Sulfur Dioxide

SO_2

(liquified gas)

D Direct Use Chemical P Precursor Chemical

Inputs to Manufacturing Process:
Sulfur Oxygen

% of Total Domestic Consumption Attributed to Water Sector:
Less than 10%

Product Family:
Sulfur

Derivative Water Treatment Chemicals:
Sodium Metabisulfite
Sodium Thiosulfate

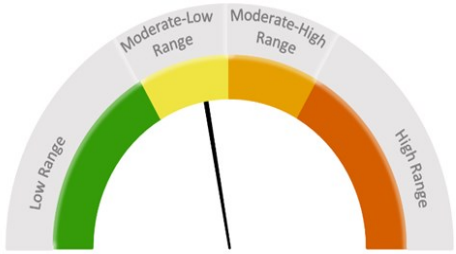
Understanding Chemical Supply Chains
Map of Suppliers & Manufacturers

CAS No.: 7446-09-5

Shelf Life:
12 Months

RISK OF SUPPLY DISRUPTION (Assessed in 2022)

RISK RATING: Moderate-Low



RISK DRIVERS

The water sector has experienced historic significant price increases and interruption of supply. Concerns are primarily due to periodic reductions in production of raw material (sulfur), the dominant use of the raw material for manufacturing of sulfuric acid, and the need for long-distance transport from limited manufacturing locations.

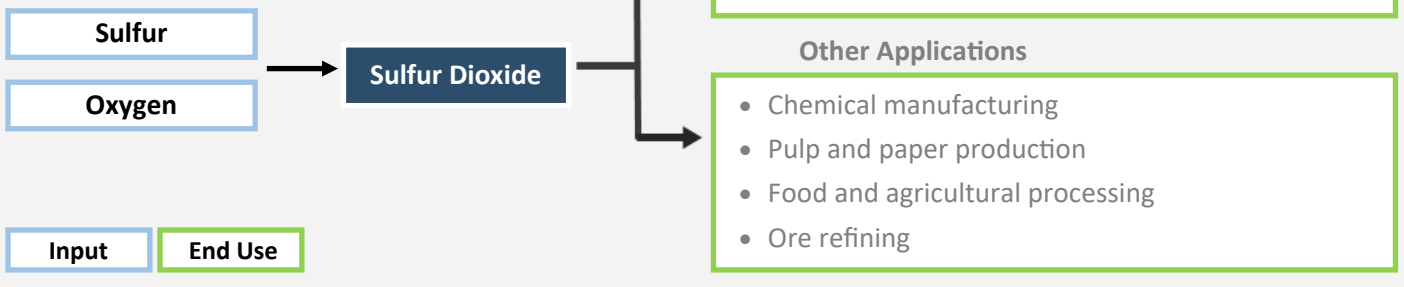
RISK SCORE PARAMETERS

Criticality: High. Essential for dechlorination and production of water treatment chemicals.

Likelihood: High. Previous significant price increases and supply disruptions. Concerns related to periodic reduction in supply of raw material (sulfur)

Vulnerability: Low. Domestic production is limited but distributed. Imports play a role in meeting domestic demand.

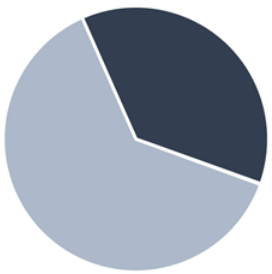
MANUFACTURING PROCESS



DOMESTIC PRODUCTION AND CONSUMPTION, AND INTERNATIONAL TRADE

Domestic Manufacturing Locations (2015):
5 locations in California, Texas, Tennessee, Illinois, and Indiana

International Trade (2019)
Primary Trading Partner (Imports):
Czech Republic
Primary Trading Partner Exports): Singapore



Domestic Consumption (2019):
146 Million kg

- Domestic Production (92 M kg)
- Imports for Consumption (54 M kg)
- Export of Domestic Production (0.13 M kg)

EPA

Product Description

Sulfur dioxide (SO_2) is an inorganic chemical and widely used reducing agent. It is commonly used for dechlorination of wastewater. The primary manufacturing process in the U.S. requires elemental sulfur. The majority of sulfur dioxide manufactured in the U.S. is used in chemical manufacturing.

Use in Water Treatment

Sulfur dioxide is used in water treatment for dechlorination of treated wastewater (AWWA, 2015).

