Tin for Tomorrow

Contributing to Global Sustainable Development

Foreword

Materials such as tin are increasingly assessed by consumers, investors and legislators on the three aspects of sustainability - economic growth, contribution to society, and protection of the environment.

Recognising the importance of these factors, the tin industry has initiated a long-term action plan which aims to demonstrate the positive contributions and sustainability of tin. This report provides an introduction to the role of tin in the global economy, describing its history, usage, production and future potential. It also provides descriptions of a series of projects in which the tin industry supports improvements in environmental health, reductions in energy consumption and economic development in some of the poorest countries.

Tin production is connected with all three aspects of sustainability. Perhaps most importantly, mining activity provides a livelihood for many thousands of miners and associated workers and their families in developing countries, which account for some 98% of total world production. Mining can also stimulate development through tax revenues and export earnings and by supporting investment in transport and other infrastructure. Leading mines and smelters are committed to corporate and social responsibility programmes and post-mining land rehabilitation.

Recycling is also playing a growing role, with more than 30% of tin use now accounted for by secondary refined tin and alloys. Products containing tin contribute to quality of life, with a number of existing and new applications connected to health and energy-saving benefits.

Contributing to Global Sustainable Development
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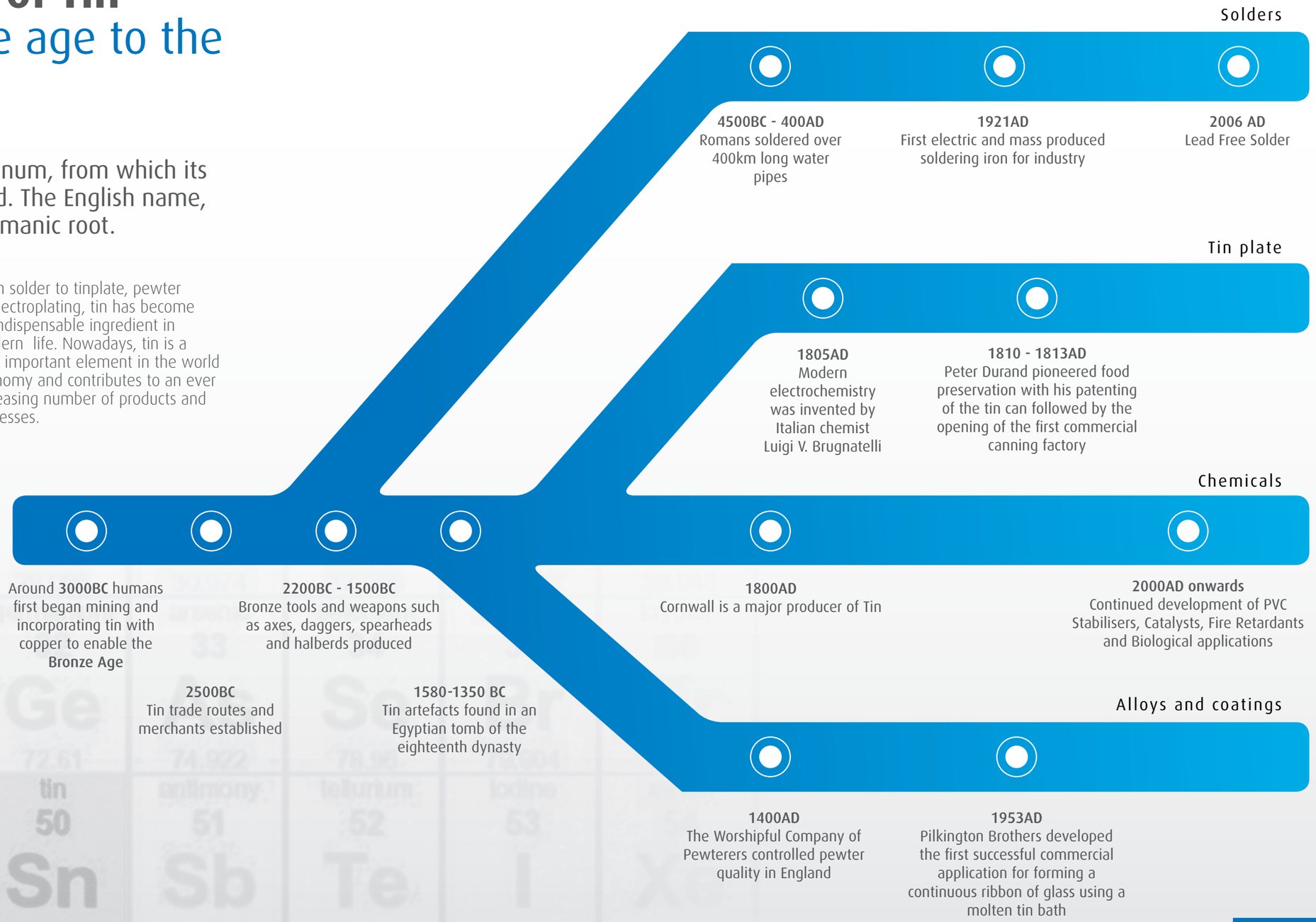
A Brief History of Tin
From the bronze age to the digital age

The Latin name for Tin is Stannum, from which its chemical symbol Sn is derived. The English name, tin, finds its origin from a Germanic root.

