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SULFUR [ADVANCE RELEASE]

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Sulfur

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The United States was the world's second-ranked producer of sulfur in 2019, behind China (table 11). Elemental sulfur and byproduct sulfuric acid, produced as a result of efforts to meet environmental requirements that limit atmospheric emissions of sulfur dioxide, were the dominant sources of sulfur around the world.

In 2019, domestic production and shipments of sulfur in all forms were 10% lower than those in 2018 (table 1). Elemental sulfur recovered at petroleum refineries was 7% lower and from natural gas operations was 48% lower than those in 2018 (table 3). Producers' stocks, equivalent to 1% of the shipments, increased by 5%. Byproduct sulfuric acid production and shipments decreased by 11% (table 4). Apparent consumption of sulfur in all forms decreased by 11% (table 1). Imports of elemental sulfur and sulfuric acid combined decreased by 13%, and exports of both decreased by 9%. The average unit value of recovered sulfur in 2019 was 37% lower than that in 2018, resulting in the value of total elemental sulfur shipments decreasing by 43% compared with the value of shipments in 2018. The total value of byproduct sulfuric acid shipments increased by 6% (table 4).

Through its major derivative, sulfuric acid, sulfur ranks as one of the most important elements used as an industrial raw material and is of prime importance to every sector of the world's fertilizer and manufacturing industries. Sulfuric acid production is the major end use for sulfur, and consumption of sulfuric acid has been regarded as one of the best indexes of a nation's industrial development. More sulfuric acid has been produced in the United States every year than any other inorganic chemical; 26 million metric tons (Mt) of sulfuric acid, which is equivalent to about 8.5 Mt of elemental sulfur, was produced in 2019 in the United States (Fiona Boyd, Director, Acuity Commodities, written commun., November 18, 2020).

Worldwide, compliance with environmental regulations has contributed to increased sulfur recovery for 2019; global sulfur production, in all forms, was slightly higher than that in 2018 (table 11). Recovered elemental sulfur was produced primarily during the processing of natural gas and crude petroleum. Estimated worldwide production of native (naturally occurring elemental) sulfur decreased slightly from that in 2018. In the few countries where iron sulfides (pyrites) remained an important raw material for sulfuric acid production, sulfur production from pyrites was estimated to have decreased slightly from that in 2018.

Since 2005, more than 75% of the world's sulfur has been produced as a byproduct of natural gas and petroleum processing or as byproduct sulfuric acid from nonferrous metal smelting. Some sources of sulfur were unspecified, which means that the material recovered was likely elemental sulfur or byproduct sulfuric acid, increasing the percentage of byproduct sulfur production to about 90% annually. The quantity of byproduct sulfur produced from recovered sources was dependent on the world demand for fuels, nonferrous metals, and petroleum products rather than for sulfur. Typically, about 50% of the sulfur produced was used in fertilizer production, and the remainder was used in many other industrial uses. In 2019, a slight decrease in global demand for phosphate fertilizers resulted in decreased sulfur consumption in the phosphate fertilizer industry (Sulphur, 2020b).

Legislation and Government Programs

On January 1, 2020, the International Maritime Organization's (IMO's) global upper limit on the sulfur content in ships' fuel oil was to be reduced to 0.5% from 3.5%. Known as "IMO 2020," the reduced limit was in addition to and mandatory for all ships operating outside certain designated Emission Control Areas, whose limits were already 0.1%. The new limit would mean an estimated 77% decrease in the overall global sulfur dioxide emissions from ships (International Maritime Organization, 2019). The decreased demand for high-sulfur fuel oil and increased demand for middle distillate-marine gasoil and diesel and very low sulfur fuel oils was expected to increase byproduct sulfur production worldwide by an estimated 1.3 to 1.5 million metric tons per year (Mt/yr) in the short term (Sulphur, 2020c).

Production

Recovered Elemental Sulfur.—U.S. production statistics were collected on a monthly basis and published in the U.S. Geological Survey (USGS) monthly sulfur Mineral Industry Surveys. Survey requests were sent to 95 operations and all responded, representing 100% of the total production listed in table 1. In 2019, sulfur production and shipments were 10% lower than those in 2018. Lower sulfur production was a result of refiners using lower sulfur crude oil in anticipation of the IMO 2020 regulation implementation and the U.S. Environmental Protection Agency's (EPA's) Tier 3 gasoline rule (established in 2017 to set new vehicle emissions standards and lower sulfur content in gasoline), which reduced sulfur content in gasoline to 10 parts per million (Sulphur, 2020f). Lower sulfur prices resulted in the value of recovery material shipments being 43% lower than that in 2018. In 2019, on average, U.S. petroleum refineries operated at 90% of capacity, a 3% decrease from that in 2018 (U.S. Energy Information Administration, 2020b).

Recovered elemental sulfur, which is a nondiscretionary byproduct from petroleum refining, natural gas processing, and coking plants, was produced primarily to comply with environmental regulations applicable directly to sulfur dioxide emissions from the processing facility or indirectly by restricting the sulfur content of the fuels sold or used by the facility. Recovered sulfur was produced by 39 companies at 95 plants in

27 States. The capacity of the sulfur recovery operations varied greatly between plants producing more than 500,000 metric tons per year (t/yr) and those producing less than 500 t/yr. Within the United States, 31 plants produced more than 100,000 metric tons (t) of elemental sulfur in 2019; 19 plants produced between 50,000 and 100,000 t; 27 plants produced between 10,000 and 50,000 t; and 18 plants produced less than 10,000 t. By source, 96% of recovered elemental sulfur production came from petroleum refineries or satellite plants that treated refinery gases and coking plants; the remainder was produced at natural-gas-treatment plants (table 3).

The leading producers of recovered sulfur, all with more than 500,000 t of sulfur production, in descending order of production, were Exxon Mobil Corp., Valero Energy Corp., Marathon Petroleum Corp., ConocoPhillips Co. (including its joint venture with Encana Corp.), Motiva Enterprises LLC, BP p.l.c., CITGO Petroleum Corp., and Chevron Corp. The 49 plants owned by these companies accounted for 81% of recovered sulfur output during the year. Texas, Louisiana, and California, in descending order of production, were the leading producing States accounting for 69% of recovered sulfur output. Recovered sulfur production by State and district is listed in tables 2 and 3.

