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SULFUR

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Sulfur

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In 2011, the global demand for sulfur was strong. Increased supply was surpassed by an increase in sulfur consumption, which kept global markets in short supply and relied on some sulfur withdrawal from stockpiles to meet the demand. Demand for sulfur was strong in the phosphate sector. Sulfur imports increased by about 10% compared with those in 2010 owing to the demand for sulfur in the production of fertilizers and industrial sectors.

The United States was second in world sulfur production following China. 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.

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 is produced in the United States every year than any other inorganic chemical; an estimated 32.0 million metric tons (Mt), which is equivalent to about 10.4 Mt of elemental sulfur, was produced in 2011, about the same as that of 2010 (U.S. Census Bureau, 2011a, b).

In 2011, domestic production of sulfur in all forms was slightly lower than that of 2010; shipments of sulfur in all forms decreased by about 3%. Elemental sulfur recovered at petroleum refineries was slightly lower than it was in 2010, and sulfur recovered from natural gas operations decreased by 4%. Producers' stocks increased by 5%, representing about 2% of shipments. Byproduct sulfuric acid production and shipments decreased by 9%. Apparent consumption of sulfur in all forms increased by 3%. Imports of elemental sulfur and sulfuric acid combined increased by 14% and exports decreased by 6%. The average unit value of recovered sulfur in 2011 was more than twice that of 2010, resulting in the value of total elemental sulfur shipments increasing by about a factor of 2 compared with the 2010 value of shipments. The total value of byproduct sulfuric acid shipments increased by about 22% (table 1).

Worldwide, compliance with environmental regulations has contributed to increased sulfur recovery; for 2011, global sulfur production increased slightly. Recovered elemental sulfur is produced primarily during the processing of natural gas and crude petroleum. Estimated worldwide production of native (naturally occurring elemental) sulfur increased by 7%. In the few countries where pyrites remain an important raw material for sulfuric acid production, sulfur production from pyrites was about the same.

Since 2005, between 81% and 83% of the world's sulfur production as elemental sulfur and byproduct sulfuric acid came from recovered sources. Some sources of sulfur were unspecified, which means that the material could have been, and likely was, elemental sulfur or byproduct sulfuric acid, raising the percentage of byproduct sulfur production to about 90% annually. The quantity of sulfur produced from recovered sources was dependent on the world demand for fuels, nonferrous metals, and petroleum products rather than for sulfur.

World sulfur consumption was estimated to have increased from that of 2010; typically, about 50% was used in fertilizer production, and the remainder, in myriad other industrial uses. World trade of elemental sulfur decreased about 2% from the levels reported in 2010. Worldwide inventories of elemental sulfur were tight owing to the increased demand for sulfur, although stocks at remote operations remained substantial (Prud'homme, 2012, p. 49–50).

Legislation and Government Programs

In November, the U.S. Department of State announced that it would delay the decision on the approval of the Keystone Xl pipeline until late 2012 or 2013. The approval and completion of the pipeline would allow for increased quantities of bitumen (oil that is too thick to flow or be pumped without being diluted or heated) from the Canadian oil sands to be exported to the United States as far south as Texas for refining. This likely would have an impact on sulfur production in the United States because this material has a high sulfur content. Many U.S. refineries have invested capital to expand facilities to enable processing of the heavier crudes (North America Sulphur Review, 2011).

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. All 102 operations to which survey requests were sent responded; this represented 99% of the total production listed in table 1. One operation was not included in the 2011 survey; therefore, the production for this site was estimated. In 2011, production was slightly lower than that of 2010, and shipments were also 3% lower. Increased prices and demand for sulfur resulted in the value of recovered shipments being more than double that of 2010. Accidents, technical problems, maintenance, and weather issues at a few refineries limited the amount of sulfur that could be recovered. For 2011, on average, U.S. petroleum refineries operated at 86.3% of capacity, about the same as that of 2010 (U.S. Energy Information Administration, 2012b).

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 that were applicable directly to 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 103 plants in 25 States and 1 plant in the U.S. Virgin Islands. The size of the sulfur recovery operations varied greatly from plants producing more than 500,000 metric tons per year (t/yr) to others producing less than 500 t/yr. Of all the sulfur operations canvassed, 32 produced more than 100,000 metric tons (t) of elemental sulfur in 2011, 15 produced between 50,000 and 100,000 t, 32 produced between 10,000 and 50,000 t, and 24 plants produced less than 10,000 t. By source, 86% 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., ConocoPhillips Co. (including its joint venture with Encana Corp.), Valero Energy Corp., Chevron Corp., Shell Oil Products US, BP p.l.c., and Marathon Petroleum Corp. The 53 plants owned by these companies accounted for 76% of recovered sulfur output during the year. Recovered sulfur production by State and district is listed in tables 2 and 3.

In 2011, 6 of the 20 largest oil refineries in the world, in terms of crude processing capacity, were in the United States. In descending order of capacity, they were Exxon Mobil's Baytown, TX, and Baton Rouge, LA, refineries; Hovensa L.L.C.'s [Hess Corp.'s joint venture with Petróleos de Venezuela S.A. (PdVSA)] St. Croix, U.S. Virgin Islands, refinery; BP's Texas City, TX, refinery; Citgo Petroleum Corp.'s Lake Charles, LA, refinery; and Marathon's Garyville, LA, refinery (Oil & Gas Journal, 2011b). The capacity to process large quantities of crude oil does not necessarily mean that refineries recover large quantities of sulfur, but all these refineries were major producers of recovered sulfur. Sulfur production depends on installed sulfur recovery capacity as well as the types of crude oil that were refined at the specific refineries. Major refineries that process low-sulfur crude oils may have relatively low sulfur production. According to Oil & Gas Journal (2011a), the United States operated 20% of world refining capacity, but had almost 39% of sulfur recovery capacity at refineries.

