SELENIUM

(Data in metric tons, selenium content, unless otherwise specified)

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 2023, 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 in agriculture as a fertilizer additive to increase plant tolerance to environmental stressors; as an active ingredient in antidandruff shampoos; 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:	2019	2020	2021	2022	2023[e]
Production, refinery[1]	W	W	W	W	W
Imports for consumption:					
Selenium	465	366	346	351	290
Selenium dioxide	5	18	71	10	5
Exports[2]	361	147	227	192	110
Consumption, apparent[3]	W	W	W	W	W
Price, average, dollars per kilogram:					
United States[4]	20.17	14.58	18.18	23.07	23
Europe[5]	20.44	14.71	18.47	19.82	19
Stocks, producer, yearend	W	W	W	W	W
Net import reliance[6] as a percentage of apparent consumption	>50	>75	>50	>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 (2019–22): Selenium: Philippines, 22%; Mexico, 17%; Germany, 13%; Canada, 9%; and other, 39%. Selenium dioxide: Republic of Korea, 86%; China, 7%; Germany, 5%; and other, 2%.

Tariff: Item	Number	Normal Trade Relations 12–31–23
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 supply of selenium is directly affected by the supply of materials of which it is a byproduct, primarily copper. In 2023, the selenium content of domestic copper anode slimes was estimated to have decreased from that in 2022, reflecting lower output of copper cathode from electrolytic refineries in the United States. The annual average price for selenium in U.S. warehouses was an estimated $23 per kilogram, unchanged from that in 2022. Higher production costs were offset by increased global supply and stable global demand.

China was the leading producer of refined selenium in 2023 and accounted for 42% of estimated global output. Production in China increased significantly over the past 10 years, correlating with an increase of approximately 60% in the production capacity of electrolytically refined copper. The leading global end use for selenium in 2023 was estimated to be for the production of electrolytic manganese in China. 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.

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World Refinery Production and Reserves: The values shown for reserves reflect the estimated selenium content of copper reserves except for those for China, which represent reported reserves of selenium. Reserves for China were revised based on Government reports, and reserves for Finland, Peru, Russia, the United States, and "Other countries" were revised based on company reports.

	Refinery production[e, 7]		Reserves[8]
	2022	2023	
United States	W	W	11,000
Belgium	200	200	—
Canada	110	120	6,000
China	1,290	1,500	5,000
Finland	[9]130	100	300
Germany	300	300	—
India	14	14	500
Japan	710	780	—
Peru	[9]57	57	19,000
Poland	[9]82	95	3,000
Russia	340	360	26,000
Sweden	10	8	500
Turkey	50	50	NA
Other countries[10]	14	15	24,000
World total (rounded)	[11]3,310	[11]3,600	95,000

World Resources:[8] 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 99.5%-minimum-purity selenium powder, free on board, U.S. warehouse. Source Argus Media Group, Argus Non-Ferrous Markets.

[5]Average annual price for 99.5%-minimum-purity selenium powder, in warehouse, Rotterdam. Source: Argus Media Group, Argus Non-Ferrous Markets.

[6]Defined as imports (excluding selenium dioxide) – exports ± adjustments for industry stock changes.

[7]Insofar as possible, data relate to refinery output only; countries that produced selenium contained in blister copper, copper anodes, copper concentrates, copper ores, and (or) refinery residues but did not recover selenium from these materials were excluded.

[8]See Appendix C for resource and reserve definitions and information concerning data sources.

[9]Reported.

[10]Includes Serbia, South Africa, and Uzbekistan. In addition to the countries listed, Australia, Chile, Iran, Kazakhstan, the Republic of Korea, Mexico, the Philippines, and Zimbabwe may have produced refined selenium, but available information was inadequate to make reliable estimates of output.

[11]Excludes U.S. production.