In 2019, 5 of the 20 largest oil refineries in the world, in terms of crude-petroleum-processing capacity, were in the United States. In descending order of capacity, they were Motiva's Port Arthur, TX, refinery; Marathon's Galveston Bay, TX, refinery; Marathon's Garyville, LA, refinery; ExxonMobil's Baytown, TX, refinery; and ExxonMobil's Baton Rouge, LA, refinery (Oil & Gas Journal, 2020). Although the capacity to process large quantities of crude petroleum does not necessarily mean that refineries recover large quantities of sulfur, all of these refineries were major producers of recovered sulfur. Sulfur production depends on installed sulfur recovery capacity as well as the types of crude petroleum refined at the specific refineries. Major refineries that process low-sulfur crude petroleum may have relatively low sulfur production. The United States operated 20% of world refining capacity but had almost 34% of world sulfur recovery capacity at these refineries (Oil & Gas Journal, 2019).

U.S. refining capacity rose by 4% from 2015 through 2019 and by about 14% from 2000 through 2019, mostly from upgrades at existing refineries. In 2019, U.S. refinery capacity was 18.8 million barrels per day, slightly higher than that in 2018. Overall U.S. refinery capacity increased by 208,000 barrels per day (bbl/d) in 2019 (U.S. Energy Information Administration, 2020b). Although sulfur capacity expansion was not specifically mentioned, any such expansions would likely include increased sulfur recovery facilities, probably proportionally higher than the increases in throughput capacity.

During the 2019 hurricane season, Hurricane Barry had significant negative effects on oil, natural gas, and sulfur production in the Gulf of Mexico region. Hurricane Barry, a Category 1 storm, made landfall on July 13, 2019, causing an estimated reduced production of 1.3 million barrels of crude oil and 44 million cubic meters of natural gas. This was 70% and 56% of the expected daily Gulf of Mexico crude oil and natural gas production, respectively (Bureau of Safety and Environmental Enforcement, 2019).

ExxonMobil announced plans to expand its Beaumont, TX, refinery by constructing a new third crude distillation unit, which would expand capacity by more than 65%, or by 250,000 bbl/d. The new distillation unit was expected to be operational by 2022 (Sulphur, 2019i).

Marathon planned to spend $1.2 billion upgrading its Galveston Bay, TX, refinery complex between 2019 and 2022 as part of its Texas refineries integration and modernization program. For the Texas refineries, Marathon planned to expand crude processing capacity by 40,000 bbl/d and allow for more production of ultra-low-sulfur diesel, distillates, and gasoil to meet the EPA's Tier 3 gasoline sulfur standards and the IMO 2020 regulation (Sulphur, 2019j).

Byproduct Sulfuric Acid.—Sulfuric acid production at copper, lead, molybdenum, and zinc roasters and smelters accounted for 6% of total domestic production of sulfur in all forms and totaled the equivalent of 596,000 t of elemental sulfur. Byproduct sulfuric acid production decreased by 11% compared with that in 2018 (tables 1, 4). The three largest byproduct sulfuric acid plants, in terms of size and capacity, operated in conjunction with copper smelters and accounted for 88% of domestic byproduct sulfuric acid output. The copper producers—ASARCO LLC, Freeport-McMoRan Copper & Gold Inc., and Rio Tinto Kennecott Corp.—each operated a sulfuric acid plant at its primary copper smelter. Two other sulfuric acid plants were byproduct operations of lead, molybdenum, and zinc smelting and roasting operations.

Consumption

Domestic apparent consumption of sulfur in all forms was 11% less than that in 2018 (table 5). Of the sulfur consumed, 70% was obtained from domestic sources as elemental sulfur (64%) and byproduct sulfuric acid (6%); elemental sulfur accounted for 69% in 2018, 72% in 2017, 73% in 2016, and 69% in 2015. The remaining 30% of the sulfur consumed was supplied by imports of recovered elemental sulfur (20%) and sulfuric acid (10%). The USGS collected end-use data on sulfur and sulfuric acid according to the Standard Industrial Classification of industrial activities (table 6).

Sulfur differs from most other major mineral commodities in that its primary use is as a chemical reagent rather than as a component of a finished product. This use generally requires that it be converted to an intermediate chemical product prior to its initial use by industry. The leading sulfur end use, sulfuric acid, represented 68% of reported consumption with an identified end use. Although reported as elemental sulfur consumption in table 6, it is reasonable to assume that nearly all the sulfur consumption reportedly used in petroleum refining was first converted to sulfuric acid, bringing sulfur used to produce sulfuric acid to 91% of the total sulfur consumption. Some identified sulfur end uses were included in the "Unidentified" category (table 6) because these data were proprietary. A significant portion of the sulfur in the "Unidentified" category may have been shipped to sulfuric acid producers or exported, although data to support such assumptions were not available.

Sulfuric acid remained the most universally used mineral acid and the most produced and consumed inorganic chemical, by volume, in 2019. Data based on USGS surveys of sulfur and sulfuric acid producers showed that reported U.S. consumption of sulfur in sulfuric acid (100% basis) decreased by 5% and total reported sulfur consumption decreased by 6%. Reported consumption figures may not correlate with calculated apparent consumption owing to reporting errors and possible double counting in some data categories. These data are considered independently from apparent consumption as an indication of market shares rather than actual consumption totals (table 6).

Agriculture was the leading sulfur-consuming industry; 2019 consumption in this end use was about 6.0 Mt, which was 4% less than that in 2018 (table 6). Based on export data reported by the U.S. Census Bureau, the estimated quantity of sulfur needed to manufacture exported phosphatic fertilizers increased by 3% to 2.1 Mt. In 2019, approximately 50% of the wet-process phosphoric acid produced in the United States was exported in the form of upgraded granular diammonium and monoammonium phosphate fertilizer and merchant-grade phosphoric acid.

In June 2019, The Mosaic Company (Mosaic) announced that it would permanently close its Plant City, FL, phosphate production facility. The plant was idled in late 2017 because it was a relatively high cost facility compared to Mosaic's other Florida phosphate operations (Green Markets, 2019).