According to data from the U.S. Energy Information Administration (2012b), U.S. refining capacity rose by about 3% from 2008 through 2011, and capacity rose by about 7% from 2000 through 2010, without building any new refineries. In 2011, U.S. refinery capacity was 17 million barrels per day (bbl/d). Overall U.S. refinery capacity decreased by 414,000 bbl/d in 2011 owing to the closure of two refineries in Pennsylvania (American Fuel & Petrochemical Manufacturers, 2012, p. 3). Although this information did not specifically mention sulfur capacity expansion, any such expansions would likely include increased sulfur recovery facilities, probably proportionally higher than the increases in throughput capacity.

Potash Corp. of Saskatchewan planned to build a 5,000-metric-ton-per-day (t/d) sulfur melting plant at its site in Aurora, NC, after plans to build a facility at Morehead City, NC, were resisted by the local community. The sulfur plant was to supply the Aurora phosphate mine in Beaufort County with its own source of molten sulfur in anticipation of a shortage of available molten sulfur. The plant was expected to take 18 months to build (Industrial Minerals, 2011).

BP planned to sell its Texas City, TX, and the Carson, CA, refineries in order to reposition its refining and marketing business in the United States by yearend 2012. BP planned to focus on improving and upgrading its other U.S. refineries: Whiting, IN, Cherry Point, WA, and its 50% interest in Toledo, OH (BP p.l.c., 2011).

During 2011, expansion and improvement projects were underway or in the planning stages at 12 refineries in the United States. In addition to increasing throughput capacity at the operations, upgrades were intended to increase the existing refineries' capabilities to process low-quality, high-sulfur crudes, such as those from Canadian oil sands, Saudi Arabia, and Venezuela. Oil sands producers were partners in some of the projects, as part of a strategy to ensure outlets for future oil sands production. Four sulfur recovery plants were completed in 2011, but most were expected to be completed between 2012 and 2015 (Sulphur, 2012a).

Byproduct Sulfuric Acid.—Sulfuric acid production at copper, lead, molybdenum, and zinc roasters and smelters accounted for about 8% of total domestic production of sulfur in all forms and totaled the equivalent of 720,000 t of elemental sulfur. Byproduct sulfuric acid production decreased by 9% compared with that of 2010 (tables, 1, 4). Three acid plants operated in conjunction with copper smelters, and three were byproduct operations of lead, molybdenum, and zinc smelting and roasting operations. The three largest byproduct sulfuric acid plants, in terms of size and capacity, were associated with copper smelters and accounted for 94% of the byproduct sulfuric acid output. The copper producers—Asarco LLC, Kennecott Utah Copper Corp., and Freeport McMoRan Copper & Gold Inc.—each operated a sulfuric acid plant at its primary copper smelter.

Consumption

Apparent domestic consumption of sulfur in all forms was 3% higher than that of 2010 (table 5). Of the sulfur consumed, 64% was obtained from domestic sources as elemental sulfur (59%) and byproduct acid (5%) compared with 67% in 2010, 78% in 2009, 64% in 2008, and 68% in 2007. The remaining 36% was supplied by imports of recovered elemental sulfur (28%) and sulfuric acid (8%). 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 67% 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 86% of the total sulfur consumption. Some identified sulfur end uses were included in the "Unidentified" category 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.

Because of its desirable properties, sulfuric acid retained its position as the most universally used mineral acid and the most produced and consumed inorganic chemical, by volume. Data based on USGS surveys of sulfur and sulfuric acid producers showed that reported U.S. consumption of sulfur in sulfuric acid (100% basis) increased by 10%, and total reported sulfur consumption increased by 13%. These reported increases in consumption can be attributed to the 12% increase in sulfur use in agricultural chemicals and fertilizers. Reported consumption figures do 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.

Agriculture was the leading sulfur-consuming industry; consumption in this end use increased by 12% to 7.51 Mt compared with 6.71 Mt in 2010 with an increase in nitrogeneous and phosphatic fertilizers and other agricultural chemicals. Based on export data reported by the U.S. Census Bureau, the estimated quantity of sulfur needed to manufacture exported phosphatic fertilizers increased by about 12% to 4.7 Mt. More than 50% of domestic fertilizer production typically is exported; in 2011 about 50% was exported.

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 increased by 4% from that of 2010. Demand for sulfuric acid in copper ore leaching, which was the third ranked end use, increased by 3%.

Production data for sulfuric acid produced as a result of recycling spent and contaminated acid from petroleum alkylation and other processes in 2011were no longer available from the U.S. Census Bureau. Two types of companies recycle this material—companies that produce acid for consumption in their own operations and also recycle their own spent acid and companies that provide 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.

Stocks

Yearend inventories held by recovered elemental sulfur producers increased to 175,000 t, 5% more than those of 2010 (table 1). Based on apparent consumption of all forms of sulfur, combined yearend stocks amounted to about a 5-day supply, which compares with a 5-day supply in 2010. Final stocks in 2011 represented 3% 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, as in 1976, 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 very little room for stocks.

Prices

Continuing increased demand for sulfur during 2011 resulted in higher prices than those of 2010. Based on total shipments and value reported to the USGS, the average value of shipments for all elemental sulfur was estimated to be $159.83 per metric ton, which was more than double that of 2010. The increased value reported by producers correlated with the trends in prices recorded in trade publications.

The contract prices for elemental sulfur at terminals in Tampa, FL, which are reported weekly in Green Markets, began the year at $162 per ton. In February, prices increased to $187 per ton. In May, prices again increased to $223 per ton and remained at that level through yearend.

