



This issue

Tin: solder on

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Introduction

This issue of *The Alchemist* looks at the properties of tin, where it is sourced, expected change in its supply, and its use in new technologies.

The period between the early 1980s and early 2000s saw a decline in the price of tin, and subsequent underinvestment in the sector. As projects were shelved due to the 2008/09 GFC and the uncertainty that followed, the current strong demand for tin is being faced with decreased sources of supply. *The Alchemist* predicts that the value of tin will surge as a steady increase in demand will face supply shortfalls.

Investment in tin is behind the curve at a time when its largest market, China, is moving from industrialisation to urbanisation. Despite commodity prices recently being at a two-year low, we expect demand for the metal to increase. The tin market will be driven by consumer products, a market that is experiencing increased miniaturisation, electrification and portability. Therefore, we predict the price of tin to stay above historical averages over the next 3-4 years.

Tin has a long history in our civilisation; it was used in the Bronze Age for its corrosion-resistant properties, and more recently for tin plating, tin cans and — especially — solder, which is its dominant application.

Tin is a very scarce base metal. It has an estimated global abundance of 2 parts per million (ppm), compared with 12ppm for lead, 63ppm for copper and 94ppm for zinc. It is mined at grades that range from 0.5% to 5.5%, and is associated with various mineable minerals, the main commercial mineral being cassiterite (SnO₂). Small quantities of tin can also be extracted from other complex sulphides. It is mined using various techniques, such as traditional underground and open pit, dredging, suction and gravel pumping.

A decline is expected in mined tin from the major global producers, China and Indonesia, with very little in the way of large new projects. The CRU Commodity heat chart forecasts a significant rise in tin prices through to 2016.

Figure 1 CRU commodity heat map for 2016: price changes average 8%



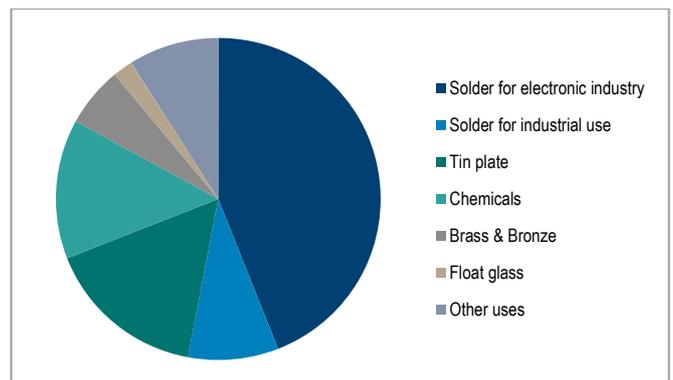
Source: CRU

How is it consumed?

Unlike copper, coal and iron ore, which are used in the early stages of industrialisation in developing economies, tin is consumed in the urbanisation phase of an economy's development, ie, it is a late-cycle metal.

Some 53% of tin is used as solder in the electronics and industrial industries. Other applications take advantage of its corrosion-resistant properties to coat steel and create alloys, such as bronze and pewter.