In September 2019, Mosaic announced that it had idled its phosphate fertilizer operations in Louisiana beginning October 1. This resulted in a 500,000-t reduction of phosphate fertilizer production, accounting for about 250,000 t of reduced sulfur consumption. The facility in Louisiana was idled for most of the fourth quarter of 2019 (Acuity Commodities, 2019b). In December 2019, Mosaic announced that it would further reduce its phosphate fertilizer production in Florida by 150,000 metric tons per month (t/mo), which would reduce sulfur consumption by about 75,000 t/mo. Mosaic's decision to curtail its phosphate production was a result of lower market demand (Acuity Commodities, 2019a).

The second-ranked end use for sulfur was in petroleum refining and other petroleum and coal products. Producers of sulfur and sulfuric acid reported that the consumption of sulfur in that end use decreased by 6% from that in 2018. Consumption of sulfuric acid in copper ore leaching, which was the third-ranked end use, decreased by 10%.

Two types of companies recycled spent and contaminated sulfuric acid from petroleum alkylation—companies that produced acid for consumption in their own operations or recycled their own spent acid and companies that provided acid regeneration services to sulfuric acid users. The petroleum-refining industry was thought to be the leading source and consumer of recycled acid for use in its alkylation process, but insufficient data were available to make reasonable estimates.

Stocks

Yearend inventories of recovered elemental sulfur held by domestic producers increased to 124,000 t, 5% higher than that in 2018 (table 1). Based on apparent consumption of all forms of sulfur, combined yearend stocks amounted to a 5-day supply, which was an increase from the 4-day supply in 2018. Final stocks in 2019 represented 2% of the quantity held in inventories at the end of 1976, when sulfur stocks peaked at 5.65 Mt, a 7.4-month supply at that time (Shelton, 1980, p. 877). When the United States mined large quantities of sulfur in the mid-1970s, mining companies had the capacity to store large quantities. When mining ceased in 2000, storage capacity declined significantly. Since that time, stocks have been relatively low because recovered sulfur producers have minimal storage capacity.

Prices

The unit value of sulfur produced in the United States was lower in 2019 than in 2018, a result of decreased global demand for phosphate fertilizers throughout 2019, which led to a period of low sulfur prices (Sulphur, 2020a). Based on value data reported to the USGS, the average unit value of shipments for all elemental sulfur was estimated to be $51.10 per metric ton, which was 37% less than that in 2018 (table 1). The decreased unit value reported by producers was lower than the trends in prices recorded in trade publications, which indicated a 32% decrease in prices from those in 2018.

The contract price for elemental sulfur at terminals in Tampa, FL, which was reported weekly in Green Markets, began the year at $140 per long ton. By early October, the price decreased to $46 per long ton and remained at this price through yearend.

Prices varied greatly on a regional basis. Although Tampa, FL, prices usually were the highest reported in the United States (because of the large demand for sulfur in central Florida), U.S. west coast average prices were about the same as Tampa, FL, prices in 2019. At yearend, the U.S. west coast price was $40 per long ton. Nearly all the sulfur produced in some regions, such as the west coast, was processed at forming plants, incurring substantial costs to make solid sulfur in forms acceptable to be shipped overseas. The majority of west coast sulfur was shipped overseas. World sulfur prices generally were higher than domestic prices in 2019.

Although prices varied by location, provider, and type, the Abu Dhabi National Oil Co.'s (ADNOC's) price was recognized as an indicator of world sulfur price trends. In 2019, the ADNOC contract price averaged $93 per metric ton, with the lowest price of $42 per metric ton in December and the highest price of $155 per metric ton in January (Fertilizer Week, 2020). International prices for 2019 averaged about 12% higher than those in the United States. Lower prices in December were due to falling prices and oversupply in the 2019 phosphate industry as global consumption decreased by nearly 2.5% (Sulphur, 2020a, b).

Foreign Trade

Elemental sulfur exports from the United States were 2.2 Mt (tables 1, 7). The average unit value of exported elemental sulfur was $78 per metric ton, a 37% decrease from $125 per metric ton in 2018. The leading destination for this material was Mexico followed by, in descending order of quantity, Canada, Morocco, Brazil, New Caledonia, and China. Export facilities in the U.S. gulf coast, which began shipping in 2006, have become significant outlets for exported sulfur. Exports from the gulf coast were 1.12 Mt, or 51% of the U.S. total. Exports from the west coast were 861,000 t, or 39% of total U.S. exports.

In 2019, the United States imported 1.8 Mt of sulfur. Recovered elemental sulfur from Canada delivered to United States terminals and consumers in the liquid phase furnished 78% of United States sulfur import requirements. Total elemental sulfur imports in 2019 were 17% lower than those in 2018, and lower prices for imported sulfur resulted in the value decreasing by 33% compared with that in 2018. Imports from Canada, mostly by rail, were 4% lower than those in 2018 (table 9).

In addition to elemental sulfur, the United States traded in sulfuric acid. Sulfuric acid exports were 220,000 t, 36% lower than those in 2018 (table 8). Sulfuric acid imports were about 13 times those of exports at 3.0 Mt (tables 1, 10). Canada and Mexico were the leading sources of imports, accounting for 81% of sulfuric acid imported into the United States, most of which was thought to be byproduct sulfuric acid from nonferrous metal smelters. Shipments from Canada and some from Mexico came by rail, and the remainder of imports came by ship, primarily from Asia and Europe. The tonnage of sulfuric acid imports was 3% less than that in 2018, and the value of imported sulfuric acid increased by 41%.

World Review

The world sulfur industry remained divided into two sectors—discretionary and nondiscretionary. In the discretionary sector, the mining of native sulfur or pyrites is the sole objective; this voluntary production of either native sulfur or pyrites (mostly naturally occurring iron sulfide) is based on the orderly mining of discrete deposits, with the objective of obtaining as nearly a complete recovery of the resource as economic conditions permit. In the nondiscretionary sector, sulfur or sulfuric acid is recovered as an involuntary byproduct; the quantity of output is subject to demand for the primary product and environmental regulations that limit atmospheric emissions of sulfur compounds irrespective of sulfur demand. Discretionary sources, once the primary source of sulfur in all forms, represented only 9% of the sulfur in all forms produced worldwide in 2019 (table 11).