Prices vary greatly on a regional basis. Tampa prices were usually the highest reported in the United States because of the large sulfur demand in the central Florida area. At yearend, U.S. West Coast prices ranged from $182 per ton to $203 per ton. Nearly all the sulfur produced in some regions, such as the West Coast, is processed at forming plants, incurring substantial costs to make solid sulfur in acceptable forms to be shipped overseas. The majority of West Coast sulfur was shipped overseas. World sulfur prices generally were higher than domestic prices in 2011.

Even though prices vary by location, provider, and type, the Abu Dhabi National Oil Co.'s (ADNOC) price is recognized as an indicator of world sulfur price trends. In 2011, the ADNOC contract price averaged nearly $215 per ton, with the lowest price of $165 per ton in January and the highest price of $240 per ton in May (Fertilizer Week, 2012).

Foreign Trade

Strong domestic demand during much of the year resulted in exports from the United States, including the U.S. Virgin Islands, decreasing by about 9% in quantity but increasing by 55% in value compared with those of 2010. The average unit value of export material was $203 per ton, an increase of 71% from $119 in 2010 (table 7). The leading destination for this material was Brazil, followed by, in descending quantity, Mexico, New Caledonia, Canada, and China. Export facilities on the Gulf Coast that began shipping in 2006 have become a significant source for exported sulfur. Exports from the West Coast were 740,000 t, or 56% of total U.S. exports. Exports from the Gulf Coast were 470,000 t, or 36% of the U.S. total.

The United States continued to be a net importer of sulfur. Imports of elemental sulfur exceeded exports by about 2.0 Mt. Recovered elemental sulfur from Canada, Mexico, and Venezuela delivered to U.S. terminals and consumers in the liquid phase furnished almost 95% of U.S. sulfur import requirements. Total elemental sulfur imports were 11% greater in quantity than those of 2010, and higher prices for imported material resulted in the value being about 40% more than that of 2010. Imports from Canada, mostly by rail, were estimated to be 16% higher than those of 2010, waterborne shipments from Mexico were 20% lower, and waterborne imports from Venezuela were estimated to have increased by 141%. Canada was the source of an estimated 83% of elemental sulfur imports, and Mexico supplied 9% (table 9).

In addition to elemental sulfur, the United States had significant trade in sulfuric acid. Sulfuric acid exports were 54% higher than those of 2010 (table 8). Acid imports were about 8 times exports (tables 1, 10). Canada and Mexico were the sources of 85% of acid imported into the United States, most of which was probably byproduct acid from smelters. Shipments from Canada and some from Mexico came by rail, and the remainder of imports came primarily by ship from Asia and Europe. The tonnage of sulfuric acid imports was about 27% greater than that of 2010, and the value of imported sulfuric acid increased by about 69%.

World Review

The world sulfur industry remained divided into two sectors—discretionary and nondiscretionary. In the discretionary sector, the mining of sulfur or pyrites is the sole objective; this voluntary production of either 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 sources of sulfur in all forms, represented 10% of the sulfur produced in all forms worldwide in 2011 (table 11).

Poland was the only country that produced more than 500,000 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; China was the only country of the top producers whose primary sulfur source was pyrites. China produced 89% of world pyrite production.

Of the 17 countries listed in table 11 that produced more than 1 Mt of sulfur, 16 obtained the majority of their production as recovered elemental sulfur. These 17 countries produced 85% of the total sulfur produced worldwide. In 2011, about 31 Mt of elemental sulfur was traded globally. The leading exporters were, in decreasing order of tonnage, Canada, Russia, Kazakhstan, Saudi Arabia, Qatar, Abu Dhabi, Iran, the United States, and Japan, all with more than 1 Mt of exports. The leading importer was China, by far, followed by, in decreasing order of tonnage, Morocco, the United States, Brazil, India, and Tunisia. All of the top importing countries had large phosphate fertilizer industries (Prud'homme, 2012, p. 49–60).

In 2011, an increase in sulfur consumption kept global markets in short supply, which resulted in the use of stocks to meet global needs. Prices were lowest at the beginning of 2011 and increased toward the end of 2011. International prices for 2011 averaged slightly higher than those in the United States. Sulfur imports increased in most of the main sulfur consuming countries, except China. China's imports in 2010 exceeded demand; therefore, China had stock carryovers into 2011.

Native sulfur production, including production of Frasch sulfur at Poland's last operating mine, was about 7% higher than that of 2010. Recovered elemental sulfur production and byproduct sulfuric acid production decreased slightly compared with those of 2010. Globally, production of sulfur from pyrites decreased slightly. Pyrites are 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 less environmentally friendly raw material to produce sulfuric acid.

Canada.—Ranked fourth in the world in sulfur production, Canada was the leading sulfur and sulfuric acid exporter. In 2011, sulfur production in Canada was 10% lower than it was in 2010. About two-thirds of Canadian sulfur is recovered at natural gas and oil sands operations in Alberta, with some recovered from natural gas in British Columbia and from oil refineries in other parts of the country. Sulfur production from natural gas processing declined in 2011, and production from oil sands was about 4% higher in 2011 than in 2010 (North America Sulphur Review, 2012).

Canada's sulfur production was expected to remain stable over the medium term and may 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 reserves decrease. Significant increases in production from oil sands operations and minor increases at petroleum refineries were expected. Canada was likely to remain a leader in world sulfur production. Byproduct acid production was expected to remain relatively stable (Prud'homme, 2012, p. 52).