Figure 2 Uses of tin



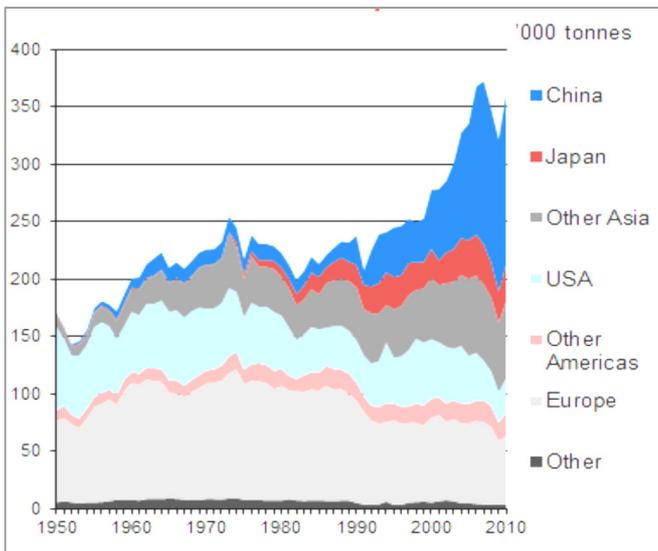
Source: ITRI

Tin is essential in the electronics industry, especially in solder, which is used in circuit boards. In 2000, demand for tin was 275,000t, and by 2012 it is expected to have risen to 365,000t. This represents a US\$9bn market at these prices. In 2006 the EU banned the use of lead in tin-lead solder, which increased demand for tin in the substitute tin-silver-copper solder. The world consumer electronics market is expected to see annual growth of 7% between 2012 and 2015 according to industry researchers RNCOS. In fact, *The Alchemist* expects the correlation between growth in the electronics industry and growth in the tin market to increase because growth in the main consumer of tin, the electronics industry, is likely to outpace that of its other markets.

The country with the greatest demand for tin is China, which accounts for over a third of global demand. Despite China's manufacturing PMI signalling flat growth from July to October 2012, demand for tin has increased. Cancelled warrants that are stockpiled and earmarked for delivery — an indicator of demand — hit a record in September 2012 of 7,910t, 68% of the total LME stockpiles of refined tin at that time (11,665t).

Europe and the US are the second- and third-largest consumers of refined tin products, but demand from both areas has declined over the past 12 months. In June 2012 semi-conductor billings, a proxy for output levels in the electronics manufacturing sector, fell by 9% YoY in Europe and 7% YoY in the US. Demand is unlikely to pick up substantially in 2013, and thus we expect material consumption to become more focused on China.

Figure 3 World tin consumption (1950-2010)



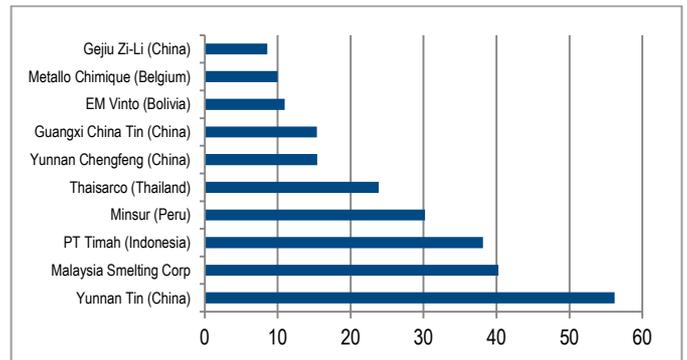
Source: ITRI

Why has demand for tin increased? Changes to legislation banned the use of lead in solder, and increased demand for solder from the electronics industry led to higher demand for tin. As a result, the tin content in solder has risen. However, a downside of using high concentrations of tin in solder is an increased melting point and the potential to generate hair-like 'whiskers' spontaneously, which can cause short circuits. This short circuiting phenomenon caused the Milestone nuclear power plant in Connecticut, US, to shut down in 2005.

Supply

The mining of tin is geographically concentrated, with over two-thirds sourced from a handful of producers in Indonesia and China. However, this dominance is expected to fall in the future. Three of the top four refined tin producers recorded a fall in production of between 5-15% in 2011.