Use as a Precursor to Other Water Treatment Chemicals

Sulfur dioxide is used to manufacture sodium metabisulfite and sodium thiosulfate.

Other Applications

Sulfur dioxide is primarily used for chemical manufacturing, pulp and paper processing, and as a food desiccant and preservative. It is also commonly used in ore processing, as a fungicide, wine production, and natural gas and oil desulfurization (INEOS, 2021; NCBI, 2022).

Primary Industrial Consumers

Demand for industrial sulfur dioxide is most dependent on demand for sulfur derivative products, including sodium hydrosulfite. Historically, the use of sulfur dioxide in chemical manufacturing accounted for 45% of domestic consumption, followed by pulp and paper production and food and agricultural processing, which each accounted for 15% of domestic consumption. Water and wastewater treatment, including industrial wastewater, accounted for approximately 10% of consumption. A variety of other applications including ore refining and oil recovery applications accounted for the remaining 15% (NCBI, 2022).

Manufacturing, Transport, & Storage

Manufacturing Process

The primary method by which sulfur dioxide is manufactured is by burning sulfur in an oxygen-rich environment. The general equation for this process is shown in Figure 1. The gas is cooled and collected, and compressed to produce liquefied sulfur dioxide. (ATSDR, 1998; INEOS, 2021).

Sulfur	+	Oxygen	→	Sulfur Dioxide
S	+	O_2	→	SO_2

Figure 1. Chemical Equation for the Reaction to Manufacture Sulfur Dioxide

Product Transport

Sulfur dioxide is highly corrosive and toxic and reacts violently with strong bases, which dictates how it can be transported. Liquified sulfur dioxide gas may be sold in bulk quantities and primarily delivered by rail or truck. Transport of sulfur dioxide must adhere to the appropriate methods and regulations related to its status as a highly corrosive substance.

Storage and Shelf Life

Sulfur dioxide gas can be pressurized and cooled to a liquified gas and stored in pressurized vessels. Pressurized storage vessels should be stored in a cool place away from direct sunlight. When stored properly, liquified sulfur dioxide gas can have a shelf life of 12 months, depending on purity and size of storage container (Airgas, 2018; NCBI, 2022).

Domestic Production & Consumption

Domestic Production

Production data was collected from the EPA Toxic Substances Control Act (TSCA) Chemical Data Reporting (CDR), while trade data was collected from the U.S. International Trade Commission (USITC) Dataweb, as characterized in Table 1. Both production and domestic trade data are specific to sulfur dioxide, while the international trade category is specific to inorganic oxygen compounds of non-metals including sulfur dioxide.

Table 1. Sulfur Dioxide Production and Trade Data Sources

Production and Trade Data			
Category	**Data Source**	**Identifier**	**Description**
Domestic Production	2020 TSCA Chemical Data Reporting	CAS No.: 7446-09-5	Sulfur Dioxide
Imports and Exports	U.S. International Trade Commission	HTS Code: 2811.29.30	Sulfur Dioxide

Total U.S. domestic manufacturing of sulfur dioxide was approximately 92 million kilograms (M kg) in 2019 (EPA, 2020). In 2019, *INEOS Calabrian* (*INEOS*) and *PVS Phosphate* were the primary domestic manufacturers. *INEOS* indicates a North American production capacity of approximately 172 M kg for their facilities in Port Neches, Texas and Timmins, Ontario. In addition to supplying sulfur dioxide to the merchant market, *INEOS* utilizes sulfur dioxide in captive production for a range of sulfur derivative chemicals including sodium metabisulfite (INEOS, 2016; INEOS, 2021). Historically, *INEOS* has been the largest U.S. producer of sulfur dioxide for commercial resale. Other known manufacturing facilities manufacture sulfur dioxide primarily for captive production of sulfur derivative products (USITC, 2005). Domestic manufacturing of sulfur dioxide takes place at a limited number of facilities in the U.S. The number of domestic manufacturing locations shown in Figure 2 represents operating facilities as of 2015. Supply of NSF/ANSI Standard 60 certified sulfur dioxide for use in drinking water treatment is also available at select locations (NSF International, 2021). For a more current listing of manufacturing locations and supplier locations, visit the U.S. Environmental Protection Agency's (EPA's) Chemical Locator Tool (EPA, 2022a).