A report from Alberta's Energy Resources Conservation Board (ERCB) showed that sulfur emissions in 2011 from Alberta's natural gas processing plants declined by 62% from levels in 2000 and 7% from those of 2010. Sulfur emissions declined as the result of improved sulfur recovery technology at several plants and closing of one plant in 2011. Although sulfur recovery increased as a percentage of gas processing, total sulfur recovery declined during the same period because of lower gas processing volumes (Energy Resources Conservation Board, 2012, p. 6).

An estimated 300,000 t of sulfur was removed from Canada's stockpiles in 2011; stocks decreased to about 11.4 Mt in Alberta (North America Sulphur Review, 2012). More than 8 Mt of the sulfur stocks was stored at Syncrude Canada Ltd.'s Fort McMurray, Alberta, oil sands operation. Fort McMurray is so remote that transporting the sulfur to market is extremely difficult and expensive (Stone, 2010).

China.—China was the leading producer of sulfur in all forms. It also was the world's leading producer of pyrites, with about 45% of its sulfur in all forms coming from that source. The country was the leading sulfur importer, with 9.3 Mt in 2011 (International Fertilizer Industry Association, 2012, p. 13). Imports represented about 70% of elemental sulfur consumption in China, with the Middle East as the leading source of the imports, followed by Morocco. Fertilizer production consumed about two-thirds of the sulfuric acid used in China.

In December 2010, the Chinese Government released its 2011 tariff rates for many phosphate fertilizers to discourage exports during periods of high domestic demand. The surcharge for the phosphate fertilizers would be 110% during January to May and October to December, and 7% during June to September (Fertilizer Week, 2010).

Mexico.—Petroleos Mexicanos (Pemex) planned to build several new oil refineries in an attempt to reduce the country's imports of gasoline. A 300,000-bbl/d refinery was planned at Tula in Hidalgo State. The refinery was expected to be completed in 2015 at a cost of $10 billion. In addition, a 100,000-bbl/d expansion at the Minatitlan refinery, originally planned for 2008, was brought online in July. This expansion added 200,000 t/yr to Mexico's sulfur production (Sulfur, 2011a; Young, 2011).

Morocco.—Office Chérifien des Phosphates (OCP) awarded Jacobs Engineering Group Inc. a contract to provide engineering, procurement, and construction service for two additional diammonium phosphate/monoammonium phosphate (DAP/MAP) plants to be built at Jorf Lasfar. Jacobs Engineering had previously been awarded contracts for two other DAP/MAP plants in December 2010 and March 2011. Each DAP/MAP plant would have the same design with a capacity of nearly 1.0 million metric tons per year (Mt/yr) and consume 500,000 t/yr sulfur. OCP expects the plants to come online, during six-month intervals, beginning July 2013 through July 2015 (Sulfur, 2011b).

Saudi Arabia.—China's National Development and Reform Commission approved the funding for a 400,000 bbl/d refinery joint venture at Yanbu in Saudi Arabia between China Petrochemical Corp. (Sinopec) and Saudi Arabian Oil Co. (Saudi Aramco). Sinopec held a 37.5% interest and the remaining 62.5% was held by Saudi Aramco. The refinery was expected to begin operations in 2014 and produce 1,200 t/d of sulfur (Sulfur, 2011d).

Saudi Aramco selected Axen IFP Group Technologies to design its Jazan refinery and terminal project. The refinery would have a throughput capacity of 400,000 bbl/d and a sulfur recovery of 1,260 t/d. The refinery was scheduled to be completed by December 2016 (Sulfur, 2011c).

Outlook

Since 2000, recovered sulfur production in the United States has been relatively stable, averaging about 8.6 Mt/yr, but increases were expected in upcoming years as expansions, upgrades, and new facilities at existing refineries were completed. The expansions will enable refiners to increase throughput of crude oil and to process higher sulfur crude oils; additional sulfur production will be a result of refinery upgrades. Projects that had been announced before or during 2011 had the potential to add sulfur recovery capacity of about 2 Mt/yr by 2015, if all were completed on proposed schedules (Sulphur, 2012a). Production from natural gas operations is expected to increase from that of 2011 as more natural gas is recovered from shale formations, horizontal drilling, and hydraulic fracturing. More efficient, cost-effective drilling techniques, primarily in shale formations, will spur development in U.S. natural gas production (U.S. Energy Information Administration, 2012a).

Worldwide recovered sulfur output was also expected to increase. In 2010 and 2011, production of sulfur nearly satisfied demand, but was expected to be in deficit in 2012 and 2013. Sulfur surpluses were not expected until 2014, increasing thereafter as a result of increased production, especially from oil sands in Canada, natural gas in the Middle East, expanded oil and gas operations in Kazakhstan, and heavy-oil processors in Venezuela.

Additional production increases were expected to come from increased sulfur recovery from natural gas in Russia and improved sulfur recovery at oil refineries and new development of sour gas deposits in Asia. Refineries in developing countries were expected to improve environmental protection measures and, in the future, eventually approach the environmental standards of plants in Japan, North America, and Western Europe. Higher sulfur recovery likely will result from a number of factors, including higher refining rates, higher sulfur content in crude oil, lower allowable sulfur content in finished fuels, and reduced sulfur emissions mandated by regulations.

World consumption of natural gas was expected to maintain strong growth, and sulfur recovery from that sector likely will continue to increase. Natural gas continued to be the fuel of choice in many regions of the world in the electric power and industrial sectors, in part because of its lower carbon intensity compared with coal and oil, which makes it an attractive fuel source in countries where governments are implementing policies to reduce greenhouse gas emissions. Some future gas production is expected to come from unconventional natural gas resources such as tight gas, shale gas, and coal bed methane (U.S. Energy Administration, 2012a, p. 43–44). Use of unconventional natural gas sources in some areas of the world may affect the sulfur supply outlook for the future because these sources have lower sulfur content. However, increased sulfur from sour gas processing in China, central Asia, and the Middle East is projected to more than compensate for the decrease in sulfur resulting from unconventional natural gas sources.