Tin has been in use since ancient times and it has played an important role in the history of the human race. Around 5,000 years ago, humans first began mining and incorporating tin with copper to create bronze thus marking the beginning of the Bronze Age. Tin was used in bronze implements because it provides an important hardening effect in copper. The importance of tin grew rapidly when the ancients understood its potential for making everything from tools, to weapons, and even jewellery. Tin artefacts have been found in an Egyptian tomb of the eighteenth dynasty which dates around to 1580-1350 BC and it was traded around the Mediterranean by the Phoenicians who obtained it from Spain, Brittany and Cornwall.

With the development of solder, pewter and tin plating, tin became more and more in demand for thousands of essential and innovative uses right through to the modern age. In the 19th century, Cornwall in the UK was the major producer of the metal, but then deposits were found in Australia, Bolivia and East Asia. Today China and Indonesia are the leading producing countries, followed in importance by Peru.

From solder to tinplate, pewter to electroplating, tin has become an indispensable ingredient in modern life. Nowadays, tin is a very important element in the world economy and contributes to an ever increasing number of products and processes.



Tin is like a spice that many modern products cannot do without

Uses of Tin Today
Growing demand in a sustainable economy

Tin is increasingly being used as a sustainable alternative to other materials and for innovative technologies.

Tin is a vital ingredient in a wide range of manufacturing sectors, including consumer goods, packaging,construction, vehicles and other forms of transport.

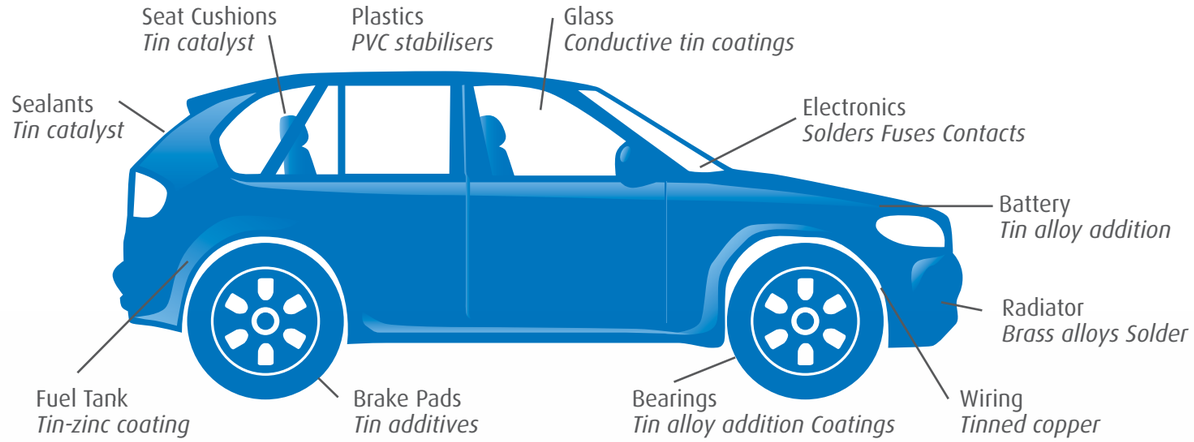
The most important alloy compositions of tin are those required to support the ever growing electronics sector, providing a wide range of highly specialised solders of higher or lower melting temperature, and physical properties that allow all new product designs to be manufactured successfully. Solder is necessary for conductive joints in almost every electronic product, and the material also maintains its use for traditional industrial applications such as joining copper water pipes.

Tinplate (steel with a thin tin coating) is used in packaging for food and beverages, for product containers and various other items. Tin coatings provide the essential corrosion protection vital to these applications and that, together with other benefits, allow this important method of food preservation to remain successful and favoured even in today's competitive world of modern packaging.

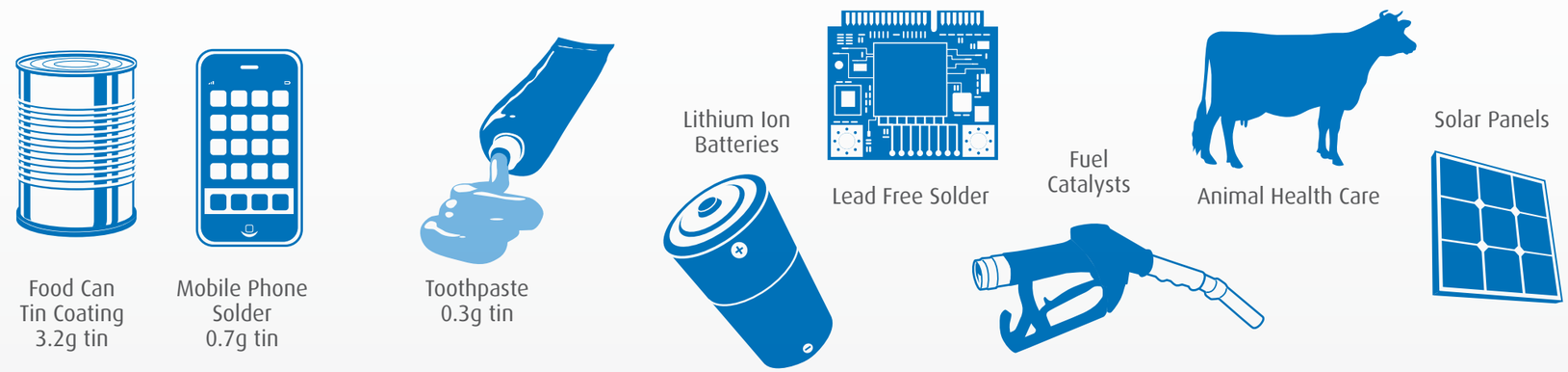
Tin chemicals are also used in a huge number of everyday applications. The biggest use is of organic tin chemicals in PVC for construction products such as doors and windows, to stop them degrading in heat and sunlight. The most important applications for inorganic tin chemicals are as catalysts for a wide range of industrial processes, glass coatings, electroplating baths, fire retardants, and in the ceramics and cement industries. Energy conservation has become a major technological driver and significant growth is expected in the use of tin catalysts for production of polyurethane foam thermal insulation and in tin oxide coatings for low emissivity 'e-glass', widely used in modern 'green' buildings.

