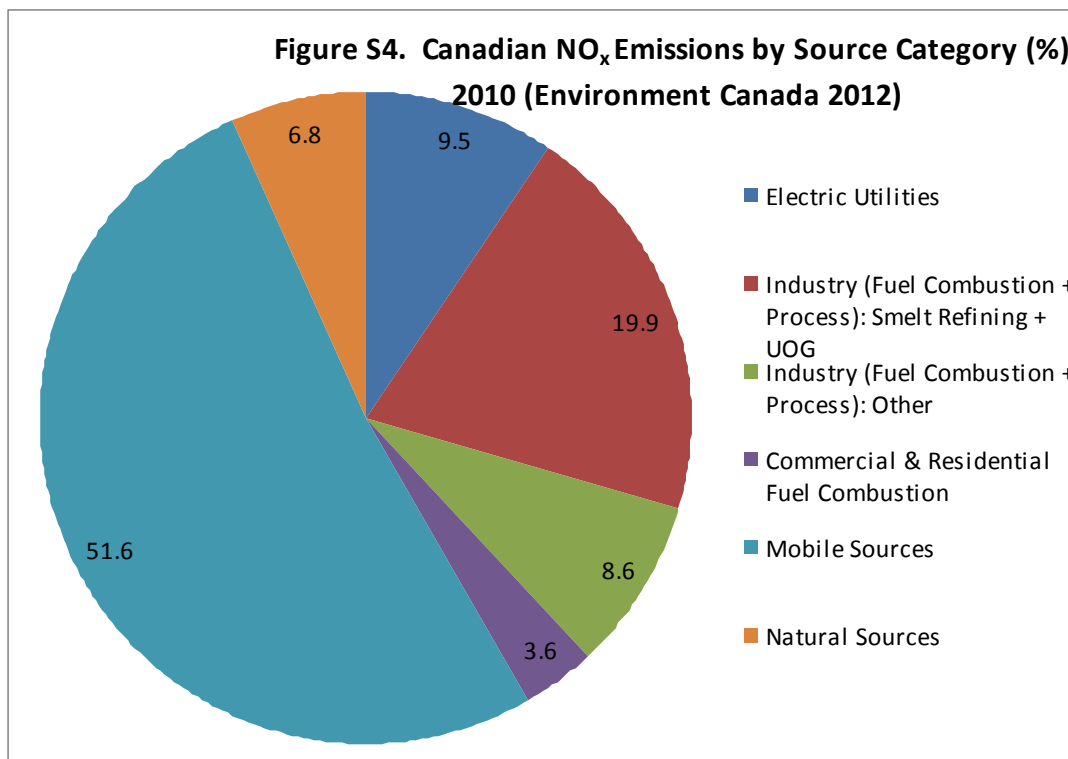
SO_x and NO_x emissions are both largely the result of combustion processes. They differ, however, in the relative contributions from stationary and mobile sources, as indicated in Figures S1 and S2 for sources in the United States (USEPA 2012) and Figures S3 and S4 for sources in Canada (Environment Canada 2012).



Effects of Decreased SO_x and NO_x Emissions
General Overview



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In the U.S., SO_x emissions are dominated by stationary sources, foremost among them electric utilities. The fuel combustion-related emissions from utilities are about five times those associated with industrial fuel combustion, the second largest source. NO_x emissions are dominated by mobile sources, which are nearly three times as great as those from utility and industrial fuel combustion combined. Emissions reductions since the 1980s have been dramatic. Ambient air quality standards for NO₂ are universally met across the United States, and the new more stringent short-term SO₂ standards are exceeded in just four limited areas in the nation (USEPA 2011). Further reductions in ambient concentrations will occur due to revision of performance standards, declining use of coal by electric utilities and industrial sources, and requirements that utilities and industry address emissions that contribute to regional haze and ozone.

Industry Performance

The most prominent source of SO_x and NO_x emissions at a pulp and paper mill is the power boilers that generate steam and electrical energy for the manufacturing process. Both SO_x and NO_x are the result of the combustion of sulfur- or nitrogen-containing fossil fuels and non-fossil fuels, respectively. Emission levels are driven largely by the choice of fuels, principally fossil fuels fired alone or in combination with wood-derived fuels, along with the facility’s approach for controlling these emissions either *in situ* or post-combustion. The magnitude of boiler emissions in 2010 relative to those from process sources is illustrated in Table S1. Note that in the pulp and paper industry, SO_x is typically measured as SO₂. NO_x is made up of NO and NO₂, and all the NO is reported as though it were NO₂ (NCASI 2012).

Table S1. Prominent Pulp and Paper Industry Sources of SO_x and NO_x (10³ tons)

Source	SO ₂	NO _x
Power Boilers	205	124
Kraft Recovery Furnaces*	29	55
Kraft Lime Kilns*	2	8
Kraft Thermal Oxidizers	1	1

*Includes units at one soda pulp mill

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Kraft recovery furnaces are the second largest source after power boilers. Together, boilers and recovery furnaces constitute approximately 98% and 92% of the pulp and paper sector's SO_x and NO_x emissions, respectively.