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 acid was more predictable. Because copper production costs in some countries are lower than in the United States, 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. Smelter acid production in the United States has decreased by 40% since 2000; during the same period, Chinese smelter acid production has more than tripled. Additional smelter capacity was expected in Brazil, India, Russia, and Zambia. Increased byproduct sulfuric acid product was expected to add another 6 to 7 Mt/yr of sulfur during the next 5 years (Sulphur, 2012b).

Frasch sulfur and pyrites production, however, has little chance of significant long-term increases. In 2011, Frasch sulfur production remained about the same as that of 2010. Because of the continued increases in elemental sulfur recovery and byproduct sulfuric acid production for environmental reasons rather than markets, discretionary sulfur has become increasingly less important as demonstrated by the decline of the Frasch sulfur industry. The Frasch process has become the high-cost process for sulfur production. Pyrites, with significant direct production costs, is an even higher cost raw material for sulfuric acid production when the environmental aspects are considered. Discretionary sulfur output is likely to continue a steady decline. The decreases likely will be pronounced when large operations are closed outright 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. Because sulfuric acid consumption for phosphate fertilizer production was expected to increase at a lower rate than for some other uses, phosphate fertilizer may become less dominant, but is expected to remain the leading end use. Ore leaching likely will be the largest area of sulfur consumption growth. Copper and nickel leaching are the major consumers of sulfuric acid, but uranium leaching is increasing as the demand increases for nuclear power (Sulfur, 2011e).

From year to year, however, the use of sulfur directly or in compounds as fertilizer likely will continue to be dependent on agricultural economies and vary according to economic conditions. If widespread use of plant nutrient sulfur is adopted, then sulfur consumption in that application could increase significantly; thus far, however, growth has been slow. Expansions of phosphate fertilizer production were expected at facilities in Brazil, China, and Morocco (Heffer and Prud'homme, 2012). Overall, one-half of all sulfur consumption (in all forms) is used for phosphate fertilizer production.

Industrial sulfur consumption has some prospects for growth. Solvent extraction-electrowinning copper projects that consume large quantities of sulfur are under development in Chile, China, India, Kazakhstan, and Peru and should be completed during the next few years. Smelter acid represents almost one-third of sulfuric acid production (Sulphur, 2010).

Less traditional uses for elemental sulfur have not increased. In the 1970s and 1980s, research was conducted that showed the effectiveness of sulfur in several construction uses that held the promise of consuming huge quantities of sulfur in sulfur-extended asphalt and sulfur concretes. In many instances, these materials were found to be superior to the more conventional products, but their use so far has been very limited. Concrete made with sulfur is more resistant to acid and saltwater; the manufacturing process lowers CO_2 emissions and does not require water to manufacture. However, when sulfur prices are high, sulfur is less attractive for unconventional applications where low-cost raw materials are an important factor.

In the near term, potential deficits of elemental sulfur are projected as a result of lower global production and a strong demand. This is expected to be followed by near-balance conditions and, in the long-term, marginal surplus worldwide. Sulfur trade is expected to show a strong increase, which would be driven by increased import demand in the fertilizer and ore leaching sectors.

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TABLE 1
SALIENT SULFUR STATISTICS[1]

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

	2007	2008	2009	2010	2011
United States:					
Quantity:					
Production:					
Recovered[2]	8,330 r	8,550	8,190	8,310 r	8,230
Other	817	753	749	791	720
Total[e]	9,150 r	9,300	8,940	9,100 r	8,950
Shipments:					
Recovered[2]	8,370 r	8,530	8,110	8,370 r	8,210
Other	817	753	749	791	720
Total	9,180 r	9,280	8,860	9,160 r	8,930
Exports:					
Elemental[3]	922	953	1,430	1,450	1,310
Sulfuric acid	110	86	83	71	109
Imports:					
Elemental[e]	2,930	3,000	1,700	2,950	3,270
Sulfuric acid	857	1,690	413	690	871
Consumption, all forms[4]	11,900	12,900	9,460	11,300	11,700
Stocks, December 31, producer, recovered	187	208 r	231 r	166 r	175
Value:					
Shipments, free on board (f.o.b.) mine or plant:					
Recovered [e, 2]	275,000 r	2,250,000	14,000	587,000 r	1,310,000 e
Other	45,200	110,000	87,500	92,400	113,000
Total	320,000 r	2,360,000	101,000	679,000 r	1,420,000
Exports, elemental[5]	84,800	272,000	82,200	171,000	266,000
Imports, elemental	79,400	753,000	54,100	214,000	301,000
Price, elemental, f.o.b. mine or plant [e] dollars per metric ton	32.87 r	264.04	1.73	70.16	159.83
World, production, all forms (including pyrites)	67,800 r	68,300 r	67,400 r	69,400 r	70,500

[e]Estimated. [r]Revised.
[1]Data are rounded to no more than three significant digits except prices; may not add to totals shown.
[2]Includes U.S. Virgin Islands.
[3]Includes exports from the U.S. Virgin Islands to foreign countries.
[4]Consumption is calculated as shipments minus exports plus imports.
[5]Includes value of exports from the U.S.Virgin Islands to foreign countries.