Other alloys of tin include bronze and brass, bearing metals, pewter and even superconductors, each of which might be found as components in a multitude of consumer and industrial products. Tin is also essential for the process of making float glass, in which molten glass is floated on the surface of molten tin, thereby creating a sheet of uniform thickness and with a very flat surface.

With so many aspects to tin use, modern life would be impossible without this versatile metal

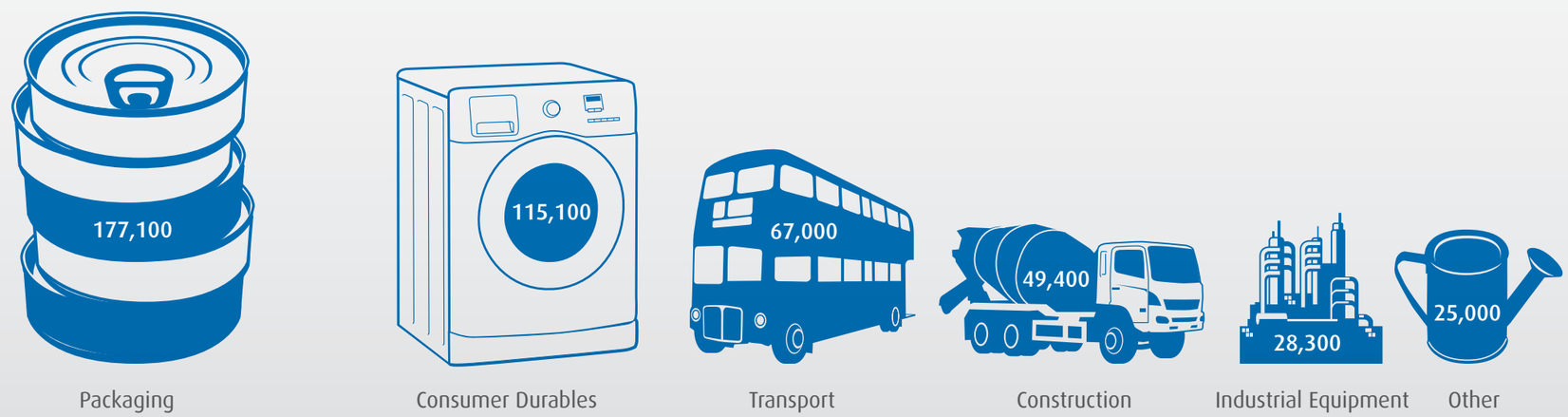


Tin found in cars



Tin – established markets

Tin - New markets



World refined tin use by industry sector, 2010 tonnages

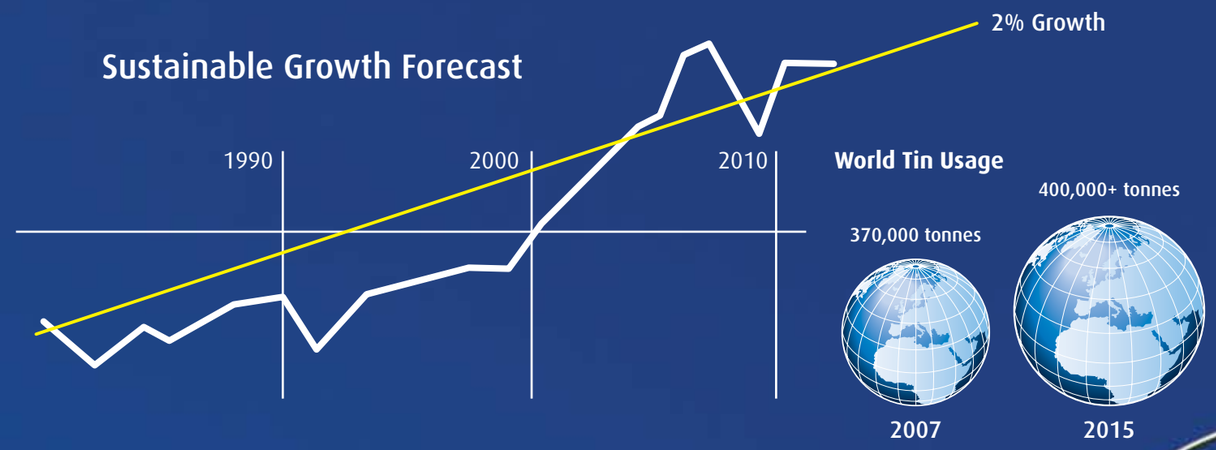
Current and Future Global Tin Demand

World tin consumption reached a peak of over 370,000 tonnes in 2007, powered by the rapid industrialisation of China, a global boom in consumer electronics and a rapid transition to the use of lead-free solders.