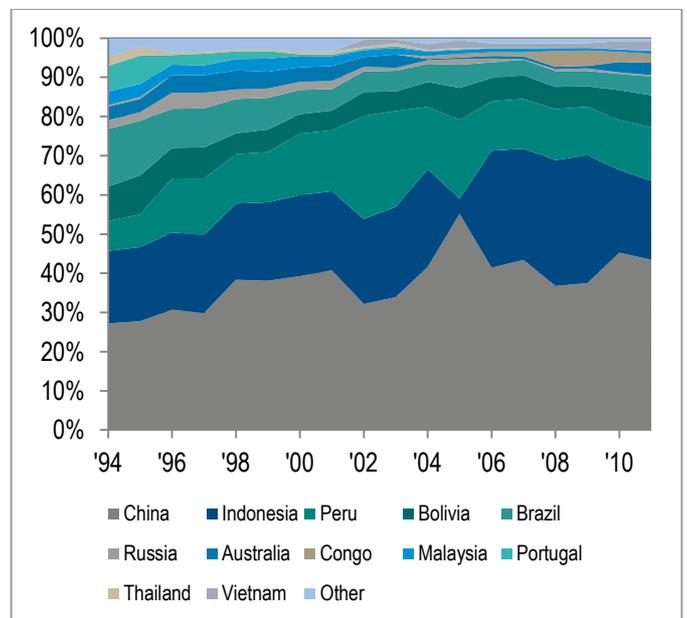
Figure 4 Top ten refined tin producers for 2011 (000t)



Source: ITRI

This trend has continued into 2012, with forecasts from the third largest producer, PT Timah, of a production fall of 21% YoY in CY12.

Figure 5 Sources of annual production



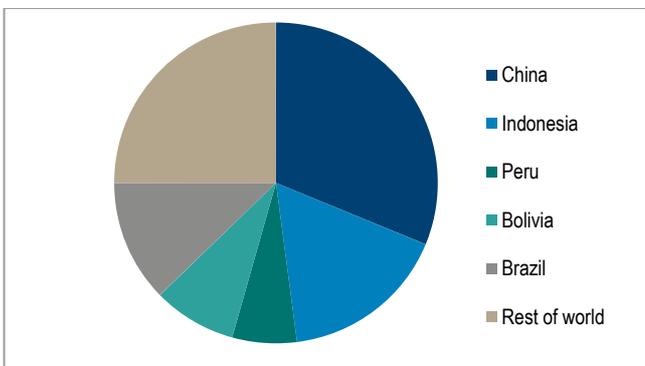
Source: USGS

Estimates by ITRI suggest that between 2011 and 2016 mine production from China and Indonesia will fall by 31% and 15%, respectively.

China

China is rich in cassiterite and hosts the largest global mineable reserves of tin in the world. However, Chinese producers have faced depleting mineable sources, mainly due to a clampdown on illegal mining and increased enforcement of environmental standards by local authorities. In 1H12 more than 100 small mines and processors were shut down to reduce the pollution in two regional rivers in the Yunnan province. It is expected that tin-in-concentrate production of the affected operations is 5-6,000tpa. Despite the unreliability of Chinese production data, overall production is expected to fall by 7% this year.

Figure 6 Global reserves

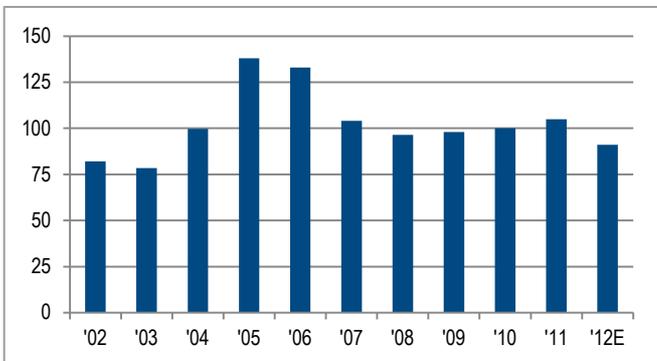


Source: USGS

Indonesia

In July 2012 the Indonesian Government halted the production of refined tin from 14 of the country's 28 smelters because of a six-month decline in prices that had resulted in unprofitable smelting margins. This decision had an effect on the tin market, which saw prices recover from a support level of US\$17,340/t. A 32% MoM decline was subsequently reported for August 2012 exports, which boosted prices by 20%; when production restarted in mid-September, prices were above US\$21,500/t.