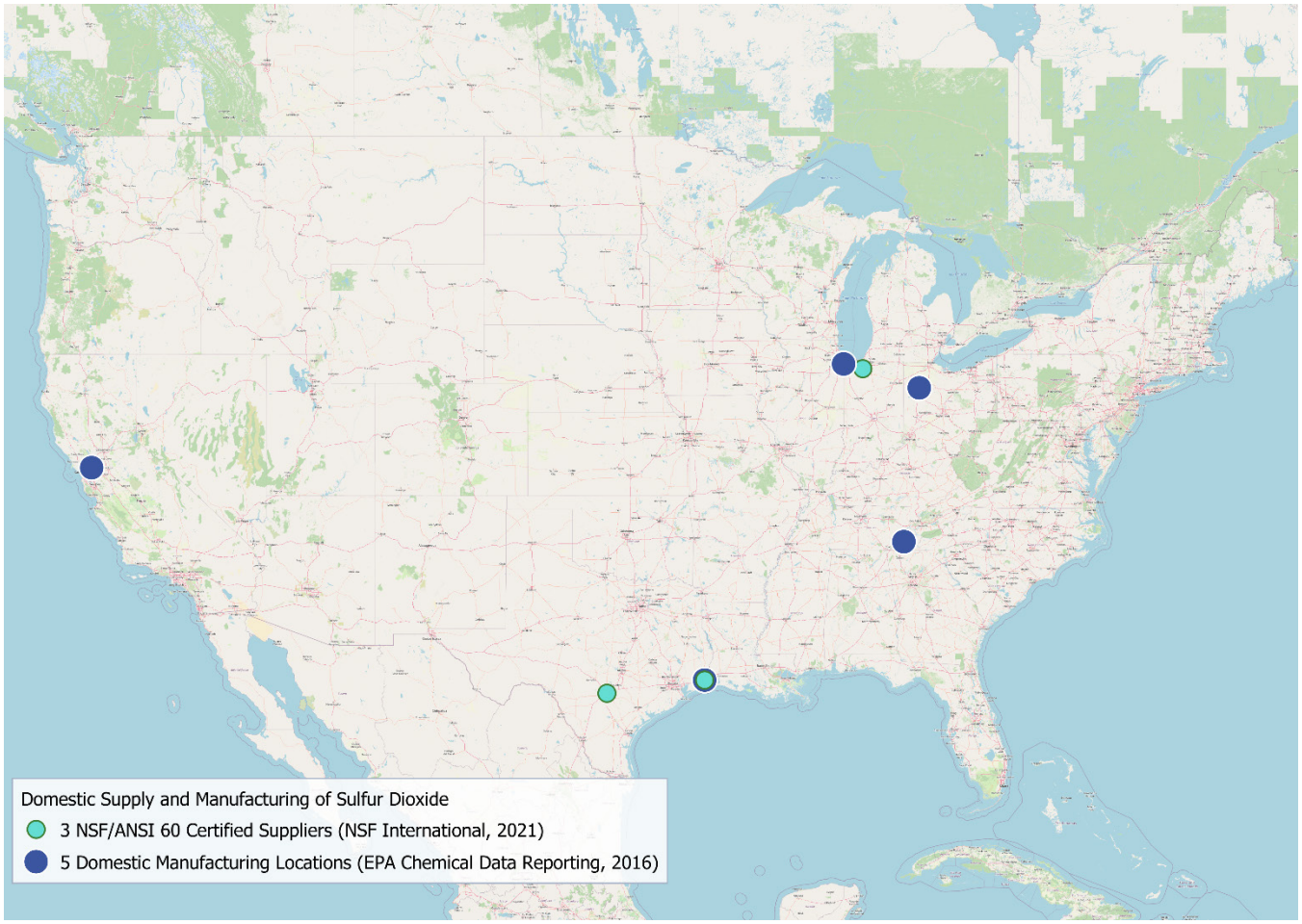


Figure 2. Domestic Supply and Manufacturing of Sulfur Dioxide

Domestic Consumption

U.S. consumption of sulfur dioxide in 2019 is estimated at 146 M kg. This includes production of 92 M kg, import of 54 M kg, minus export of 0.13 M kg (EPA, 2020; USITC, 2021), as shown in Figure 3.