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

(Thousand metric tons and thousand dollars)

	2010			2011		
		Shipments			Shipments	
State	Production	Quantity	Value[e]	Production	Quantity	Value[e]
Alabama	259	258	25,100	297	298	55,400
California	1,050	1,100	60,800	995	993	141,000
Illinois	458	457	28,500	495	495	81,100
Louisiana	1,260	1,240	89,400	1,480	1,480	220,000
New Mexico	25	25	734	21	21	3,880
Ohio	126	125	13,000	136	137	27,000
Texas	3,100	3,100	233,000	2,910	2,900	470,000
Washington	139	138	5,890	127	127	17,000
Wyoming	624	625	29,100	647	649	121,000
Other[2]	1,270 r	1,310 r	101,000 r	1,140	1,130	178,000
Total	8,310 r	8,370 r	587,000 r	8,230	8,210	1,310,000

[e]Estimated. [r]Revised.
[1]Data are rounded to no more than three significant digits; may not add to totals shown.
[2]Includes Arkansas, Colorado, Delaware, Florida, Indiana, Kansas, Kentucky, Michigan, Minnesota, Mississippi, Montana, New Jersey, North Dakota, Pennsylvania, Utah, Virginia, Wisconsin, and the U.S. Virgin Islands.

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

(Thousand metric tons)

	2010		2011	
District and source	Production	Shipments	Production	Shipments
PAD 1:				
Petroleum and coke	136	136	66	61
Natural gas	13	13	13	13
Total	150	149	79	74
PAD 2:				
Petroleum and coke	1,030 r	1,030 r	1,020	1,030
Natural gas	23	23	21	21
Total	1,060 r	1,060 r	1,040	1,050
PAD 3:[2]				
Petroleum and coke	4,680	4,660	4,760	4,730
Natural gas	486	509	461	462
Total	5,160	5,170	5,220	5,190
PAD 4 and 5:				
Petroleum and coke	1,290	1,350	1,260	1,260
Natural gas	647	648	630	632
Total	1,940	2,000	1,890	1,890
Grand total	8,310 r	8,370 r	8,230	8,210
Of which:				
Petroleum and coke	7,140 r	7,170 r	7,100	7,080
Natural gas	1,170	1,190	1,130	1,130

[r]Revised.
[1]Data are rounded to no more than three significant digits; may not add to totals shown.
[2]Includes the U.S. Virgin Islands.

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

(Thousand metric tons of sulfur content and thousand dollars)

Type of plant	2010	2011
Copper[2]	704	679
Zinc, lead, and molybdenum[3]	87	41
Total:		
Quantity	791	720
Value	92,400	113,000

[1]May include acid produced from imported raw materials. Data are rounded to no more than three significant digits, may not add to totals shown.
[2]Excludes acid made from pyrites concentrates.
[3]Excludes acid made from native sulfur.

TABLE 5
CONSUMPTION OF SULFUR IN THE UNITED STATES[1]

(Thousand metric tons of sulfur content)

	2010	2011
Elemental sulfur:		
Shipments[2]	8,370 r	8,210
Exports	1,450	1,310
Imports[e]	2,950	3,270
Total	9,870 r	10,200
Byproduct sulfuric acid:		
Shipments	791	720
Exports[3]	71	109
Imports[3]	690	871
Total	1,410	1,480
Grand total	11,300	11,700

[e]Estimated. [r]Revised.
[1]Crude sulfur or sulfur content. Data are rounded to no more than three significant digits; may not add to totals shown. Consumption is calculated as shipments minus exports plus imports.
[2]Includes the U.S. Virgin Islands.
[3]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 of sulfur content)

		Elemental sulfur[2]		Sulfuric acid (sulfur equivalent)		Total	
SIC[3]	End use	2010	2011	2010	2011	2010	2011
102	Copper ores	--	--	400	410	400	410
1094	Uranium and vanadium ores	--	--	--	3	--	3
10	Other ores	--	--	62	77	62	77
26, 261	Pulp mills and paper products	W	W	79	168	79	173
28, 285, 286, 2816	Inorganic pigments, paints, and allied products; industrial organic chemicals; other chemical products[4]	W	W	31	118	31	118
281	Other inorganic chemicals	W	W	57	75	57	75
282, 2822	Synthetic rubber and other plastic materials and synthetics	W	W	6	70	6	70
2823	Cellulosic fibers including rayon	--	--	--	--	--	--
284	Soaps and detergents	--	--	2	2	2	2
286	Industrial organic chemicals	--	--	9	43	9	43
2873	Nitrogenous fertilizers	--	--	16	163	16	163
2874	Phosphatic fertilizers	--	--	5,700	5,740	5,700	5,740
2879	Pesticides	--	--	12	5	12	5
287	Other agricultural chemicals	952	1,560	30	38	982	1,600
2892	Explosives	--	--	11	11	11	11
2899	Water-treating compounds	--	--	26	38	26	38
28	Other chemical products	--	--	21	74	21	74
29, 291	Petroleum refining and other petroleum and coal products	2,050	2,100	368	422	2,410	2,520
331	Steel pickling	--	--	11	11	11	11
33	Other primary metals	--	--	--	--	--	--
3691	Storage batteries (acid)	--	--	30	21	30	21
	Exported sulfuric acid	--	--	3	2	3	2
	Total identified	3,000	3,650	6,880	7,500	9,880	11,100
	Unidentified	494 r	282	96	149	590 r	431
	Grand total	3,490 r	3,940	6,980	7,650	10,500	11,600

rRevised. W Withheld to avoid disclosing company proprietary data; included with "Unidentified." -- Zero.

[1]Data are rounded to no more than three significant digits; may not add to totals shown.

[2]Does not include elemental sulfur used for production of sulfuric acid.

[3]Standard industrial classification.

[4]No elemental sulfur was used in inorganic pigments, paints, and allied products.