Figure 7 Indonesian tin-in-concentrate production (000t)



Source: ITRI

Tin production has been declining in Indonesia since 2005, and the changes to the mining law this year are expected to contribute to a decline in CY12. Between PT Timah, PT Koba and illegal mining activities, production for CY12 is forecast to be about 90,000tpa, a 10% YoY decline.

In 2Q12 the world's largest shipper of tin DSO, Indonesia, introduced a 20% tax on unprocessed metals and a ban on DSO exports of 65 mineral types, including tin in 2014. The law change was designed to allow Southeast Asia's largest economy to generate more value from the mining industry, which contributes 12% to GDP.

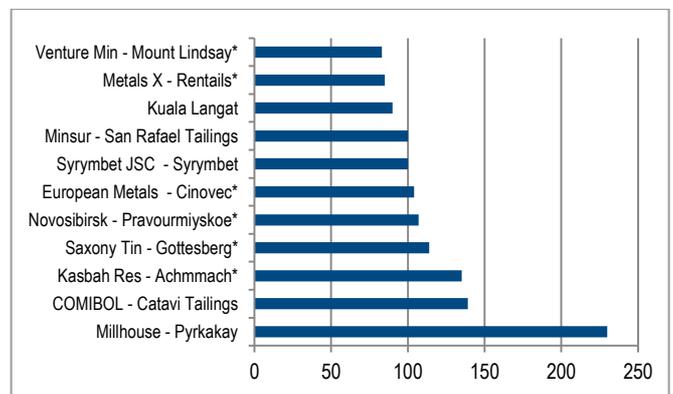
The recent fiscal and mining law changes in Indonesia saw DSO producers focus efforts on the development of processing facilities to complement existing mining operations rather than search for new deposits and, therefore, new supply.

However, in November 2012 the Indonesian Chamber of Commerce claimed that the Supreme Court had scrapped the law that imposed the 2014 ban on the export of unprocessed minerals. A new law will be drafted, but no indication of when this will be has been given so far. We expect fiscal conditions to improve, but by how much remains unclear; as a result, we are unlikely to see a rush of money back into resource projects. Furthermore, any effect on increased tin supply could be prolonged.

Developers & explorers

The supply of tin is falling and no major mining projects are due to be commissioned in the foreseeable future to meet this deficit. Juniors are currently unable to offer projects that can sustainably support long-term supply market dynamics.

Figure 8 Known largest undeveloped tin deposits (000t)



Source: ITRI

*JORC Resource

The Conflict-Free Tin Initiative (CFTI) is a scheme designed to secure a conflict-free supply chain of tin in the global market. It is especially directed towards the Democratic Republic of Congo (DRC), which is rich in cassiterite, which is often mined illegally. The latest milestone in the initiative was made in October 2012, when tin was produced at the South Kivu mine, eastern DRC, outside the control of armed groups or the first time. Tin as a conflict mineral is recognised by the OECD and, as of August 2012, the SEC. Therefore, companies selling products containing tin will be required to disclose fully the source of their minerals.

Substitute risk

Many commodities are susceptible to substitution risk if prices rise too high; *The Alchemist* believes this risk is low for tin. Lead and tin form the basis of solder, which also includes other elements in minor proportions, such as silver, copper, antimony, gold, zinc and cadmium. As the use of lead solder is widely restricted in the manufacturing and end use of many products in the US and EU, we expect tin to be protected from substitution in solder.

New technologies

The modern consumer electronics market is focused on the development of products that are portable, always on, always connected, and that are light and agile (ie, miniaturisation). Power for these devices needs wireless technology, and thus the use of portable energy sources. This trend towards miniaturisation, led by smart phones and tablet computers, has greatly advanced battery technologies, specifically the lithium ion battery, a product that holds over 40% of the market.