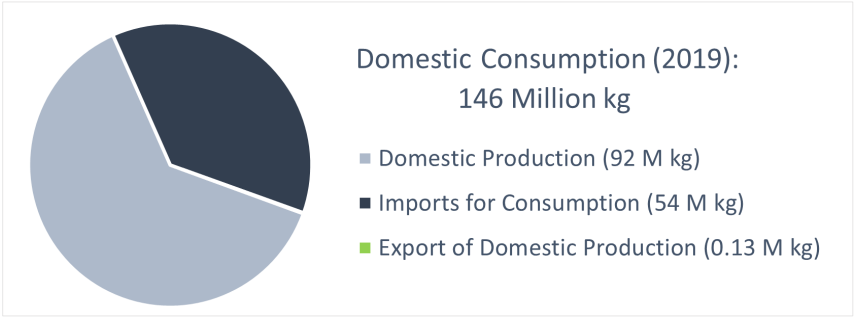


Figure 3. Domestic Production and Consumption of Sulfur Dioxide in 2019

Trade & Tariffs

Worldwide Trade

Worldwide import and export data for sulfur dioxide are reported through the World Bank's World Integrated Trade Solutions (WITS) software as a category specific to inorganic oxygen compounds of non-metals including sulfur dioxide. In 2021, U.S. ranked 14th worldwide in total exports and first in total imports of inorganic oxygen

compounds of non-metals including sulfur dioxide. In 2021, France ranked first worldwide in total exports (WITS, 2022), as shown in Table 2.

Table 2. WITS Worldwide Export and Import of Inorganic Oxygen Compounds of Non-Metals Including Sulfur Dioxide, in 2021

2021 Worldwide Trade Inorganic Oxygen Compounds of Non-Metals (HS Code 2811.29)			
Top 5 Worldwide Exporters		Top 5 Worldwide Importers	
France	43 M kg	**United States**	**95 M kg**
Sweden	41 M kg	Austria	22 M kg
China	35 M kg	Russian Federation	18 M kg
Belgium	19 M kg	Malaysia	17 M kg
Spain	13 M kg	Netherlands	14 M kg

Domestic Imports and Exports

Domestic import and export data are reported by USITC in categories specific to sulfur dioxide. Figure 4 summarizes imports for consumption[1] and domestic exports[2] of sulfur dioxide between 2015 and 2020. During this period, the overall quantity of imports and exports steadily increased, with imports for consumption greatly exceeding domestic exports. Over this five-year period, Singapore was the primary recipient of domestic exports and the Czech Republic the primary source of imports (USITC, 2021).