After the global financial crisis of 2008-2009, Chinese consumption has risen again to a new peak, but in the rest of world demand has not fully recovered. Asia now accounts for over two-thirds of global tin use, with China alone using more than 40%. China's growth has been export-driven, but rising domestic personal incomes and deteriorating international competitiveness is gradually changing the mix.

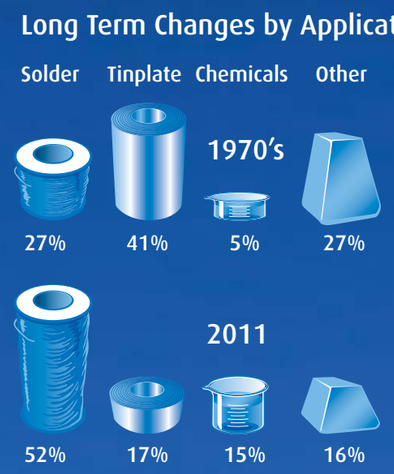
The share of the market accounted for by solders has declined from a peak of over 54% in 2007 to a little under 52% in 2011. This reflects cyclical weakness in the world electronics industry recently and also a trend towards products and assembly techniques involving smaller quantities of solder.

Other than the temporary cyclical dip in 2009, global tin use in tinplate has been remarkably stable at about 60,000 tpy in recent years. The tin chemicals business has been the strongest major application in the last two years, and is estimated to have accounted for over 15% of total refined tin use for the first time in 2011.



Following the trend over the last three decades, global tin use is forecast to increase at a trend rate of just under 2% a year in the next five to ten years. The size of the market is forecast to exceed 400,000 tpy from around 2015.

While the gradual continuing transition to lead-free solders will support future tin use in solders, miniaturisation and changes in assembly technologies will be a negative factor offsetting this. Overall however, the development of new tin applications such as lithium-ion batteries, new stainless steel alloys and a range of energy-related products should ensure a healthy demand for the metal.

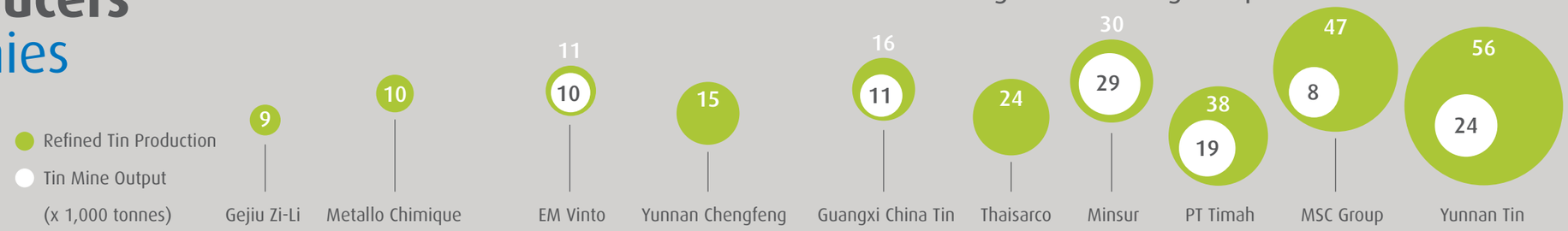


Tin is set to create a whole new generation of stainless steel. Nippon Steel has launched a new more sustainable stainless steel grade that uses no nickel and less chromium. Tests show it is also more corrosion resistant and more formable.

International Tin Producers

The leading tin companies and countries

Leading Tin Producing Companies Production 2011



World Tin Supply Major Producers 2011

Leading Tin Mining Countries 2011

- Indonesia - 104,800 tonnes
- China - 101,900 tonnes
- Peru – 29,022 tonnes
- Bolivia – 20,373 tonnes
- Brazil – 8,800 tonnes
- Australia – 5,134 tonnes
- DR Congo – 5,000 tonnes

● Major tin mine projects

China and Indonesia have long histories as major tin producers, but despite substantial reserves it may not be possible for them to sustain output at recent rates. This means that additional supplies to meet future growth in demand will come from other parts of the world. The very large shares of world production those two countries now account for have only been achieved since the 1990s.

Up to the mid-1980s Malaysia, Bolivia and (to a lesser extent) Thailand were also major producers. For example, the cumulative production from Malaysia since 1950, at over 2.45 million tonnes, is only slightly less than that of China (2.7 Mt) and Indonesia (2.6 Mt).

The other million tonne plus producer has been Bolivia, with 1.38 Mt since 1950. Bolivia remains a significant producer today, but in Malaysia and Thailand tin mining is now subservient to the needs of the manufacturing and leisure sectors. The two other countries that have figured at times as leading producers have been Brazil and Peru. Brazil briefly became the world's largest producer in the late 1980s, while Peru became a significant supplier in the 1990s.