TABLE 7

U.S. EXPORTS OF ELEMENTAL SULFUR, BY COUNTRY[1]

(Thousand metric tons and thousand dollars)

	2010		2011	
Country	Quantity	Value	Quantity	Value
Brazil	632	58,000	594	105,000
Canada	58	8,620	71	16,100
Chile	47	5,950	44	7,190
China	317	48,900	62	26,500
Mexico	169	22,100	277	55,200
New Caledonia	--	--	83	16,300
Other	222 r	27,700 r	178	40,100
Total	1,450	171,000	1,310	266,000

rRevised. -- Zero.

[1]Includes exports from the U.S. Virgin Islands. 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[1]

Country	2010 Quantity (metric tons)	2010 Value (thousands)	2011 Quantity (metric tons)	2011 Value (thousands)
Canada	155,000	$12,500	238,000	$21,000
China	4,670	1,060	2,900	579
Dominican Republic	2,530	363	2,690	502
India	63	7	1,050	120
Israel	1,760	2,270	952	1,050
Jamaica	2	6	1,580	298
Kazakhstan	30	26	1,430	177
Latvia	--	--	7,470	1,310
Mexico	14,700	2,390	5,300	1,440
Morocco	2,010	229	1,010	115
Netherlands	2,000	261	2,000	260
Philippines	1,540	661	6,100	897
Singapore	2,180	591	9,730	1,720
St. Maarten	--	--	3,700	541
Trinidad and Tobago	10,500	858	6,360	4,220
United Kingdom	2,460	327	1,250	205
Venezuela	8,440	577	34,800	5,040
Other	7,650 r	4,270 r	6,100	2,020
Total	215,000	26,400	332,000	41,500

[r]Revised. -- Zero.

[1]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[1]

(Thousand metric tons and thousand dollars)

Country	2010 Quantity	2010 Value[2]	2011 Quantity	2011 Value[2]
Canada	2,320	122,000	2,700 e	188,000
Mexico	378	37,400	303	54,500
Venezuela	41	4,200	99	16,400
Other	211	50,200	168	42,700
Total	2,950	214,000	3,270 e	301,000

[e]Estimated.

[1]Data are rounded to no more than three significant digits; may not add to totals shown.

[2]Declared customs valuation.

Source: U.S. Census Bureau and ICIS PentaSul North American Sulphur Service; data adjusted by the U.S. Geological Survey.

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

	2010		2011	
Country	Quantity (metric tons)	Value[2, 3] (thousands)	Quantity (metric tons)	Value[2] (thousands)
Australia	19,400	$2,100	17,800	$2,480
Bulgaria	--	--	18,900	1,950
Canada	1,150,000	84,100	1,820,000	167,000
China	91,000	9,430	15,600	976
Egypt	11,500	1,700	--	--
Germany	133,000	6,050	93,500	10,700
Japan	60,900	5,190	94	81
Korea, Republic of	17,000	2,240	56,000	7,800
Mexico	199,000	11,800	434,000	30,400
Poland	79,300	5,840	77,700	10,600
Saudi Arabia	6,150	3,390	4,590	3,300
Spain	258,000	14,100	72,100	8,560
Sweden	27,600	1,170	18,100	1,940
Switzerland	1,260	237	15,100	2,250
Taiwan	191	220	2,980	1,380
Venezuela	7,520	3,610	13,400	9,330
Other	44,200 r	3,550	2,690	1,770
Total	2,110,000	155,000	2,670,000	261,000

[r]Revised. -- Zero.
[1]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.
[3]May include revisions to previously published data.

Source: U.S. Census Bureau.

TABLE 11

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

(Thousand metric tons)

Country and source[3]	2007	2008	2009	2010	2011
Australia, byproduct:[e]					
Metallurgy	890	880	870	880	880
Petroleum	60	58	60	60	60
Total	950	938	930	940	940
Brazil:					
Frasch[e]	22 [4]	22	22	22	22
Byproduct:					
Metallurgy	322	322	322	322 [e]	322 [e]
Petroleum	136	136	136	136	136 [e]
Total	480	480	480	480	480 [e]
Canada, byproduct:					
Metallurgy[e]	1,167 [4]	1,148 [4]	890	900	609 [p]
Natural gas, petroleum, oil sands	7,622	7,008	6,577	6,355	5,914 [p]
Total	8,789	8,156	7,467	7,255	6,523 [p]
Chile, byproduct, metallurgy	1,559 [r]	1,586 [r]	1,658 [r]	1,686 [r]	1,723
China:[e]					
Elemental	960	960	1,000	1,100	1,100
Pyrites	4,200	4,300	4,370	4,400	4,400
Byproduct, metallurgy	3,300	3,350	4,000	4,100	4,200
Total	8,460	8,610	9,370	9,600	9,700
Finland:[e]					
Pyrites	250	250	250	225	225
Byproduct:					
Metallurgy	300	300	300	300	300
Petroleum	65	65	65	65	65
Total	615	615	615	590	590
France, byproduct:[e]					
Natural gas and petroleum	606 [4]	605	605	605	605
Unspecified	700	700	700	700	700
Total	1,306 [4]	1,310	1,310	1,310	1,310
Germany, byproduct:					
Metallurgy	2,454	2,458	2,137	2,266 [r]	2,394
Natural gas and petroleum	1,637	1,709	1,623	1,447	1,514
Total	4,091	4,167	3,760	3,713 [r]	3,908
India:[e]					
Pyrites	32	32	31 [r]	31	30
Byproduct:					
Metallurgy	590	600	590	600	610
Natural gas and petroleum	530	540	530	540	550
Total	1,150	1,170	1,150 [r]	1,170	1,190
Iran, byproduct:[e]					
Metallurgy	70	70	70	80	80
Natural gas and petroleum	1,500	1,500	1,500	1,700	1,700
Total	1,570	1,570	1,570	1,780	1,780
Italy, byproduct:[e]					
Metallurgy	90	90	90	90	90
Petroleum	650	650	650	650	650
Total	740	740	740	740	740
Japan, byproduct:					
Metallurgy	1,250 [e]	1,300	1,350	1,400	1,400 [e]
Petroleum	1,966	2,034	1,864	1,892	1,900 [e]
Total	3,216	3,334	3,214	3,292	3,300 [e]
Kazakhstan, byproduct:[e]					
Metallurgy	300	300	300	300	300
Natural gas and petroleum	1,661 [4]	1,733 [4]	2,200 [r]	2,400 [r]	2,400
Total	1,961 [4]	2,033 [4]	2,500 [r]	2,700 [r]	2,700
Korea, Republic of, byproduct, petroleum[e]	670	600	660	1,200 [r, 4]	1,200 [4]

See footnotes at end of table.