The largest growth in the lithium ion market has been in China, where it is predicted to almost double from US\$5bn in 2012 to US\$9.2bn in 2016 due to an increased consumer electronics industry, a by-product of China's urbanisation.

Lithium ion batteries represent a large new market for tin. Researchers at Washington State University (WA, US) are developing a new type of lithium ion battery in which the graphite anode is replaced with tin. A fully charged battery has the lithium ions stored in the anodes and over the life of the charge the ions flow to the cathode and discharge electrons, providing a direct current. Taking advantage of tin's ability to generate 'whiskers' enables the material to store more ions from the increased surface area. The researchers claim the new model can store 3x as many lithium ions in the anode; as a result, the battery can recharge quicker and last up to 3x as long as its graphite predecessor. Tin-based anodes are also cheaper to make than graphite batteries, an important factor considering that materials make up 70% of total battery production costs.

Other new markets where tin could be introduced include:

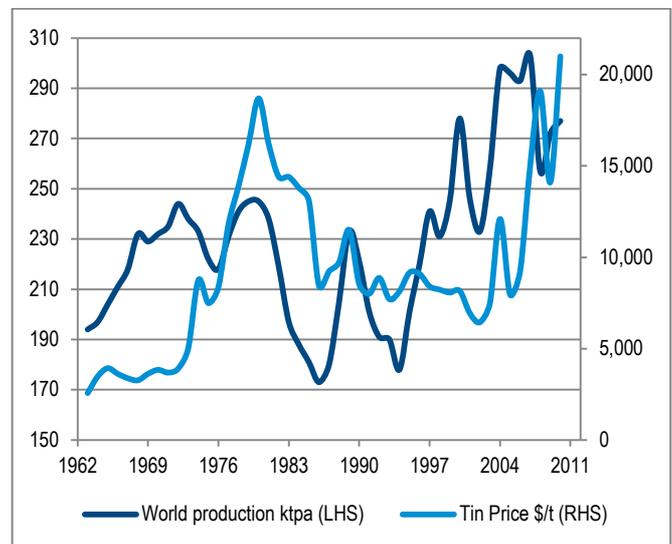
- **Solar cells** — Tin mineral kesterite (which contains up to 30% tin) has been used in improving the efficiency of photovoltaic cells over 10%.
- **Improved vehicle efficiency and braking** — Tin alloy in the fuel tank and fuel line are believed to increase efficiency by 10%. Also, using tin sulphides in brake pads to increase braking performance.
- **Fire retardant** — Tin-based coatings have the potential to replace the antimony-based solutions that currently make up most of the market.

Will the tin crisis happen again?

The Alchemist doesn't believe a 'tin crisis' can happen again. Before the collapse of the International Tin Council (ITC) in 1986, the market was a cartel made up of the 22 leading tin-producing and tin-consuming nations.

The rise in tin prices ahead of its (then record) peak of some US\$17,000/t in 1980 was the result of a naturally tightened market. While demand for tin in the late 1970s was in decline, this was offset by the supply from the then two largest tin suppliers — Malaysia and Bolivia — falling.

Figure 9 World production of tin vs. unit price per tonne



Source: USGS

The subsequent protracted downfall of tin prices after the 1981-82 recession was a result of the ITC bankruptcy in 1985-86. The ITC borrowed US\$500m from 16 international financial institutions to stockpile excess market supply to support prices during the recession; however, the price of tin did not recover and the ITC went bankrupt, which led to a market collapse in 1986 and a suspension of trading on the LME until 1989.

After the 'tin crisis' the price of tin declined throughout the 1980s and 1990s until the early 2000s, when it eventually started to recover. The 20-year bear market, started by the release of accumulated ITC stockpiles into the market, was further exacerbated by new, low-cost mine supply from Brazil and China. Only as recently as 2008 have nominal prices recovered back to the levels last experienced in 1980. However, when inflation adjusted the price is still 50% below this peak, which after adjustment would be US\$45-50,000/t currently.

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