In recent years artisanal and small-scale mining has accounted for as much as 60% of world production, although this share has now dropped to a little below 40%. The main centres of artisanal mining have been Indonesia, China, Bolivia and Central Africa. However depletion of ore deposits, especially onshore, is expected to result in a continuing decline in Indonesian production, while Central African tin, principally from DR Congo, has been experiencing political controls on the trade in "conflict minerals".

World Production

Recycled tin on the rise

Taking into account the re-use of recovered tin alloys, notably solders, brass and bronzes and lead alloys, secondary materials contribute over 30% of total tin use in any typical year. These alloys can be re-used without the need for re-refining to pure tin. However there has also been recent growth in secondary re-refined tin production which has exceeded 50,000 tonnes in each of the last five years, equivalent to around 16 - 17% of total refined metal production and amounted to over 65,000 tonnes last year.

Tin can be easily recycled with no loss of quality with secondary material refined to high purity grades. Currently 98% of global mine production occurs in developing countries, providing livelihoods, export earnings and opportunities for future infrastructural and other forms of development.

Tin recycling in different forms, 2010

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Tin Production Methods
From mining to refining

Tin is produced from the mineral cassiterite (tin oxide, SnO2), a tin ore containing various impurities which are removed during concentration, smelting or refining. Cassiterite occurs both in deep hard rock mines and in near surface alluvial deposits and can be mined relatively easily, using industrial methods or basic and simple tools. Unlike many other metals, mining of cassiterite is carried out by artisanal and small mines (ASMs), as well as by larger scale producers.

Hard-rock mining

Hard-rock underground mining is predominant in China, South America and Australia, although there are some open pit operations in all these places. Vein and disseminated tin deposits are mined by the same methods used in hard-rock mining of other non-ferrous ores such as zinc. The ore is broken by drilling and blasting, transported to a concentrator where it is crushed and ground and then concentrated primarily by gravity methods.

Although flotation is not as efficient for tin ores as it is for sulphide ores, it is used increasingly to improve the amount of fine tin recovered and to recover tin from the residues of earlier treatment. Processing circuits may also allow for the recovery of by-products including copper, lead, zinc and a range of other minerals. In some mines tin is itself a by-product of the mining of other metals, including zinc, silver, tantalum and tungsten.

Alluvial mining

Tin alluvial deposits, where the hard rock has already been broken down and distributed by a natural weathering, are also an important source. The main centre of alluvial mining has been the South East Asian tin belt. Until the mid-1980s, the main method of mining large placer tin deposits was by bucket ladder dredging. The alluvium containing the tin is excavated and transported by a continuous chain of buckets to the interior of the dredge where it is washed and roughly concentrated. In the last few years smaller cutter-suction dredges have become widely used, which are more manoeuvrable and produce a higher grade concentrate on-board.

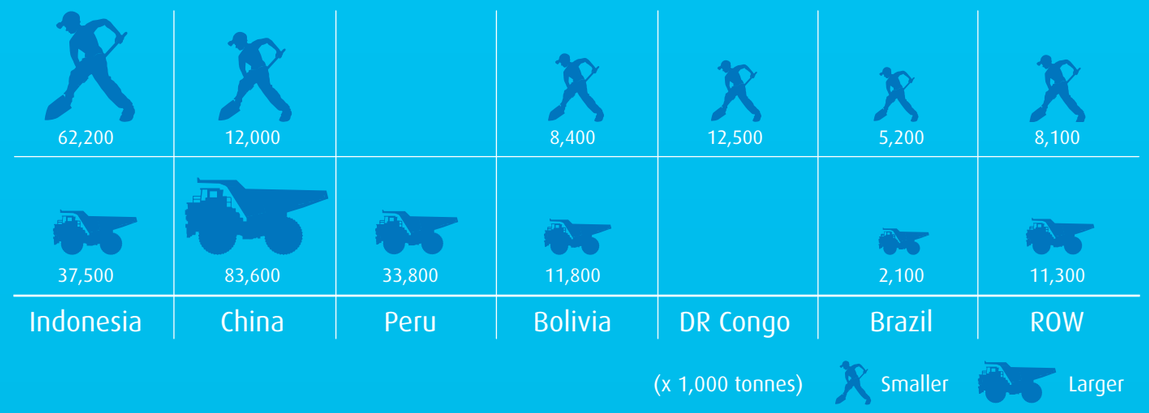
In South-East Asia particularly, smaller deposits, or those unsuitable for dredging (e.g. because the bedrock is very rough) are worked by gravel pumping. The alluvium is broken up by a high pressure jet of water and the resulting slurry is pumped to the concentrating plant. In recent years there has been a boom in small-scale alluvial mining in Indonesia, using simple gravel pumps or off-shore suction boats - floating platforms or converted fishing boats.