Poland, with an estimated 620,000 t, was the only country that produced more than 300,000 t of native sulfur by using either the Frasch process or conventional mining methods (table 11). The Frasch process is the term for hot-water mining of native sulfur associated with the caprock of salt domes and in sedimentary deposits. In this mining method, the native sulfur is melted underground with superheated water and brought to the surface by compressed air. The United States, where the Frasch process was developed early in the 20th century, was the leading producer of Frasch sulfur until 2000. Small quantities of native sulfur were produced in Asia, Europe, and South America. The importance of pyrites to the world sulfur supply has significantly decreased. In 2019, China and Finland were the top producers of sulfur from pyrites; China accounted for 92% of the world pyrites production.

Of the 14 countries listed in table 11 that produced more than 1 Mt of sulfur, 12 obtained the majority of their production as recovered elemental sulfur. These 14 countries produced 88% of the total sulfur produced worldwide.

Native sulfur production, including production of Frasch sulfur at Poland's last operating mine, was estimated to be slightly lower than that in 2018. Recovered elemental sulfur production and byproduct from metallurgy was slightly lower than that in 2018. Globally, production of sulfur from pyrites was slightly lower than that in 2018. Pyrites is a less attractive alternative to elemental sulfur for sulfuric acid production. The environmental remediation costs of mining pyrites are onerous, and additional costs are incurred when using this method to produce sulfuric acid.

Canada.—Ranked fourth in the world in sulfur production, Canada was one of the leading sulfur and sulfuric acid exporters. In 2019, sulfur production, in all forms, in Canada was 30% higher than that in 2018. About 89% of Canada's sulfur was recovered at natural gas and oil sands operations in Alberta, some sulfur was recovered from oil sands in Saskatchewan and from oil refineries in other parts of the country, and some as byproduct sulfuric acid from metallurgy.

Canada's sulfur production was expected to remain stable over the medium term or increase during the long term as a result of expanded oil sands production. Sulfur production from natural gas was expected to decline as natural gas production decreased. Exploration for conventional natural gas in Canada came to a halt in 2012. Sulfur production from oil sands operations was expected to overtake that from natural gas processing, and sulfur recovered from petroleum refineries was expected to remain relatively stable. Canada was likely to remain a leader in world sulfur production and export of sulfur. Byproduct sulfuric acid production was expected to remain relatively stable.

Environment and Climate Change Canada (2020) published information on Canada's sulfur emissions in 2018 reported in terms of sulfur oxides (SO_x). The report indicated a 16% decrease of SO_x emissions from those in 2017 and a 73% decrease from those in 1990. SO_x emissions in Canada have declined as the result of improved SO_x recovery technology at nonferrous metal smelters, reduced emissions from coal-fired electric utilities, plant closures, and emissions reductions from the petroleum-refining sector. Further decreases in SO_x emissions were achieved through the implementation of low-sulfur fuel standards.

China.—China was the leading global producer of sulfur in all forms and the leading producer of pyrites, with about 34% of its sulfur coming from pyrites. The country was the leading sulfur importer with a total of 11.7 Mt of sulfur being imported in 2019, which was about one-third of global trade. China was transitioning to be a net exporter of sulfuric acid as more smelting capacity was coming online (Sulphur, 2020e).

China Petrochemical Corp. (Sinopec) planned to produce 10 Mt/yr of low-sulfur fuel by 2020 to meet the growing market demand for low-sulfur fuel as a result of the IMO 2020 regulation. The company planned to expand its production capacity to 15 Mt/yr by 2023. Beginning January 1, 2020, Sinopec expected to start supplying low-sulfur fuel to all major ports in China and to more than 50 key overseas ports (Sulphur, 2019a).

Germany.—HES International B.V. planned to restart its 260,000-bbl/d refinery at Wilhelmshaven in northern Germany to produce about 40,000 bbl/d of low-sulfur marine fuels. The vacuum distillation unit was to be operational before January 1, 2020, when the new IMO 2020 regulation on sulfur marine fuels was to be implemented. The refinery was idled in 2010 for economic reasons, but the storage facilities at the refinery had remained operational (Sulphur, 2019d).

India.—Hindustan Petroleum Co. Ltd. selected Axens to provide technologies as part of its Visakh refinery upgrades. The project would increase the refinery output to 300,000 bbl/d from 167,000 bbl/d and include the installation of two 360-metric-ton-per-day sulfur-recovery units and a 112,000-t/yr sulfur-recovery unit at its liquefied petroleum gas treating unit. Increased refinery output was expected by July 2020 (Sulphur, 2019e).

Singapore.—ExxonMobil planned upgrades to its Singapore refinery to increase production capacity of low-sulfur fuels by 48,000 bbl/d including 0.5%-sulfur marine fuel to achieve compliance with the IMO 2020 regulation. The upgrades to the plant were scheduled to be completed by 2020 (Sulphur, 2019f).

United Arab Emirates.—ADNOC awarded Wood Group PLC the pre-front-end engineering design for its new 600,000-bbl/d refinery in Ruwais. Design work was expected to be completed by yearend 2019; however, no timetable for the completion of the refinery was announced (Sulphur, 2019g).

United Kingdom.—ExxonMobil planned to spend $1 billion to expand its Fawley refinery, which would increase ultra-low-sulfur diesel production by 38,000 bbl/d including 0.5%-sulfur marine fuel in compliance with the IMO 2020 regulation. The expansion was expected to be completed by 2023 (Sulphur, 2019h).

Outlook

Worldwide recovered sulfur output is expected to increase because of higher sulfur recovery in the oil and gas sector. New sulfur supplies are expected to come mostly from India, Kuwait, and Saudi Arabia. Through 2015, worldwide production of sulfur was nearly equal to consumption; however, in 2016 sulfur was in surplus. In 2017 and 2018, sulfur production was not enough to meet demand because of project delays and production declines at existing facilities. In 2019, sulfur production was slightly less than consumption. From 2020 onward, the sulfur market is expected to be in oversupply, as result of the IMO 2020 regulation (Sulphur, 2019c).

