SELENIUM

(Data in metric tons of contained selenium unless otherwise noted)

Domestic Production and Use: Selenium is primarily recovered as a byproduct of the electrolytic refining of copper, where it accumulates in the residues of copper anodes. In 2022, two electrolytic copper refineries operated in the United States, one in Texas and one in Utah, and produced selenium-bearing anode slimes. Domestic selenium production, consumption, and stocks were withheld to avoid disclosing company proprietary data.

Selenium is used as an active ingredient in antidandruff shampoos; in agriculture as a fertilizer additive to increase plant tolerance to environmental stressors; in blasting caps to control delays; in catalysts to enhance selective oxidation; in copper, lead, and steel alloys to improve machinability; in the electrolytic production of manganese metal to increase yields; in glass manufacturing to decolorize the green tint caused by iron impurities in container glass and other soda-lime silica glass; in gun bluing to improve cosmetic appearance and provide corrosion resistance; in photocells and solar cells used in electronics for its photovoltaic and photoconductive properties; in pigments to produce a red color; in plating solutions to improve appearance and durability; in rubber compounding chemicals to act as a vulcanizing agent; and in thin-film photovoltaic copper-indium-gallium-diselenide (CIGS) solar cells. Selenium is also an essential micronutrient and is used as a dietary supplement for humans and livestock.

Salient Statistics—United States:	2018	2019	2020	2021	2022[e]
Production, refinery[1]	W	W	W	W	W
Imports for consumption:					
Selenium	445	465	366	346	360
Selenium dioxide	12	5	18	71	10
Exports[2]	158	361	147	227	270
Consumption, apparent[3]	W	W	W	W	W
Price, average, dollars per pound:					
United States[4]	16.85	9.15	6.61	8.25	10.00
Europe[5]	17.68	9.27	6.67	8.38	9.00
Stocks, producer, yearend	W	W	W	W	W
Net import reliance[6] as a percentage of apparent consumption	>75	>50	>75	>50	>50

Recycling: Domestic production of secondary selenium was estimated to be very small because most scrap from older photocopiers and electronic materials was exported for recovery of the contained selenium.

Import Sources (2018–21): Selenium: Philippines, 21%; Mexico, 15%; Germany, 13%; China,[7] 9%; and other, 42%. Selenium dioxide: Republic of Korea, 79%; China, 8%; Germany, 6%; Philippines, 5%; and other, 2%.

Tariff: Item	Number	Normal Trade Relations 12–31–22
Selenium	2804.90.0000	Free.
Selenium dioxide	2811.29.2000	Free.

Depletion Allowance: 14% (domestic and foreign).

Government Stockpile: None.

Events, Trends, and Issues: The selenium content of domestic copper anode slimes was estimated to have increased in 2022. The annual average price for selenium in the United States was an estimated $10 per pound, an increase of 21% from that in 2021. Producers in China, which accounted for about 40% of estimated global output of refined selenium in 2022, raised their price offers for selenium to counteract increasing production costs. The supply of selenium is directly affected by the supply of the materials from which it is a byproduct, primarily copper.

In China, coronavirus disease 2019 (COVID-19) pandemic lockdowns throughout the country affected the demand for selenium from the ceramics, glass, and manganese industries, and multiple leading manganese producers in the country reportedly reduced output. The leading global end use for selenium in 2022 was estimated to be for the production of electrolytic manganese in China. In June 2022, the Government of China released a development plan for renewable energy and set goals of generating 25% of energy consumption and installing 1.2 million megawatts of capacity for wind and solar power by 2030. If realized, the proposals would likely increase the demand for selenium from the solar industry for thin-film CIGS solar panels. End uses for selenium in global consumption were, in descending order by estimated quantity, metallurgy (including electrolytic manganese metal production), glass manufacturing, agriculture, chemicals and pigments, electronics, and other applications.

Prepared by **Daniel M. Flanagan [(703) 648–7726, dflanagan@usgs.gov]**

SELENIUM

World Refinery Production and Reserves: The values shown for reserves reflect the estimated selenium content of copper reserves, with the exception of China. Reserves for China were revised based on Government reports, and reserves for India and Sweden were revised based on company reports.

	Refinery production[e, 8]		Reserves[9]
	2021	2022	
United States	W	W	10,000
Belgium	200	200	—
Canada	57	65	6,000
China	1,260	1,300	6,100
Finland	80	65	NA
Germany	300	300	—
India	14	15	500
Japan	720	730	—
Peru	36	40	13,000
Poland	74	75	3,000
Russia	300	350	20,000
Sweden	5	5	500
Turkey	50	50	NA
Other countries[10]	21	25	22,000
World total (rounded)[11]	3,100	3,200	81,000

World Resources:[9] Reserves for selenium are based on identified copper deposits and average selenium content. Other potential sources of selenium include lead, nickel, and zinc ores. Coal generally contains between 0.5 and 12 parts per million selenium, or about 80 to 90 times the average for copper deposits. The recovery of selenium from coal fly ash, although technically feasible, does not appear likely to be economical in the foreseeable future.

Substitutes: Amorphous silicon and cadmium telluride are the two principal competitors with CIGS in thin-film photovoltaic solar cells. Organic pigments have been developed as substitutes for cadmium sulfoselenide pigments. Silicon is the major substitute for selenium in low- and medium-voltage rectifiers. Sulfur dioxide can be used as a replacement for selenium dioxide in the production of electrolytic manganese metal but is not as energy efficient. Other substitutes include bismuth, lead, and tellurium in free-machining alloys; bismuth and tellurium in lead-free brasses; cerium oxide as either a colorant or decolorant in glass; and tellurium in pigments and rubber.

[e]Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data. — Zero.
[1]Selenium content of copper anode slimes.
[2]Includes Schedule B code 2804.90.0000 (selenium) only because there is no exclusive Schedule B code for selenium dioxide.
[3]Production + imports (excluding selenium dioxide) – exports ± adjustments for industry stock changes.
[4]Average annual price for selenium powder, free on board, U.S. warehouse, 99.5% minimum purity. Source: Argus Media group, Argus Metals International.
[5]Average annual price for selenium powder, in warehouse, Rotterdam, 99.5% minimum purity. Source: Argus Media group, Argus Metals International.
[6]Defined as imports (excluding selenium dioxide) – exports ± adjustments for industry stock changes.
[7]Includes Hong Kong.
[8]Insofar as possible, data include refinery output only; countries that produced selenium contained in blister copper, copper concentrates, copper ores, and (or) refinery residues but did not recover refined selenium from these materials were excluded to avoid double counting.
[9]See Appendix C for resource and reserve definitions and information concerning data sources.
[10]Refinery production data include Serbia, South Africa, and Uzbekistan. Australia, Iran, Kazakhstan, Mexico, and the Philippines may also have produced refined selenium, but output was not reported, and available information was inadequate to make reliable production estimates.
[11]Excludes U.S. production.