Smelting and refining

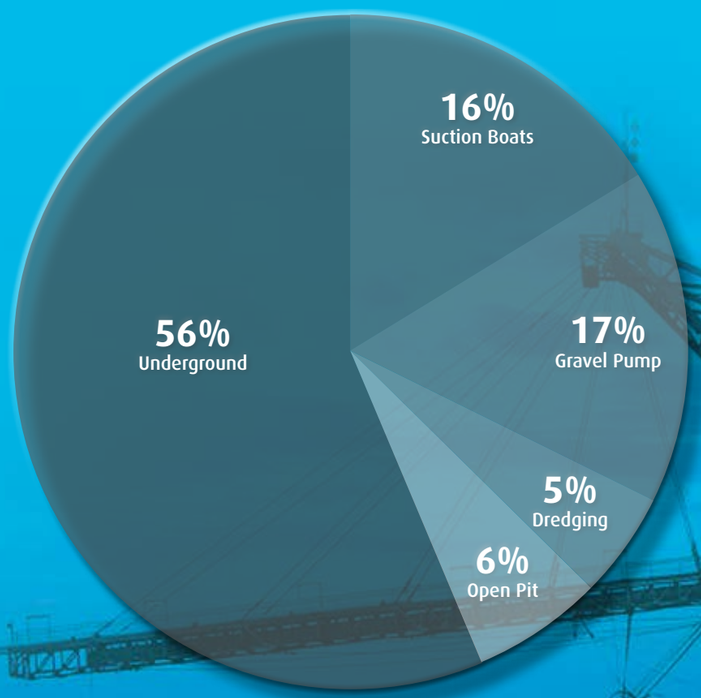
Smelting is carried out to produce a metal from its ore. The principle of tin smelting is therefore the chemical reduction of tin oxide by heating with carbon to produce tin metal and carbon dioxide gas. In practice, the furnace feed contains the tin oxide concentrate and any remaining associated impurities, carbon in the form of anthracite coal or coke, and limestone or similar material to act as a flux and a slag-producing agent. While tin oxide is comparatively easy to reduce by using carbon at high temperatures this operation differs from the smelting of most common metals because retreatment of the slag is necessary to obtain efficient metal recovery. Tin smelting can be carried out in older type furnaces - reverberatory, blast, or electric - or in the newer Ausmelt process.

Crude tin produced by smelting requires further refining. This is mainly done by pyrometallurgical (fire) refining which produces tin of around 99.85% or 99.9% purity suitable for general commercial use. Occasionally electrolytic refining is used to produce a high grade tin of anywhere up to 99.999% purity used in specialist applications.

Mine Output by Scale of Operation 2010



World Mine Production by Method



A wetland has been established from old dredging grounds in Dengkil, Selangor. This area can now boast of hosting a vast array of fauna and flora.

Tin mining has many positive impacts

Responsible Mining
Employees, Communities and the Environment

The tin industry takes Sustainability and Corporate and Social Responsibility very seriously. It is as important to look after people and the planet, as it is to generate economic growth. All of the leading Tin producers have in place CSR and Sustainability programmes.

Tin Industry

The most important resource of any company is its employees. A great deal of effort has gone into encouraging employees to be at the forefront of ethical and socially responsible behaviour, from education and implementation of best practices, to helping the local community at large.

Heath and Safety also plays a critical role ensuring that the workforce maintains safe systems of work, handling, storage and transportation of equipment and materials. Mining and smelting companies provide support facilities such as doctors and fire fighting teams as well as training, rigorous monitoring and continuous improvements.

Community programmes

IIn addition to employment, local communities benefit from a variety of support services and assistance. This can include in the case of Minsur sponsoring programmes likes 'Mathematics For All' and "Useful Vacations" during the months of January to March, directed at children of school age. In Indonesia a Small Business and Cooperatives partnership program initiated by PT Timah is concerned with the improvement of people's lives and finances. One of the main objectives is to encourage business activity and economic growth of the local community, in terms of sustainable development through the expansion of work and business opportunities

Post-mining land rehabilitation

Land reclamation and rehabilitation programmes are also initiated for long-term environmental stability and economic post mining land-use. While mining operations have a significant impact on the natural environment, there is often no long-term damage. Land is returned to other uses such as fruit production, leisure activities and improving native bio diversity.

Case Study: Malaysia

The development of tin mining in Malaysia helped develop the country's infrastructure. In Peninsular Malaysia many of the roads and certainly the railway lines were developed because of the need to transport tin ore. More than two thirds of mined out land has now been rehabilitated and transformed into housing, resorts and golf courses, plantations and wetlands.

The tin mining industry was one of the earliest to practice CSR in the country. The Tung Shin Hospital in Kuala Lumpur, which began as a clinic providing free medical services in 1881 was started with contributions from the tin mining community. Malay miners also contributed to education in local communities as well as sponsoring employee scholarships.

Malaysia shows how the industry in partnership with local communities, businesses and the government can build a sustainable economy by embracing environmental and social responsibility.

Projects and Progress

The tin industry working through ITRI has an active portfolio of joint projects working to develop new and emerging uses for tin. These projects contribute to an increased understanding of the key environmental, scientific, social and business issues interacting throughout the life cycle of the metal.

Sustainability has become the focus of many new developments in technology with industry currently evaluating, for example, tin use in solar panels, longer life lithium batteries and fuel catalysts.

Lead Free Solder
A tin technology solution

In the 1990s waste electrical and electronic equipment (WEEE) was identified in Europe as one of three major waste streams causing issues with landfill space and hazardous waste disposal.