Since 2000, recovered sulfur production in the United States has been relatively stable, averaging 8.6 Mt/yr. Production from natural gas operations is expected to increase from that in 2019 as more natural gas is recovered from shale formations as improved technologies reduce natural gas production costs (U.S. Energy Information Administration, 2020a, p. 49).

Domestic byproduct sulfuric acid production may fluctuate somewhat as the copper industry reacts to market conditions and varying prices by adjusting output at operating smelters. Worldwide, the outlook for byproduct sulfuric acid is more predictable. Because copper production costs in some countries are lower than those in the United States, sulfuric acid production from those countries has increased, and continued increases are likely. Many copper producers have installed more efficient sulfuric acid plants to limit sulfur dioxide emissions at new and existing smelters. Worldwide, sulfur emissions at nonferrous smelters declined as a result of improved sulfur recovery; increased byproduct acid production is likely to become more a function of metal demand than a function of improved recovery technology. Byproduct sulfuric acid production in the United States has decreased by 42% since 2000. China's smelter sulfuric acid production has nearly doubled in the past 10 years; however, the rate of increase has begun to slow. China has invested in new copper smelter capacity, which is likely to result in increased sulfuric acid production. In 2019, China accounted for 40% of copper smelter production worldwide (Sulphur, 2019b).

Frasch sulfur and pyrites production are unlikely to significantly increase in the long term. Because of the continued increases in elemental sulfur recovery and byproduct sulfuric acid production for environmental reasons, discretionary sulfur has become increasingly less important as demonstrated by the lack of expansion in the Frasch sulfur industry. The Frasch process has become a high-cost process for elemental sulfur production and any new projects would require sulfur prices to increase enough to justify investment. Pyrites, with significant direct production costs, are an even higher cost raw material for sulfuric acid production when the environmental aspects are considered. Discretionary sulfur output is likely to decline. The decrease likely will be pronounced when large operations are closed for economic reasons, as was the case in 2000 and 2001.

For the long term, sulfur and sulfuric acid likely will continue to be important in agricultural and industrial applications. Phosphate processing, mainly for agricultural uses, continues to be the dominant use of sulfuric acid (about 60%). Phosphate fertilizer is expected to remain a leading end use because the global demand for fertilizer remains strong. Ore leaching (about 10%) likely will be the largest area of sulfur consumption growth. Copper and nickel leaching are major consumers of sulfuric acid; however, high costs and technical difficulties in the high-pressure acid leach process for nickel may result in the use of a less expensive option. In addition, uses of sulfuric acid are expanding in other industrial applications such as titanium dioxide pigment production in China and Europe, caprolactum (a precursor of nylon 6) manufacture, and many others. The sulfur demand for industrial uses continues to increase at a higher rate than that for fertilizer use (Sulphur, 2020d).

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GENERAL SOURCES OF INFORMATION

U.S. Geological Survey Publications

Historical Statistics for Mineral and Material Commodities in the United States. Data Series 140.
Sulfur. Ch. in Mineral Commodity Summaries, annual.
Sulfur. Ch. in United States Mineral Resources, Professional Paper 820, 1973.
Sulfur. Mineral Industry Surveys, monthly.

Other

Acuity Commodities, biweekly.
Chemical and Engineering News, weekly.
Chemical Engineering, weekly.
Fertilizer International, bimonthly.
Fertilizer Week, weekly.
Green Markets, weekly.
ICIS North America Sulphur Review, monthly.
Industrial Minerals, monthly.
Oil & Gas Journal, weekly.
Sulfur. Ch. in Mineral Facts and Problems, U.S. Bureau of Mines Bulletin 675, 1985.
Sulphur, bimonthly.

TABLE 1
SALIENT SULFUR STATISTICS[1]

(Thousand metric tons, sulfur content, and thousand dollars unless otherwise specified)

		2015	2016	2017	2018	2019
United States:						
Quantity:						
Production:						
Recovered		8,890	9,070	9,070	9,000	8,110
Other		646	673	560	672 r	596
Total		9,540	9,740	9,630	9,670 r	8,710
Shipments:						
Recovered		8,910	9,080	9,120	9,020	8,110
Other		646	673	560	672 r	596
Total		9,560	9,750	9,680	9,690 r	8,700
Exports:						
Elemental		1,850	2,060	2,340	2,390	2,200
Sulfuric acid		58	59	80	112	72
Imports:						
Elemental		2,240	1,810	1,850	2,230	1,850
Sulfuric acid		1,160	1,050	954	997	971
Consumption, apparent, all forms[2]		11,100	10,500	10,100	10,400	9,250
Stocks, December 31, producer, recovered		138	142 r	124	118 r	124
Value:						
Shipments, free on board (f.o.b.) mine or plant:						
Recovered[e]		781,000	344,000	423,000	732,000	414,000
Other		75,500	64,800	62,500	87,500 r	92,800
Total		857,000	409,000	486,000	819,000 r	507,000
Average unit value, elemental[e]	dollars per metric ton	87.62	37.88	46.39	81.16	51.08
Exports, elemental		284,000	214,000	251,000	299,000	172,000
Imports, elemental		142,000	81,700	110,000	205,000	137,000
World, production, all forms (including pyrites)		77,800	78,900	79,600 r	79,600 r, e	80,000 e

[e]Estimated. [r]Revised.
[1]Table includes data available through September 4, 2020. Data are rounded to no more than three significant digits, except prices; may not add to totals shown.
[2]Calculated as shipments minus exports plus imports.

