UKERC
UK Energy Research Centre

Indium
Fact sheet

High future demand for indium is anticipated due to expected increases in thin film PV manufacturing

Indium is most commonly recovered during the production and refining of zinc.

Indium was discovered in 1863 by German chemists Ferdinand Reich and Heironymous Richter.

They identified the existence of a new metal from the presence of indigo blue lines in the spectrum of a zinc ore. Indium metal was isolated a year later and was named after the colour of the spectral lines. Indium is silver in colour and very soft.

Indium does not occur naturally in its native state but is found as a trace element in a number of sulphide minerals. Zinc bearing minerals typically contain the highest concentration of indium, followed by lead and copper minerals. As such indium is most commonly recovered during the production and refining of zinc.

Concerns over future indium availability arise as a consequence of forecast demand in the thin film PV manufacturing sector.

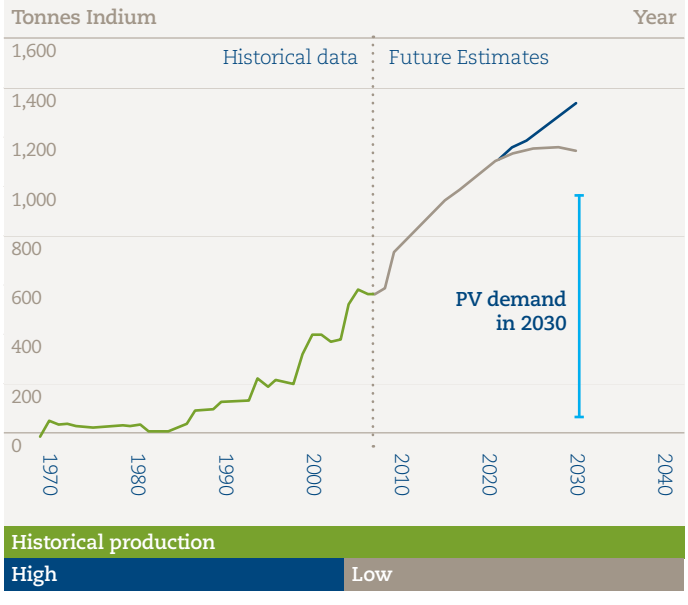
Key Facts

Symbol	In
Atomic number	49
Density (g/cm^3)	7.31
Crustal abundance (ppm)	0.16 - 0.25
Energy-related uses	Thin-film PV

Key points

- High future demand for indium is anticipated due to expected increases in thin film PV manufacturing
- Most indium supply is as a by-product of zinc production
- Efficiency of indium recovery techniques is relatively high, but these techniques are not always applied and indium is discarded in mine waste
- Some believe that these wastes can be exploited in the future, and that they represent a significant resource that should be accounted for
- Indium is recycled within the manufacturing process, though end-of-life modules are often not recycled

Historical production, forecast supply, and estimated future PV demand



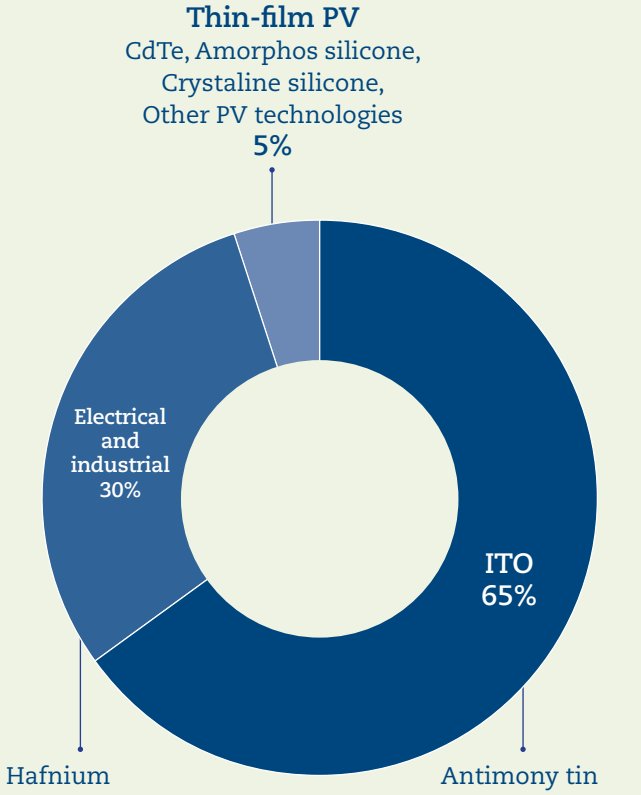
Source: USGS (2012); Speirs et al (2011); Fthenakis (2009)