The result was the 2002 EU WEEE Directive, setting policies for increased recovery and recycling of e-waste, and a co-ordinated strategy for the reduction of hazardous substances in products through the parallel 2002 EU RoHS (Reduction of Hazardous Substances) Directive. Requirements for use of lead-free soldering technology therefore arose, and have since been replicated around the world.

At the same time Japan, also faced with serious landfill issues, and leading the world in many aspects of sustainability through voluntary actions, became the birthplace of commercial lead-free soldering, launching the first mass-produced product, a Panasonic MiniPlayer, in 1998.

The move promoted a silent revolution for tin. Solder, the essential glue that holds together all of the electronics and electrical equipment that we depend on so much, changed significantly. The 40% lead was removed and tin content was increased from about 60% to about 95%.

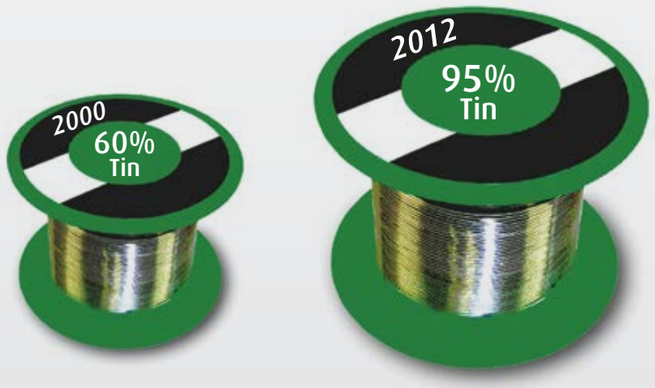
A huge amount of technical work needed to be done. The new solders had higher melting point, different flow properties and made joints with different mechanical and electrical behaviour. ITRI and other industry bodies in Japan and the US coordinated large R&D programmes to supplement implementation by companies and find the best solution.

Combined with other developments such as design for recycling, halogen-free technologies and weight reduction the end result is a significantly improved level of sustainability for all electronic products.

The need to understand materials through the entire supply chain has hugely improved the availability and exchange of data within the industry.

For solders the technical transition continues. Firstly lead-free conversion has continued to spread well beyond its original driver of consumer goods waste disposal and is now even reaching sectors such as automotive, aerospace, defence and medical applications. In China, the largest market, recent legislation will start to add further pressure to the national solder market, currently using about 25% of the world's tin.

Secondly, new second generation lead-free solders are being launched. These are more sustainable using less energy, and producing higher strength joints for better reliability.



Today's solders are almost pure tin. They will continue to connect our world together tomorrow and for a long time to come.

iTSCi
(ITRI Tin Supply Chain Initiative) Capacity building and due diligence in Central Africa

The iTSCi traceability and due diligence programme has become especially important following the introduction on July 21st 2010, of the US 'conflict minerals law'.

The tin industry is unusual among the mining sector in the high proportion of the metal produced by locally owned companies, small-scale and artisanal miners. All producers understand the importance of assisting in the formalisation and development of these smaller groups. In 2008 the industry became aware of concerns relating to the possible link between tin mining and conflict in certain areas of the Democratic of Congo (DRC), and acted immediately to address the situation.

A working group was formed in 2009. It undertook immediate actions to improve document collection, and implemented a practical system on the ground to differentiate between 'conflict' and 'conflict-free' mineral in what is recognised to be one of the most challenging areas of the world. Speed was critical to maintain the livelihoods of miners in the central African region, while providing confidence to tin users that purchases are not contributing to conflict.

Aside from the implementation of iTSCi, leading producers helped develop international guidance, such as the OECD Due Diligence Guidance for Responsible Supply Chains of Minerals from Conflict-Affected and High-Risk Areas, for the re-assurance of their customers.

iTSCi is a traceability and due diligence system supporting local Government mine agencies to control and benefit from the exploitation of their natural resources, as well as verification through independent third party audits, field visits, document checking, data analysis and risk management through local stakeholder committees.

iTSCi has been operating across Rwanda and the Katanga Province of the DRC since April 2011. The project team have helped to map the location and operational circumstances in over 1,500 artisanal or small scale mine areas, introduce traceability, and ensure miners in those areas continue to have access to international mineral markets and prices. Several hundred tonnes of mineral concentrate are tagged and exported each month, providing a living for around 45,000 miners, and benefiting associated workers involved in transportation and other services, as well as an estimated 5 dependents for each of those workers.

The benefits arising from iTSCi will increase progressively in the future as plans to roll out the programme in other parts of Central Africa are realised.

COMMENTS ON iTSCi IN THE UN GROUP OF EXPERTS REPORT S/2011/738 OF 2.12.2011

"In non-conflict areas, where companies and other traders have exercised due diligence and introduced traceability systems, mining sector governance has improved, and mineral production and export have risen."

"In areas where no traceability systems have been introduced, mineral production and exports have fallen. This has not only decreased conflict financing, but also weakened mining sector governance, with a greater proportion of trade becoming criminalized and with continued involvement by military and/or armed groups."