The pulp and paper industry has a history of reducing emission levels of SO_x and NO_x. Practices that have been applied or have potential application include

- increased energy efficiency;
- use of alternative fuels with low nitrogen and sulfur content or lower emission potential;
- decreasing the moisture content and increasing the heat value of pulping liquors fired in recovery furnaces;
- optimization of combustion conditions; and
- growing use of add-on control technologies.

Wood products mills are smaller than pulp and paper mills, have lower overall emissions, and have received less attention over the years. Unlike for pulp and paper, NCASI does not track emission trends from wood products plants or estimate national emissions. SO_x emissions from the wood products industry are small enough to be considered insignificant, as few wood products mills combust coal or oil and the amount of sulfur in wood is very small. NO_x emissions at wood products plants are significant. Major sources of NO_x are boilers, thermal oil heaters, and burners used to direct fire wood dryers.

Trend in Pulp and Paper Industry SO_x and NO_x Emissions

For its part, the pulp and paper industry has had a sustained reduction in emissions of SO_x and NO_x since the 1980s. In the U.S., SO₂ emissions have declined over 70% from 1980 levels despite increases in production. NO_x emissions in 2010 were 30% lower than in 1980. Figure S5 illustrates these trends. In Canada, SO₂ emissions dropped by 51% between 2001 and 2010, from 2.29 kg/tonne to 1.13 kg/tonne (production-weighted mean). NO_x emissions in Canada were more consistent during this period of time, but were reduced by 11%, from 1.42 kg/tonne to 1.27 kg/tonne (production-weighted mean) (NCASI file information).

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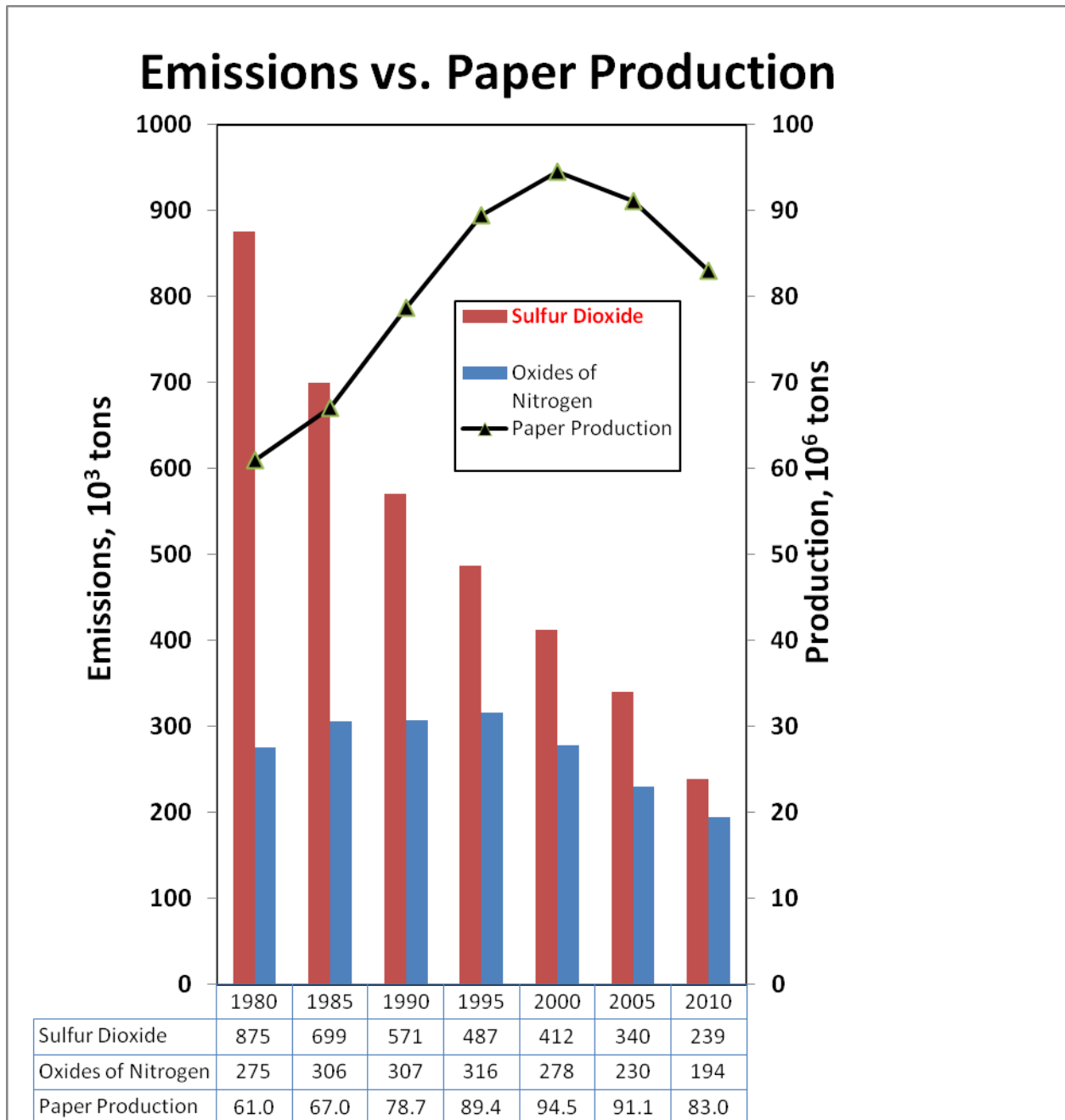


