SELENIUM

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

Domestic Production and Use: Selenium is recovered principally as a byproduct of the electrolytic refining of primary copper, where it accumulates in the residues of copper anodes. In 2024, two primary electrolytic copper refineries operated in the United States, one in Texas and one in Utah, and produced crude selenium and selenium-bearing anode slimes. Selenium was not refined in the United States. Downstream companies processed imported selenium to manufacture high-purity selenium products, selenium dioxide, and other selenium compounds. 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; in antidandruff shampoos as an active ingredient; 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. In 2024, estimated end uses for selenium in global consumption were metallurgy (including electrolytic manganese metal production), 40%; agriculture and animal health, 20%; glass manufacturing, 20%; electronics and photovoltaics, 10%; chemicals and pigments, 5%; and other applications, 5%.

Salient Statistics—United States:	**2020**	**2021**	**2022**	**2023**	**2024[e]**
Production, crude and anode slimes	W	W	W	W	W
Imports for consumption:					
Selenium	366	346	351	269	230
Selenium dioxide	18	71	10	8	5
Exports[1]	147	227	192	94	60
Consumption, apparent[2]	W	W	W	W	W
Price, annual average, dollars per kilogram:					
United States[3]	14.58	18.18	23.07	23.11	24
Europe[4]	14.71	18.47	19.82	19.30	24
Stocks, producer, yearend	W	W	W	W	W
Net import reliance[5] as a percentage of apparent consumption	>75	>50	>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 (2020–23): Selenium: Philippines, 24%; Mexico, 15%; Canada, 10%; Poland, 10%; and other, 41%. Selenium dioxide: Republic of Korea, 82%; China, 7%; Philippines, 7%; Germany, 4%; and other, <1%.

Tariff: Item	**Number**	**Normal Trade Relations 12–31–24**
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 from which it is a byproduct, primarily copper. In 2024, domestic production of crude selenium and selenium-bearing copper anode slimes was estimated to have increased from that in 2023, reflecting greater output of copper cathode from electrolytic refineries in the United States. The annual average price for selenium in U.S. warehouses was an estimated $24 per kilogram in 2024 compared with $23.11 per kilogram in 2023. In Europe, limited availability of selenium, steady demand, and higher costs of purchasing selenium from China increased the annual average price to an estimated $24 per kilogram in 2024 from $19.30 per kilogram in 2023.

China was the leading producer of refined selenium in 2024 and accounted for nearly 50% of estimated global output (excluding production in multiple countries for which available information was inadequate to make reliable estimates of output). Production in China increased significantly over the past 10 years, corresponding with an increase of about

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60% in the production capacity of electrolytically refined copper. The production capacity of copper anode, the feedstock material for electrolytic copper refineries, nearly doubled over the same time period. Selenium demand in China for electrolytic manganese production and glass manufacturing has decreased in recent years, whereas demand for use in agriculture and animal health, electronics, and solar cells has increased. In 2024, output of refined selenium in Sweden was estimated to be zero because of a fire in June 2023 that prevented operations at the Ronnskar refinery. Production in Serbia was estimated to increase significantly in 2024 owing to a recently completed expansion at the Bor refinery.

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

	Refinery production[e, 6]		Reserves[7]
	2023	2024	
United States (crude and anode slimes)	W	W	10,000
Belgium	200	200	—
Canada	130	130	6,500
China	[8]1,780	1,800	5,000
Finland	[8]122	170	300
Germany	50	50	—
India	14	14	500
Japan	680	710	—
Peru	[8]50	50	16,000
Poland	[8]74	74	3,000
Russia	350	340	26,000
Serbia	24	60	NA
South Africa	9	9	NA
Sweden	4	—	500
Turkey	50	50	NA
Uzbekistan	2	2	NA
Other countries[9]	NA	NA	24,000
World total (rounded)	[10]3,530	[10]3,700	92,000

World Resources:[7] 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 significant quantities of selenium, but 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]Includes Schedule B of the United States number 2804.90.0000 (selenium) only; there is no exclusive Schedule B number for selenium dioxide.

[2]Defined as production (selenium content of crude selenium and anode slimes) + imports (excluding selenium dioxide) – exports ± adjustments for industry stock changes.

[3]Minimum purity of 99.5%, free on board, U.S. warehouse. Source: Argus Media Group, Argus Non-Ferrous Markets.

[4]Minimum purity of 99.5%, in warehouse, Rotterdam. Source: Argus Media Group, Argus Non-Ferrous Markets.

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

[6]Unless otherwise noted, data relate to refinery output only insofar as possible. Countries that produced selenium contained in copper ore and concentrates, copper smelter products (blister and anodes), and (or) refinery residues but did not recover refined selenium from these materials are excluded.

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

[8]Reported.

[9]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.

[10]Excludes U.S. production.