"The Initiative has also helped to build Democratic Republic of the Congo Government capacity in the mining sector, to safeguard the livelihoods of miners at tagged mining sites and, according to some North Katanga civil society activists, to reduce corruption among State officials in the mining sector."

Mines and companies who are members of iTSCi and fully participate in the tracking process for all mineral purchases will be able to demonstrate to their customers their implementation of appropriate due diligence practices. This involves two types of bar-coded tags, each with unique reference numbers and clearly visible areas of allocation. Data is then fed into the iTSCi database providing complete traceability from mine to smelter.

Secure mining delivers market confidence in investment and demand, credibility and sustainability.

Chemical Stewardship
Protecting human health and the environment

Tin has been used safely for many years, but responding to the increasing consumer interest in understanding the exact science of the metals behaviour in the environment and the human body, the industry has come together to carry out new research. That work has included studying the benefits and behaviour of tin in food packaging materials, as well as responding to the regulators needs for more extensive and wide ranging proof on the safety of all substances.

The EU REACH Regulation on the 'Registration Evaluation and Authorisation of Chemicals' challenged the entire metal and chemical sectors to prove the safety of their substances in all applications where they are used.

The tin industry acted swiftly to form a consortium of leading companies to fund an extensive programme of new scientific research on safe levels of tin in the environment, as well as the limited impact of tin on human health.

The success of this joint programme provides confidence to users, consumers and regulators through the availability of a full scientific understanding of the behaviour and safety of the metal, and ensures the market for tin in the EU.

The industry is committed to follow on from this recent activity to support new chemical regulations in different regions as outlined in the Strategic Approach to International Chemicals Management (SAICM).

Fuel Catalysts
Tin could save up to 10% of fuel consumption

A remarkable but little known fact about tin is that it can save energy and reduce emissions when added to fuel.

When added into a fuel tank or a fuel-line tin is able to stabilise the fuel in such a way as to make engines burn cleaner and generate more power. It is a so-called 'fuel catalyst'.

There is good reason to believe that this tin technology could in fact make a significant contribution to energy saving, reduction of urban pollution, and global sustainability.

Tin fuel catalysts have now been used in a variety of engines for more than 20 years – cars, motorcycles, ships, generators and even boilers. They have been tested by ITRI and other laboratories with positive results. Some of these tests have shown fuel savings of up to 10% and emissions reductions of 30% or more. Field trials have shown similar performance.

The challenge now is to put a significant amount of new research and development effort behind this technology to explain the interaction between tin and fuel and to verify these remarkable effects.

If confirmed it will put tin firmly on the map as an important contributor to the sustainability of tomorrow's world.

Tin has a Bright Future

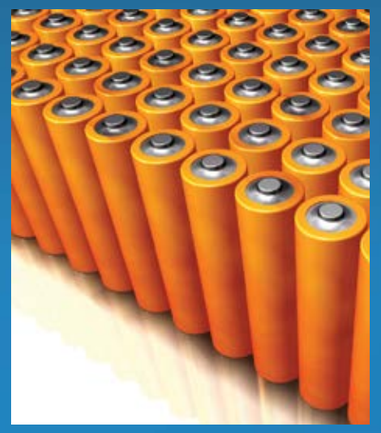
Tin has established a long-term future as an innovative, competitive and sustainable material.

Solar Panels
Tin is ahead in the race for the next generation of cheaper solar cell materials. Today solar cells use expensive and rare elements such as gallium and more 'earth-abundant' materials are needed. Kesterite, containing 30% tin, was the first to cross the 10% efficiency barrier in an IBM research laboratory.

Fire Retardants
Tin is replacing antimony fire retardants used in most plastics. Stopping fire and smoke saves lives and tin has been shown to work well. Until now antimony trioxide has been widely used but more sustainable alternatives are needed and zinc stannate use is growing fast.

Lithium Ion Batteries
Tin can make lithium ion batteries last more than three times longer. This can help meet a huge demand for better batteries in mobile phones, cameras, iPads and other mobile devices. A new market for tin, this looks set to grow fast, especially if lithium ion batteries are used in hybrid cars.

Animal Healthcare
Tin and zinc work well together to heal wounds and kill bacteria. A new range of animal healthcare products is being launched in the US, including pet and agricultural treatments. The biggest new use may be in footbaths for treating hoof infections in dairy cattle.



ITRI
Over 80 years experience in the tin industry

ITRI is the only organisation dedicated to supporting the tin industry and expanding tin use. A primary goal is to ensure an innovative, competitive, and sustainable supply chain and market for tin.

ITRI is the focal point for discussion and action on important regional and global issues affecting the tin industry. It promotes the industry worldwide, providing authority, leadership and voice.

Today ITRI continues to evaluate and act upon a wide range of market drivers and global technology trends including sustainability, climate change and energy efficiency, recycling and recovery, and nano-materials.

The organisation has been able to adapt its role to meeting the rapidly changing requirements and dynamics of the tin market to ensure that the industry can meet the sustainability demands of tomorrow's world.

ITRI works on behalf of tin producers to ensure that key industry drivers are understood and that ITRI's activities are correctly focused to support sustainable production and markets for tin.

Members of ITRI are strongly committed to the concept of sustainability and are taking a leadership role in working towards a positive future for tin and those whose livelihoods depend upon it.

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