INDIUM

(Data in metric tons unless otherwise noted)

Domestic Production and Use: Indium was not recovered from ores in the United States in 2008. Indium-containing zinc concentrates produced in Alaska were exported to Canada for processing. Two companies, one in New York and the other in Rhode Island, produced indium metal and indium products by upgrading lower grade imported indium metal. High-purity indium shapes, alloys, and compounds were also produced from imported indium by several additional firms. Production of indium tin oxide (ITO) continued to be the leading end use of indium and accounted for most global indium consumption. ITO thin-film coatings were primarily used for electrically conductive purposes in a variety of flat-panel devices—most commonly liquid crystal displays (LCDs). Other end uses included solders and alloys, compounds, electrical components and semiconductors, and research. The estimated value of primary indium metal consumed in 2008, based upon the annual average U.S. producer price, was about $89 million.

Salient Statistics—United States:	**2004**	**2005**	**2006**	**2007**	**2008**[e]
Production, refinery	—	—	—	—	—
Imports for consumption[1]	143	142	100	147	160
Exports	NA	NA	NA	NA	NA
Consumption, estimated	100	115	125	125	130
Price, average annual, dollars per kilogram[2]	643	946	918	795	685
Stocks, producer, yearend	NA	NA	NA	NA	NA
Net import reliance[3] as a percentage of estimated consumption	100	100	100	100	100

Recycling: Data on the quantity of secondary indium recovered from scrap were not available. Indium is most commonly recovered from ITO. Sputtering, the process in which ITO is deposited as a thin-film coating onto a substrate, is highly inefficient; approximately 30% of an ITO target is deposited onto the substrate. The remaining 70% consists of the spent ITO target, the grinding sludge, and the after-processing residue left on the walls of the sputtering chamber. It was estimated that 60% to 65% of the indium in a new ITO target will be recovered, and research was underway to improve this rate further. A short recycling process time for used ITO targets is critical as a recycler may have millions of dollars worth of indium in the recycling loop at any one time, and a large increase in ITO scrap could be problematic owing to large capital costs, environmental restrictions, and limited storage space. It was reported that the ITO recycling loop—from collection of scrap to production of secondary materials—now takes less than 30 days. ITO recycling is concentrated in China, Japan, and the Republic of Korea—the countries where ITO production and sputtering take place.

An LCD manufacturer has developed a process to reclaim indium directly from scrap LCD panels. The panels are crushed into millimeter-sized particles then soaked in an acid solution to dissolve the ITO, from which the indium is recovered. Indium recovery from tailings was thought to have been insignificant, as these wastes contain low amounts of the metal and can be difficult to process. However, recent improvements to the process technology have made indium recovery from tailings viable when the price of indium is high.

Import Sources (2004-07):[1] China, 43%; Japan, 18%; Canada, 17%; Belgium, 7%; and other, 15%.

Tariff: Item	Number	Normal Trade Relations 12-31-08
Unwrought indium, including powders	8112.92.3000	Free.

Depletion Allowance: 14% (Domestic and foreign).

Government Stockpile: None.

Events, Trends, and Issues: In 2008, global consumption of indium was estimated to have increased from that of 2007, and the indium market was forecast to remain in a supply deficit for at least another year. Japanese ITO manufacturers predicted that their ITO production would increase in 2008 compared with that of 2007, as demand for the material was projected to increase 10% to 15% along with rising flat-panel shipments. Secondary indium production, which accounted for a larger share of production than primary, was expected to rise significantly. Primary production was expected to increase as well, but not considerably. Several refineries have added or expanded capacity, but primary production will continue to be limited by the availability of indium-bearing concentrates. A few indium-bearing deposits located in Argentina, Australia, Bolivia, Brazil, Canada, and China were either being actively explored or developed.

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INDIUM

Photovoltaic (PV) applications could become another large market opportunity for indium. Thin-film PV technologies—including copper-indium-gallium-diselenide (CIGS)—accounted for less than 6% of the global solar cell market. Silicon-based technologies continued to dominate with a 94% share. However, a shortage of high-purity polysilicon has prompted the development of thin films, which are less efficient but more economical than the silicon-based counterparts. Flexible CIGS solar cells could be used in roofing materials and in various applications in the aerospace, military, and recreational industries.

The U.S. producer price for indium began 2008 at $685 per kilogram and remained at that level for most of the year.

World Refinery Production, Reserves, and Reserve Base: World indium reserves and reserve base are not sufficiently well delineated to report consistent figures.

	Refinery production		Reserves[4]	Reserve base[4]
	2007	2008[e]		
United States	—	—	NA	NA
Belgium	30	30	NA	NA
Canada	50	50	NA	NA
China	320	330	NA	NA
France	10	—	NA	NA
Japan	60	60	—	—
Korea, Republic of	50	50	—	—
Peru	6	6	NA	NA
Russia	12	12	NA	NA
Other countries	25	30	NA	NA
World total (rounded)	563	568	NA	NA

World Resources: Indium's abundance in the continental crust is estimated to be approximately 0.05 part per million. Trace amounts of indium occur in base metal sulfides—particularly chalcopyrite, sphalerite, and stannite—by ionic substitution. Indium is most commonly recovered from the zinc-sulfide ore mineral sphalerite. The average indium content of zinc deposits from which it is recovered ranges from less than 1 part per million to 100 parts per million. Although the geochemical properties of indium are such that it occurs with other base metals—copper, lead, and tin—and to a lesser extent with bismuth, cadmium, and silver, most deposits of these metals are subeconomic for indium.

Vein stockwork deposits of tin and tungsten host the highest known concentrations of indium. However, the indium from this type of deposit is usually difficult to process economically. Other major geologic hosts for indium mineralization include volcanic-hosted massive sulfide deposits, sediment-hosted exhalative massive sulfide deposits, polymetallic vein-type deposits, epithermal deposits, active magmatic systems, porphyry copper deposits, and skarn deposits.

Substitutes: Indium's recent price volatility and various supply concerns associated with the metal have accelerated the development of ITO substitutes. Antimony tin oxide (ATO) coatings, which are deposited by an ink-jetting process, have been developed as an alternative to ITO coatings in LCDs and have been successfully annealed to LCD glass. Carbon nanotube coatings, applied by wet-processing techniques, have been developed as an alternative to ITO coatings in flexible displays, solar cells, and touch screens. Poly(3,4-ethylene dioxythiophene) (PEDOT) has also been developed as a substitute for ITO in flexible displays and organic light-emitting diodes. PEDOT can be applied in a variety of ways, including spin coating, dip coating, and printing techniques. Graphene quantum dots have been developed to replace ITO electrodes in solar cells and also have been explored as a replacement for ITO in LCDs. Researchers have recently developed a more adhesive zinc oxide nanopowder to replace ITO in LCDs. The technology was estimated to be commercially available within the next 3 years. Indium phosphide can be substituted by gallium arsenide in solar cells and in many semiconductor applications. Hafnium can replace indium in nuclear reactor control rod alloys.

[e]Estimated. NA Not available. — Zero.
[1]Imports for consumption of unwrought indium and indium powders (Tariff no. 8112.92.3000).
[2]Indium Corp.'s price for 99.97% purity metal; 1-kilogram bar in lots of 10,000 troy ounces. Source: Platts Metals Week.
[3]Defined as imports – exports + adjustments for Government and industry stock changes; exports were assumed to be no greater than the difference between imports and consumption.
[4]See Appendix C for definitions.