2007 Data (Tonnes)

Country	Production	Reserves
United States	–	280
Belgium	30	–
Canada	50	150
China	250	8,000
France	10	–
Japan	50	–
Korea	85	–
Peru	6	360
Russia	17	80
Other	15	1,800
World Total	**513**	**10,670**

Source: USGS (2008)

End uses and substitutes

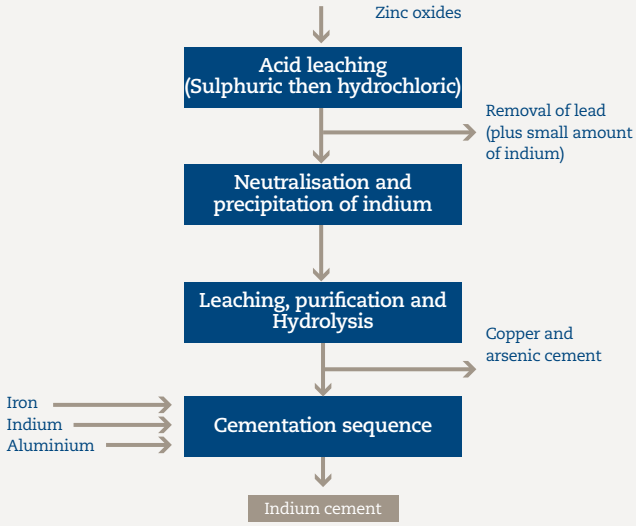


Source: USGS (2012)

Production, extraction and refining

The most important zinc ore is sphalerite, which can typically contain 10-20ppm indium. The mined ore is crushed and milled to a fine powder which is then concentrated by froth flotation to separate ore minerals.

Indium production from Zinc



Source: Ullman & Bohnet (2012)

The concentrated sulphide is roasted in air to convert the sulphide to oxide. The oxide is converted to zinc metal either by high temperature smelting or by acid leaching and electrolysis. When the lead content of the concentrate is high, it is fed in lump form with metallurgical coke to a blast furnace which is heated to about 950˚C by injection of hot air into the base of the furnace. The air converts coke to CO which reduces zinc and lead oxides to metal. The zinc metal exits the top of the furnace as vapour. Approximately half the indium contained accompanies the zinc from which it can be separated. The remainder stays with lead and other impurities in the furnace and is lost.

In the leaching process the calcined ore is dissolved in sulphuric acid. Before electrolysis, iron is removed as jarosite or oxide then zinc powder is added to remove other impurities including the indium. These impurities are selectively re-dissolved in hydrochloric acid then selectively re-precipitated with copper dust. In this way impure indium metal is produced.

Impure indium is refined electrolytically using an acid electrolyte, usually hydrochloric acid. The impure metal is cast into bars or slabs which form the anodes. Pure indium is rolled into sheets to form the cathodes. Repeated refining produces indium of 99.9999% (6N) purity; this level of purity being required for some applications.