TABLE 2
RECOVERED SULFUR PRODUCED AND SHIPPED IN THE UNITED STATES, BY STATE[1]

(Thousand metric tons and thousand dollars)

	2018			2019		
		Shipments			Shipments	
State	Production	Quantity	Value[e]	Production	Quantity	Value[e]
Alabama	136	135	13,200	123	124	6,950
California	1,210	1,210	92,000	1,160	1,160	43,900
Illinois	587	589	41,400	579	578	27,300
Louisiana	1,540	1,540	133,000	1,370	1,370	85,700
Ohio	132	132	9,030	115	115	4,570
Texas	3,380	3,390	341,000	3,050	3,050	180,000
Washington	158	159	6,850	151	151	4,730
Wyoming	509	511	15,900	230	232	8,290
Other[2]	1,340	1,360	80,300	1,330	1,330	52,300
Total	9,000	9,020	732,000	8,110	8,110	414,000

[e]Estimated.
[1]Table includes data available through September 4, 2020. Data are rounded to no more than three significant digits; may not add to totals shown.
[2]Includes Colorado, Delaware, Florida, Indiana, Kansas, Kentucky, Michigan, Minnesota, Mississippi, Montana, New Jersey, New Mexico, North Dakota, Oklahoma, Pennsylvania, Tennessee, Utah, and Wisconsin.

TABLE 3
RECOVERED SULFUR PRODUCED AND SHIPPED IN THE UNITED STATES, BY PETROLEUM ADMINISTRATION FOR DEFENSE (PAD) DISTRICT[1]

(Thousand metric tons)

	2018		2019	
District and source	Production	Shipments	Production	Shipments
PAD 1:				
Petroleum and coke	241	240	184	185
Natural gas	13	13	13	13
Total	254	253	197	198
PAD 2:				
Petroleum and coke	1,340	1,340	1,350	1,350
Natural gas	6	6	2	2
Total	1,340	1,350	1,350	1,350
PAD 3:				
Petroleum and coke	5,280	5,280	4,770	4,760
Natural gas	127	126	118	116
Total	5,410	5,410	4,890	4,880
PAD 4 and PAD 5:				
Petroleum and coke	1,520	1,530	1,490	1,490
Natural gas	473	476	188	191
Total	2,000	2,010	1,680	1,680
Grand total	9,000	9,020	8,110	8,110
Of which:				
Petroleum and coke	8,380	8,400	7,790	7,780
Natural gas	619	621	321	322

[1]Table includes data available through September 4, 2020. Data are rounded to no more than three significant digits; may not add to totals shown.

TABLE 4
BYPRODUCT SULFURIC ACID PRODUCED IN THE UNITED STATES[1]

(Thousand metric tons, sulfur content, and thousand dollars)

Type of plant	2018	2019
Copper[2]	586	522
Zinc, lead, and molybdenum	86 r	74
Total:		
Quantity	672 r	596
Value	87,500 r	92,800

r Revised.
[1]Table includes data available through September 4, 2020. Data are rounded to no more than three significant digits; may not add to totals shown.
[2]Excludes acid made from pyrites concentrates.

TABLE 5
APPARENT CONSUMPTION OF SULFUR IN THE UNITED STATES, BY TYPE[1]

(Thousand metric tons, sulfur content)

Type	2018	2019
Elemental sulfur:		
Shipments	9,020	8,110
Exports	2,390	2,200
Imports	2,230	1,850
Total	8,860	7,760
Byproduct sulfuric acid:		
Shipments	672 r	596
Exports[2]	112	72
Imports[2]	997	971
Total	1,560 r	1,500
Grand total	10,400	9,250

[r]Revised.
[1]Table includes data available through September 4, 2020. Crude sulfur or sulfur content. Data are rounded to no more than three significant digits; may not add to totals shown. Apparent consumption is calculated as shipments minus exports plus imports.
[2]May include sulfuric acid other than byproduct.

TABLE 6
SULFUR AND SULFURIC ACID SOLD OR USED IN THE UNITED STATES, BY END USE[1]

(Thousand metric tons, sulfur content)

		Elemental sulfur[3]		Sulfuric acid (sulfur equivalent)		Total	
SIC code[2]	End use	2018	2019	2018	2019	2018	2019
102	Copper ores	--	--	278	250	278	250
1094	Uranium and vanadium ores	--	--	1	--	1	--
10	Other ores	--	--	93	73	93	73
26, 261	Pulp mills and paper products	W	W	139	133	139	133
28, 285, 286, 2816	Inorganic pigments, paints, and allied products; industrial organic chemicals; other chemical products[4]	W	W	107	70	107	70
281	Other inorganic chemicals	W	W	67	66	67	66
282, 2822	Synthetic rubber and other plastic materials and synthetics	W	W	12	11	12	11
284	Soaps and detergents	--	--	5	5	5	5
286	Industrial organic chemicals	--	--	12	12	12	12
2873	Nitrogenous fertilizers	--	--	311	311	311	311
2874	Phosphatic fertilizers	--	--	5,070	4,850	5,070	4,850
2879	Pesticides	--	--	16	18	16	18
287	Other agricultural chemicals	877	842	22	20	899	862
2892	Explosives	--	--	8	8	8	8
2899	Water-treating compounds	--	--	51	43	51	43
28	Other chemical products	--	--	93	58	93	58
29, 291	Petroleum refining and other petroleum and coal products	2,300	2,150	338	337	2,640	2,490
331	Steel pickling	--	--	11	11	11	11
3691	Storage batteries (acid)	--	--	21	21	21	21
	Exported sulfuric acid	--	--	72	72	72	72
	Total identified	3,210 r	3,000	6,730	6,370	9,910	9,370
	Unidentified	1,820 r	1,720	59 r	97	1,910	1,810
	Grand total	5,030 r	4,710	6,790	6,470	11,800	11,200

[r]Revised. W Withheld to avoid disclosing company proprietary data; included with "Unidentified." -- Zero.
[1]Table includes data available through September 4, 2020. Data are rounded to no more than three significant digits; may not add to totals shown.
[2]Standard Industrial Classification.
[3]Does not include elemental sulfur used for production of sulfuric acid.
[4]No elemental sulfur was used in inorganic pigments, paints, and allied products.

TABLE 7
U.S. EXPORTS OF ELEMENTAL SULFUR, BY COUNTRY OR LOCALITY[1]

(Thousand metric tons and thousand dollars)

	2018		2019	
Country or locality	Quantity	Value	Quantity	Value
Brazil	650	88,400	265	31,900
Canada	154	9,410 r	497	9,300
China	255 r	32,200	64	6,530
Mexico	686	96,300	741	68,800
Morocco	334	39,000	317	27,100
New Caledonia	102	11,700	106	12,400
Other	214	22,200	208	16,400
Total	2,390	299,000	2,200	172,000

[r]Revised.
[1]Table includes data available through August 10, 2020. Data are rounded to no more than three significant digits; may not add to totals shown.