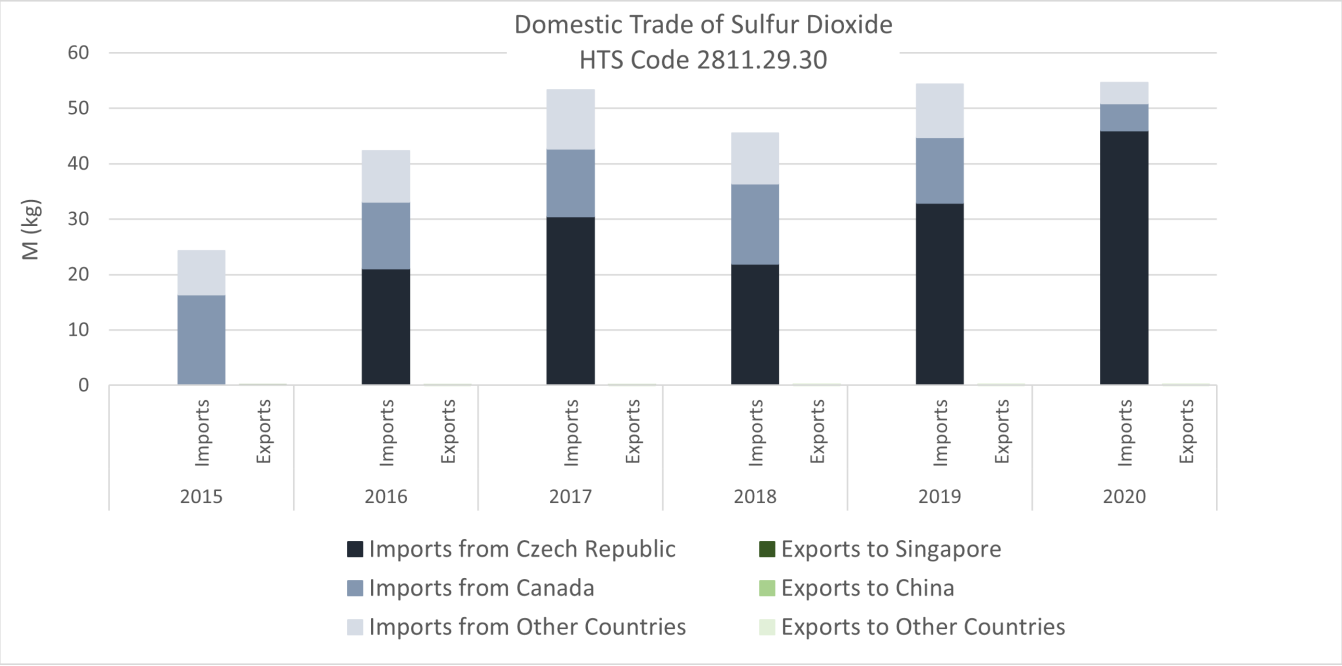


Figure 4. USITC Domestic Import and Export of Sulfur Dioxide between 2015 and 2020

[1] Imports for consumption are a subset of general imports, representing the total amount cleared through customs and entering consumption channels, not anticipated to be reshipped to foreign points, but may include some reexports.

[2] Domestic exports are a subset of total exports, representing export of domestic merchandise which are produced or manufactured in the U.S. and commodities of foreign origin which have been changed in the U.S.

Tariffs

There is a 4.2% general duty for import of sulfur dioxide and an additional 25% duty on imports from China (USITC, 2022), as summarized in Table 3.

Table 3. Domestic Tariff Schedule for Sulfur Dioxide in 2022

HTS Code	General Duty	Additional Duty – China (Section 301 Tariff List)	Special Duty
2811.29.30	4.2%	25%	None

Market History & Risk Evaluation

History of Shortages

The majority of elemental sulfur, which is a necessary input to sulfur dioxide production, is recovered as a byproduct of natural gas and petroleum processing. As described in the history of shortages for the sulfur supply chain profile (EPA, 2022b), the price and availability of sulfur is closely tied to demand for fuels and petroleum products (USGS, 2022). This has led to price fluctuations for sulfur dioxide.

Due to the concentration of sulfur dioxide producers at a small number of domestic manufacturing facilities combined with the widespread need for sulfur dioxide, long-distance transport of sulfur dioxide is often required. There is a high dependence on rail and long-distance transport. In 2021, the disruptions in availability of qualified transporters caused by the COVID-19 pandemic led to regional interruptions in domestic sulfur dioxide supply.

Risk Evaluation

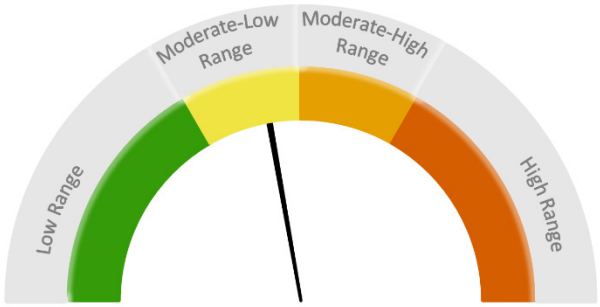
The complete risk assessment methodology is described in *Understanding Water Treatment Chemical Supply Chains and the Risk of Disruptions* (EPA, 2022c). The risk rating is calculated as the product of the following three risk parameters:

Risk = Criticality x Likelihood x Vulnerability	
Criticality	Measure of the importance of a chemical to the water sector
Likelihood	Measure of the probability that the chemical will experience a supply disruption in the future, which is estimated based on past occurrence of supply disruptions
Vulnerability	Measure of the market dynamics that make a chemical market more or less resilient to supply disruptions

The individual parameter rating is based on evaluation of one or more attributes of the chemical or its supply chain. The ratings and drivers for these three risk parameters are shown below in Table 4.

Table 4. Supply Chain Risk Evaluation for Sulfur Dioxide

Risk Parameter Ratings and Drivers		
Criticality: High	**Likelihood: High**	**Vulnerability: Low**
Sulfur dioxide is essential to the water sector and has widespread application for dechlorination of wastewater. It is a precursor in the production of other water treatment chemicals.	The water sector has experienced disruptions in supply and significant price increases. Concerns are primarily due to periodic reductions in production of raw material (sulfur), the dominant use of the raw material for manufacturing of sulfuric acid, and the need for long-distance transport from limited manufacturing locations.	Domestic manufacturing is limited but distributed. However, imports play a role in meeting domestic demand.
Risk Rating: Moderate-Low		



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