Resources and geography

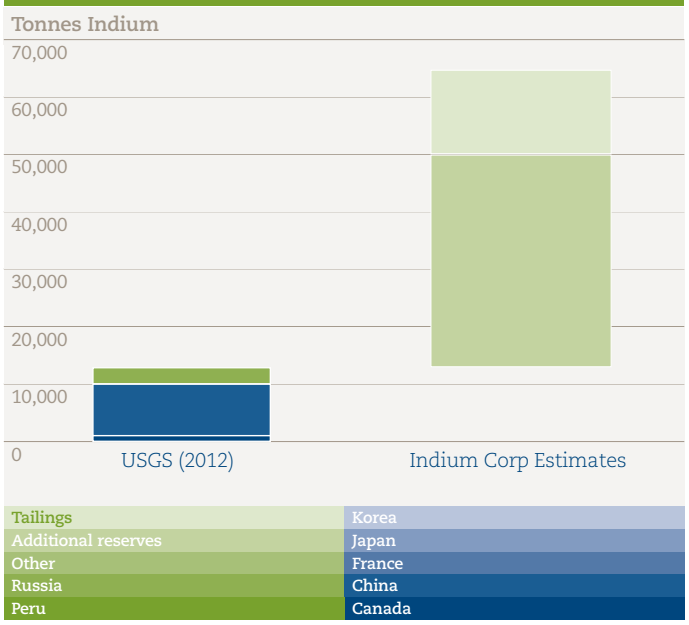
Based on indium content of zinc ores the world reserves are estimated to be approximately 11,000 tons. Major indium producers claim that with improved recovery rates from zinc ores and extracting indium from tin and copper minerals future indium production can be increased.

The largest producer of indium is China, which produced about half the world's indium in 2009. Other producers include Canada, Japan, Republic of Korea and Peru.

Indium reserves have not been published by USGS since 2008 with unreliable data given as reason. In 2007 USGS reported that China produced more than it had in reserves, suggesting inaccuracy in the data available at the time.

Some suggest that resource estimates could be increased significantly through improving recovery factors, exploiting indium associated with other base metals, and by exploiting zinc mine wastes.

Indium reserves



Source: USGS (2012); Mikolajzak & Jackson (2012)

Market factors

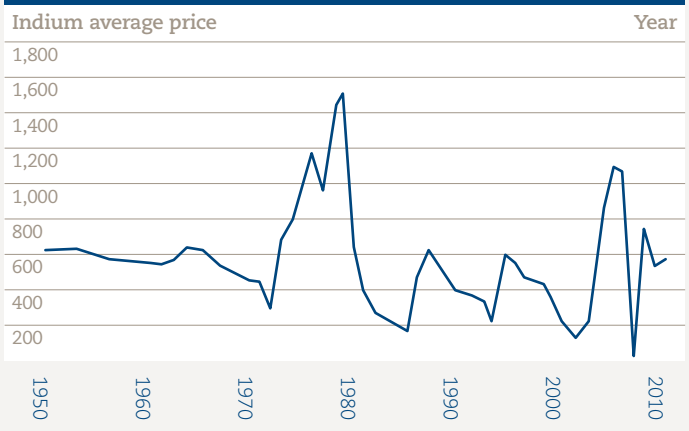
Indium has many applications including the compound indium tin oxide (ITO) used in coatings for sodium street lightings to improve efficiency or as a transparent conductive layer in flat panel displays and thin-film PV.

Flat panel displays account for approximately 65% of annual indium production. However, given concerns over future cost and supply many display manufacturers hope to develop low cost alternatives. If indium was substituted in this way then its availability would become less concerning and thin film PV manufacturing may not be affected.

Indium recycling from end-of-life scrap is unknown and likely small. Recycling of indium within the manufacturing process however, is extensive, particularly recycling of ITO from flat panel display manufacture. Total tonnage of recycled indium is unknown.

The indium price has generally increased in recent years, though volatility can be seen in the figure below. This is the result of increasing demand for flat panel displays, and the Chinese indium export quota, which was unchanged in 2011 at 233 tonnes per year.

Indium average yearly price



Source: USGS (2011)