Source: U.S. Census Bureau.

TABLE 8
U.S. EXPORTS OF SULFURIC ACID (100% H_2SO_4), BY COUNTRY OR LOCALITY[1]

	2018		2019	
Country or locality	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Canada	154,000	$14,200	155,000	$14,500
Colombia	11,300	45	48	65
Dominican Republic	23	29	1,060	176
Ireland	7,620	10,100	1,610	2,320
Israel	2,500	3,270	6,040	7,680
Jamaica	8,200	541	5,780	707
Korea, Republic of	3,600	284	579	439
Mexico	58,500	1,130	8,450	1,160
Saudi Arabia	5,940	369	316	29
Singapore	3,140	167	186	380
Suriname	17,000	1,250	9,150	857
Taiwan	6,950	405	61	240
Trinidad and Tobago	2,930	299	3,560	487
Venezuela	59,400	7,410	--	--
Other	901 r	895 r	28,600	2,170
Total	342,000	40,400	220,000	31,200

[r]Revised. -- Zero.
[1]Table includes data available through August 10, 2020. Data are rounded to no more than three significant digits; may not add to totals shown.

Source: U.S. Census Bureau.

TABLE 9
U.S. IMPORTS OF ELEMENTAL SULFUR, BY COUNTRY OR LOCALITY[1]

(Thousand metric tons and thousand dollars)

Country or locality	2018 Quantity	2018 Value[2]	2019 Quantity	2019 Value[2]
Canada	1,510	90,600	1,450	65,900
Mexico	(3)	11	(3)	21
Other	722	115,000	400	71,200
Total	2,230	205,000	1,850	137,000

[1]Table includes data available through August 10, 2020. Data are rounded to no more than three significant digits; may not add to totals shown.
[2]Declared customs valuation.
[3]Less than ½ unit.

Sources: U.S. Census Bureau and Acuity Commodities; data adjusted by the U.S. Geological Survey.

TABLE 10
U.S. IMPORTS OF SULFURIC ACID (100% H_2SO_4), BY COUNTRY OR LOCALITY[1]

Country or locality	2018 Quantity (metric tons)	2018 Value[2] (thousands)	2019 Quantity (metric tons)	2019 Value[2] (thousands)
Algeria	1,830	$1,010	440	$189
Belgium	80	13	20,600	1,900
Canada	1,900,000	88,100	1,920,000	149,000
China	1,570	226	227	90
Colombia	3,040	680	4,580	1,010
Finland	46,600	2,680	79,100	6,500
Germany	221,000	11,200	106,000	7,250
Iraq	4,610	1,990	--	--
Japan	2,460	343	51,500	4,030
Libya	1,680	834	2,010	1,130
Mexico	470,000	18,400	485,000	29,700
Norway	--	--	2,390	1,140
Russia	2,550	1,190	14,600	6,770
Saudi Arabia	39,800	19,400	7,050	3,040
Spain	238,000	12,300	217,000	15,900
Sweden	104,000	5,400	45,200	2,760
Taiwan	6,540	5,110	10,100	7,870
Other	2,060	1,410	4,560	2,150
Total	3,050,000	170,000	2,970,000	240,000

-- Zero.
[1]Table includes data available through August 10, 2020. Data are rounded to no more than three significant digits; may not add to totals shown.
[2]Declared cost, insurance, and freight paid by shipper valuation.

Source: U.S. Census Bureau.

TABLE 11

SULFUR: WORLD PRODUCTION IN ALL FORMS, BY COUNTRY OR LOCALITY AND SOURCE[1, 2]

(Thousand metric tons, sulfur content)

Country or locality	2015	2016	2017	2018	2019
Australia, byproduct:					
Metallurgy[e]	810	810	810	810	810
Petroleum	90 e	90	90 e	90 e	90 e
Total[e]	900	900	900	900	900
Belgium, all forms and sources[e]	400	400 r	400 r	400 r	400
Brazil, byproduct:					
Metallurgy	259	260 e	260 e	260 e	260 e
Petroleum	236	240 e	240 e	240 e	240 e
Total	495	500 e	500 e	500 e	500 e
Canada, byproduct:					
Metallurgy	558	635	524	505 r	520
Natural gas and petroleum	5,187	4,746	4,803	4,828 r	6,418
Total	5,745	5,381	5,327	5,333 r	6,938
Chile, byproduct, metallurgy	1,488	1,596	1,524	1,476 r	1,500 e
China:					
Byproduct:					
Metallurgy[e]	7,400	6,300 r	5,650 r	5,700 r	5,700
Natural gas and petroleum	5,530	5,500	5,940	5,900 e	5,900 e
Pyrites	4,360	5,200 r	5,850 r	5,900 r, e	5,900 e
Total	17,290	17,000	17,440	17,500 r, e	17,500 e
Finland:					
Byproduct:					
Metallurgy	336	340	340 e	340 e	340 e
Petroleum	130 e	130	130 e	130 e	130 e
Pyrites	556	384	470	345 r	296
Total	1,022	854	940 e	815 r, e	766 e
France, byproduct, natural gas and petroleum[e]	400	400	400	400	400
Germany, byproduct:					
Metallurgy	384	352	328	254 r	250 e
Natural gas and petroleum	628	578	538	420 r	420 e
Total	1,012	930	866	674 r	670 e
India, byproduct:					
Metallurgy[e]	1,200	1,200	1,200	1,200	1,200
Petroleum	1,928	2,010 r, e	2,230 r, e	2,390 r, e	2,400 e
Total	3,128	3,210 r, e	3,430 r, e	3,590 r, e	3,600 e
Iran, byproduct, natural gas and petroleum[e]	2,200	2,200	2,200	2,200	2,200
Italy, byproduct:					
Metallurgy	40	40	40 e	40 e	40 e
Petroleum[e]	510	510	510	510	510
Total[e]	550	550	550	550	550
Japan, byproduct:					
Metallurgy	1,629	1,700	1,583 r	1,711 r	1,700 e
Petroleum	1,733	1,818	1,789	1,697	1,700 e
Total	3,362	3,518	3,372 r	3,408 r	3,400 e
Kazakhstan, byproduct:					
Metallurgy	604 e	604 e	600 r	600 r	600 e
Natural gas and petroleum	2,520 e	2,547	2,914	2,910 e	2,900 e
Total	3,120 e	3,151	3,514	3,510 e	3,500 e
Korea, Republic of, byproduct:					
Metallurgy[e]	1,080	1,080 r	1,080	1,080	1,080
Natural gas and petroleum	1,450	2,000	2,000	2,000 e	2,000 e
Total	2,528	3,078	3,078 r	3,080 e	3,080 e
Kuwait, byproduct, petroleum	850	850	850 e	850 e	850 e
Mexico, byproduct, natural gas and petroleum	858	673	551	443 r	365