Figure S5. U.S. Pulp and Paper Mill Emission and Production Trends, 1980 – 2010 (NCASI 2012)

These reductions, in part, reflect a response to technology-driven regulatory standards, equipment modernization, improved operating and energy efficiency, alternative fuel selection, and industry restructuring.

Effects of Decreased SO_x and NO_x Emissions

General Overview

Opportunities for Improvement

Table S2 illustrates the range of observed SO_x and NO_x emissions from various pulp and paper mill sources, along with emission levels derived on the basis of control technology benchmarks. Data are derived from experience compiled for mills in the United States and the European Union (NESCAUM 2005; IPPC 2001).

The span of the data for the various sources illustrates, in part, the physical and operational factors that limit options for emissions reduction, specific to each source type. Other factors include the choice of fuels, the site-specific manner in which total reduced sulfur emissions (TRS) are controlled, and the interdependence of pollutant response to control choices.

Challenges to Reducing SO_x and NO_x

There are significant barriers that limit the transfer of utility boiler emission control approaches and performance to industrial sources. Industrial combustion sources have

- smaller unit size and dimensions;
- an array of different fuel choices and properties;
- widely varying loads and capacity utilization generally lower than base-load power plants;
- greater emission variability;
- restrictive space limitations; and
- unique characteristics and process chemistry.

The smaller size, lower capacity utilization, and more modest emission levels typically exhibited by industrial combustion sources also skew the economics of emissions control. Large-scale utility boilers enjoy an economy of scale and greater capacity utilization that is not possible for their smaller industrial counterparts. Therefore, the relative cost to achieve a given reduction in emissions may therefore be higher for industrial combustion sources.

In addition, further control of SO_x and NO_x emissions cannot be addressed without considering implications for emissions of other substances from the same combustion sources and impact on related components of the manufacturing process. Non-air quality impacts, both beneficial and adverse, that accompany further controls are addressed elsewhere on this tab of the website.

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Table S2. Range of Observed Emissions of SO_x and NO_x from Pulp and Paper Mill Sources

Emission Source		SO _x		NO _x	
		United States	European Union	United States	European Union
Recovery Furnace	Observed Emission Levels	~0 to 300 ppm	4 to 280 ppm	40 to 130 ppm	49 to 127 ppm
	Best Available Control Technology (BACT) ^a	50 to 300 ppm		75 to 150 ppm	
	Best Available Technique (BATNEEC) ^b		1.8 to 18 ppm		40 to 58 ppm
Lime Kiln	Observed Emission Levels	~0 to 20 ppm	2 to 11 ppm	30 to 350 ppm	125 to 315 ppm
	Best Available Control Technology (BACT)	30 to 80 ppm		30 to 300 ppm	
	Best Available Technique (BATNEEC)		1.8 to 105 ppm		49 to 292 ppm
Wood and Wood/Gas Fired Boilers	Observed Emission Levels	0.025 lbs/10 ⁶ Btu (AP-42 Factor)	0.02 to 0.07 lbs/10 ⁶ Btu Heat Input	0.15 to 0.3 lbs /10 ⁶ Btu	0.16 to 0.23 lbs/10 ⁶ Btu Heat Input
	Best Available Control Technology (BACT)	0.01 to 0.045 lbs /10 ⁶ Btu		0.15 to 0.3 lbs /10 ⁶ Btu	
	Best Available Technique (BATNEEC)		<10 ppm		29 to 49 ppm
Wood/Coal and Wood/Oil Fired Boilers	Observed Emission Levels	Depends upon fuel mix and coal/oil Sulfur content	0.12 to 0.47 lbs/10 ⁶ Btu (Oil @ 0.1 to 0.4 % S)	0.25 to 0.7 lbs /10 ⁶ Btu	0.14 to 0.35 lbs/10 ⁶ Btu Heat Input
	Best Available Control Technology (BACT)	0.3 to 0.5 lbs /10 ⁶ Btu		0.3 to 0.7 lbs /10 ⁶ Btu	
	Best Available Technique (BATNEEC)				

^a BACT/Best Available Control Technology (United States): A site-specific emission limitation that considers the cost of energy, environment, and economics in developing a degree of emission reduction that is achievable through application of good production processes, control systems, and techniques (Finto et al. 2006).

^b BATNEEC/Best Available Techniques Not Entailing Excessive Cost (European Union): The most efficient pollution control technique, including controls and management practices taking into account a balance between economic costs and environmental protection achieved (Slater and John 2001).

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