TABLE 11—Continued

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

(Thousand metric tons)

Country and source[3]	2007	2008	2009	2010	2011
Kuwait, byproduct, natural gas and petroleum[e]	830	830 r	800 r	820 r	830
Mexico, byproduct:					
Metallurgy[e]	550	700	700	700	700
Natural gas and petroleum	1,026	1,041	1,114	992 r	959
Total	1,576	1,741	1,814	1,692 r	1,659
Netherlands, byproduct:[e]					
Metallurgy	130	130	130	130	130
Petroleum	400	400	400	400	400
Total	530	530	530	530	530
Poland:[5]					
Native	834	762	263	517	657
Byproduct:					
Metallurgy	304	294	257	260 e	260 e
Natural gas	23	21	25	25 e	25 e
Petroleum	188	201	190	200 e	200 e
Unspecified	1	1	1	1 e	1 e
Total	1,350 r	1,279 r	736 r	1,000 r, e	1,140 e
Qatar, byproduct, natural gas	360 e	527	658	1,124	1,200
Russia:[e, 6]					
Native	50	50	50	50	50
Pyrites	200	200	200	200	200
Byproduct:					
Metallurgy	800	820	820	820	830
Natural gas	6,000	6,100	6,000	6,000	6,200
Total	7,050	7,170	7,070	7,070	7,280
Saudi Arabia, byproduct, all sources[e]	3,089 4	3,163 4	3,200	3,200 r	4,600
South Africa:					
Pyrites, S content, from gold mines	71	61	60	30	20 e
Byproduct:					
Metallurgy, copper, platinum, zinc plants	236	188 r	185 r	166 r, e	120 e
Petroleum	335	323	291 r	261 r, e	230 e
Total	642	571 r	536 r	457 r	370 e
Spain, byproduct:[e]					
Coal, lignite, gasification	1	1	1	1	1
Metallurgy	500	500	500	500	500
Petroleum[6]	136 4	136 4	136 4	136	136
Total	637	637	637	637	637
United Arab Emirates, byproduct, natural gas and petroleum[e, 6]	1,950	2,175 4	2,000	1,763 4	1,800
United States, byproduct:					
Metallurgy	817	753	749	791	720
Natural gas	1,320 r	1,300	1,220	1,170 r	1,130
Petroleum	7,000	7,240	6,970	7,140 r	7,100
Total	9,150 r	9,300	8,940	9,100 r	8,950
Uzbekistan, byproduct:[e]					
Metallurgy	170	170	170	170	170
Natural gas and petroleum	350	350	350	350	350
Total	520	520	520	520	520
Venezuela, byproduct, natural gas and petroleum[e]	800	800	800	800	800
Other[e]	3,550 r	3,570 r	3,570 r	4,030 r	3,890
Of which:					
Native	75 r	85 r	84 r	90 r	91
Pyrites	190	205	106	64	64
Unspecified	1,150	1,160	1,190	1,170	1,110

See footnotes at end of table.

TABLE 11—Continued

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

(Thousand metric tons)

Country and source[3]	2007	2008	2009	2010	2011
Other[e]—Continued:					
Of which:					
Byproduct:					
Metallurgy	933 r	936 r	1,100 r	1,200 r	1,140
Natural gas and petroleum, undifferentiated	407 r	363	358	399 r	367
Petroleum	793 r	821 r	735 r	1,110 r	1,120
Grand total	67,800 r	68,300 r	67,400 r	69,400 r	70,500
Of which:					
Frasch	22	22	22	22	22
Native[7]	2,050 r	1,990 r	1,520	1,890	2,030
Pyrites	4,940	5,050	5,020	4,950	4,940
Unspecified	4,940	5,030 r	5,090	5,070 r	6,410
Byproduct:					
Coal, lignite, gasification[e]	1	1	1	1	1
Metallurgy	16,700 r	16,900 r	17,200 r	17,700 r	17,500
Natural gas	7,710 r	7,950	7,900	8,320 r	8,550
Natural gas, petroleum, oil sands, undifferentiated	19,000	18,700	18,500 r	18,200 r	17,900
Petroleum	12,400	12,700	12,200	13,200 r	13,200

[e]Estimated. [P] Preliminary. [r]Revised.

[1]World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2]Table includes data available through September 28, 2012.

[3]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 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 artificial 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, pyrite-derived sulfur, mined gypsum derived sulfur, byproduct sulfur from extraction of crude oil and natural gas, and recovery from oil sands are 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 country of the crude product from which the sulfur is extracted.

[4]Reported figure.

[5]Government of Poland sources report total Frasch and native mined elemental sulfur output annually, undifferentiated; this figure has been divided between Frasch and other native sulfur on the basis of information obtained from supplementary sources.

[6]Sulfur is thought to be produced from Frasch and as a petroleum byproduct; however, information is inadequate to formulate estimates.

[7]Includes "China, elemental."