See footnotes at end of table.

TABLE 11—Continued
SULFUR: WORLD PRODUCTION IN ALL FORMS, BY COUNTRY OR LOCALITY AND SOURCE[1, 2]

(Thousand metric tons, sulfur content)

Country or locality	2015	2016	2017	2018	2019
Netherlands, byproduct:[e]					
Metallurgy	120	120	120	120	100
Petroleum	400	400	400	400	410
Total	520	520	520	520	510
Poland:					
Byproduct:[3]					
Metallurgy[e]	280	280	280	280	280
Natural gas	24	25	23	23 e	23 e
Petroleum[e]	269	269	269	269	269
Other, unspecified	1	1	1 e	1 e	1 e
Frasch and native[3]	628	621	663	617 r	620 e
Total	1,202	1,196	1,236	1,190 r	1,190 e
Qatar, byproduct, natural gas	2,377	2,419	2,000 e	1,800 r	1,800 e
Russia:					
Byproduct:					
Metallurgy	200 e	200	200 e	200 e	200 e
Natural gas	5,961	6,098 r	6,321 r	6,597 r	6,600 e
Petroleum[e]	500	500	500	500	500
Native	110	94	96	84 r	84 e
Pyrites[e]	180	180	180	180	180
Total	6,951	7,072 r	7,297 r	7,561 r	7,560 e
Saudi Arabia, all forms and sources, unspecified	4,900	6,000	6,500	6,500 e	6,500 e
Turkmenistan	600	400	200	450 r	450 e
United Arab Emirates, byproduct, natural gas and petroleum[e]	3,300	3,300	3,300	3,300	3,300
United States, byproduct:					
Metallurgy	646	673	560	672 r	596
Natural gas	982	781	662	619	322
Petroleum	7,910	8,290	8,410	8,380	7,790
Total	9,540	9,740	9,630	9,670 r	8,710
Uzbekistan, byproduct:[e]					
Metallurgy	125	130	130	130	130
Natural gas and petroleum	340	350	340	340	340
Total	465	480	470	470	470
Venezuela, byproduct, natural gas and petroleum	700	700 e	620 r, e	430 r, e	320 e
Undistributed:[4]					
Byproduct:					
Metallurgy	340	349 r	453 r	523 r	528
Natural gas and petroleum	430	424 r	412 r	414 r	405
Petroleum	514 r	556 r	609 r	615 r	614
All forms and sources, unspecified	315	224 r	235	230 r	255
Frasch and other native	251	257 r	259	260 r	251
Pyrites	40	40	40	40	40
Total	1,890 r	1,850 r	2,007 r	2,081 r	2,093
Grand total	77,800	78,900	79,600 r	79,600 r, e	80,000 e
Of which:					
Byproduct:					
Metallurgy	17,300 r	16,500 r	15,400 r	15,500 r	15,400
Natural gas	9,340	9,320	9,010 r	9,040 r	8,750
Natural gas and petroleum	23,500 r	23,400 r	24,000 r	23,600 r	25,000
Petroleum	14,900 r	15,500 r	15,900 r	15,900 r	15,400
All forms and sources, unspecified	6,510 r	7,350 r	7,810 r	8,120 r	8,150
Frasch and other native	989	971	1,020	961 r	955
Pyrites	5,140	5,800 r	6,540 r	6,470 r	6,420

See footnotes at end of table.

TABLE 11—Continued
SULFUR: WORLD PRODUCTION IN ALL FORMS, BY COUNTRY OR LOCALITY AND SOURCE[1, 2]

[1]Table includes data available through September 9, 2020. All data are reported unless otherwise noted. Grand totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.
[2]The term “source” reflects the means of collecting sulfur and the type of raw material. Sources listed include the following: Frasch recovery; native, comprising all production of elemental sulfur by traditional mining methods (thereby excluding Frasch); pyrites (whether or not the sulfur is recovered in the elemental form or as acid); byproduct recovery, either as elemental sulfur or as sulfur compounds from coal gasification, metallurgical operations including associated coal processing, crude oil and natural gas extraction, petroleum refining, oil sand cleaning, and processing of spent oxide from stack-gas scrubbers; and recovery from processing mined gypsum. Recovery of sulfur in the form of sulfuric acid from synthetic gypsum produced as a byproduct of phosphatic fertilizer production is excluded, because to include it would result in double counting. Production of Frasch sulfur, other native sulfur, pyrites-derived sulfur, mined gypsum-derived sulfur, byproduct sulfur from extraction of crude oil and natural gas, and recovery from oil sands are all credited to the country of origin of the extracted raw materials. In contrast, byproduct recovery from metallurgical operations, petroleum refineries, and spent oxides are credited to the nation where the recovery takes place, which is not the original source of the crude product from which the sulfur is extracted.
[3]Government of Poland sources report total Frasch and native mined elemental sulfur output annually, undifferentiated.
[4]Includes Algeria, Austria, Bahrain, Colombia, Croatia, Denmark, Egypt, Greece, Hungary, Iraq, Israel, Libya, Lithuania, Morocco, Nigeria, Norway, Oman, Pakistan, South Africa, Taiwan, Turkey, and Ukraine.