Zinc
...essential for life

Zinc Environmental Profile

Life Cycle Assessment

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Introduction

Increasingly the zinc industry is being asked to provide information to downstream users of zinc and zinc-containing products on the environmental footprint of the materials it produces. Material specifiers and product engineers in key end-use markets such as building, construction and transportation are more and more interested in selecting materials that have the best environmental profile while meeting traditional cost, quality and technical performance criteria.

Understanding the environmental footprint of zinc starts with documenting the resource requirements (energy and non-energy) and environmental releases associated with zinc mining and refining, but it also involves understanding the impacts and the benefits of using zinc during other stages in the product life cycle. These benefits can arise in use (e.g. extending the life of galvanized steel products) and through end-of-life recycling (e.g. by utilizing recycled zinc to create new products).

The zinc industry understands that to properly demonstrate the sustainability attributes of zinc, data and information is needed that enables users of zinc to evaluate its impacts and benefits across the life cycle (from raw material extraction to end-of-life recycling). This environmental profile was developed to provide information and life cycle data on primary zinc to actors along the zinc value chain.

It can be used to understand, and where appropriate, improve the life cycle impacts and benefits of zinc and zinc-containing products.

What is zinc?

Recognized in India as a metal in 1374, zinc and zinc oxides have been used for centuries for a variety of applications such as making brass to healing wounds. Today we know that zinc is present naturally in rock and soil, air, water and the biosphere, and it is a material that is essential to human, animal and crop health and well-being. When the supply of plant-available zinc is inadequate, crop yields are reduced, and the quality of crop products is frequently impaired. Dietary zinc deficiency is a critical problem that affects hundreds of millions of people in many parts of the world.

A very versatile material, zinc also plays a key role in a variety of industrial and product applications. Zinc protects steel from rust – making steel more durable by lasting longer. Less corrosion also means less costs and less environmental impact for maintenance. Zinc sheet applications such as roofing, gutters and downpipes, for instance, can last longer than a lifetime. Like other metals, zinc can be recycled without changing its properties.

These inherent characteristics of zinc – natural, essential, durable, recyclable – make it a desirable material for a range of applications in transportation, infrastructure, consumer products and food production. Zinc's durability and recyclability means that in many applications it can help save natural resources and improve sustainability performance. Zinc's ability to increase crop yields is a critical contribution to sustainable development in many parts of the world.

Sustainability Attributes of Zinc

Zinc is Natural
- Zinc is present naturally in rock and soil, air, water and the biosphere.

Zinc is Essential
- All living organisms – plants, animals and humans – need zinc to live.

Zinc is Durable
- Zinc extends the life cycle of steel and reduces maintenance costs.

Zinc is Sustainable
- Zinc can be recycled indefinitely, without loss of its physical or chemical properties.

Zinc is Vital
- Zinc is vital for construction, food production, health, pharmaceuticals, infrastructure, transport… for life itself.

Where does zinc come from?

Minerals and metals are mostly obtained from the earth's crust. The average natural level of zinc in the earth's crust is 70 mg/kg, but it ranges between 10 and 300 mg/kg. In some areas, zinc has been concentrated to much higher levels by natural geological and geochemical processes (5-15% or 50,000-150,000 mg/kg). Such concentrations, found at the earth's surface and underground, are being exploited as ore bodies.

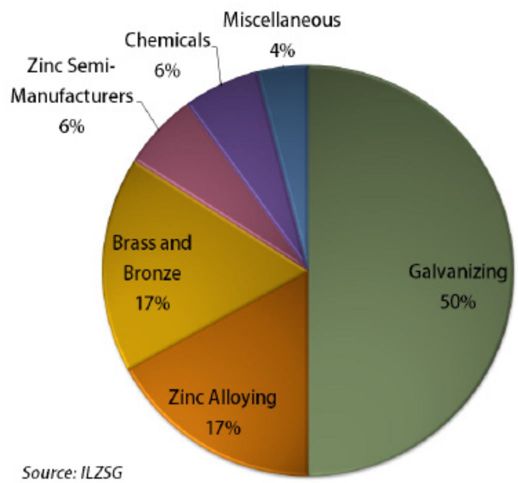
Zinc ore deposits are widely spread throughout the world. In addition to the European continent, zinc ores are extracted in more than 50 countries. China, Australia, Peru, India and Canada are among the biggest zinc mining countries. Zinc is normally associated with lead and other metals including copper, gold and silver.

How is zinc used?

Worldwide, over 11 million tons of zinc are produced annually. Nearly 50% of this amount is used for galvanizing to protect steel from corrosion. Approximately 17% is used to produce brass, and 17% goes into the production of zinc base alloys (e.g. for use by the die casting industry). Significant amounts are also utilized for compounds such as zinc oxide and zinc sulfate and semi-manufacturers including roofing, gutters and down-pipes.

These first-use suppliers then convert zinc into in a broad range of products. Main application areas are: construction (45%), transport (25%), consumer goods and electrical appliances (23%) and general engineering (7%).

Zinc: Major End Uses



How is zinc produced?

Zinc Mining

80% of zinc mines are underground, 8% are of the open pit type and the remainder is a combination of both. However, in terms of production volume, open pit mines account for as much as 15%; underground mines produce 64%; and 21% of mine production comes from the combined underground and open pit mining.

Rarely is the ore, as mined, rich enough to be used directly by smelters; it needs to be concentrated. Zinc ores contain 5-15% zinc. To concentrate the ore, it is first crushed and then ground to enable optimal separation from the other minerals. Typically, a zinc concentrate contains about 55% of zinc with some copper, lead and iron. Zinc concentration is usually done at the mine site to keep transport costs to smelters as low as possible.

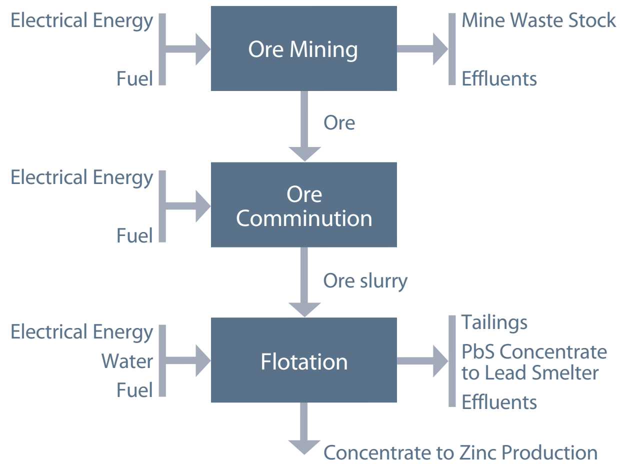


Figure 1: Schematic illustration of zinc concentrate production

Zinc Metal Refining

Over 95% of the world's zinc is produced from zinc blend (ZnS). Apart from zinc, the concentrate contains some 25-30% or more sulphur as well as different amounts of iron, lead and silver and other minerals. Before metallic zinc can be recovered, by using either hydrometallurgical or pyrometallurgical techniques, sulphur in the concentrate must be removed. This is done by roasting or sintering. The concentrate is brought to a temperature of more than 900°C where zinc sulphide (ZnS) converts into the more active zinc oxide (ZnO). At the same time, sulphur reacts with oxygen, giving out sulphur dioxide which subsequently is converted to sulphuric acid – an important commercial by-product.

Today over 90% of zinc is produced in hydrometallurgically in electrolytic plants. Figures 1 and 2 show the basic steps in the production of special high grade zinc using the electro-metallurgical zinc smelting process.

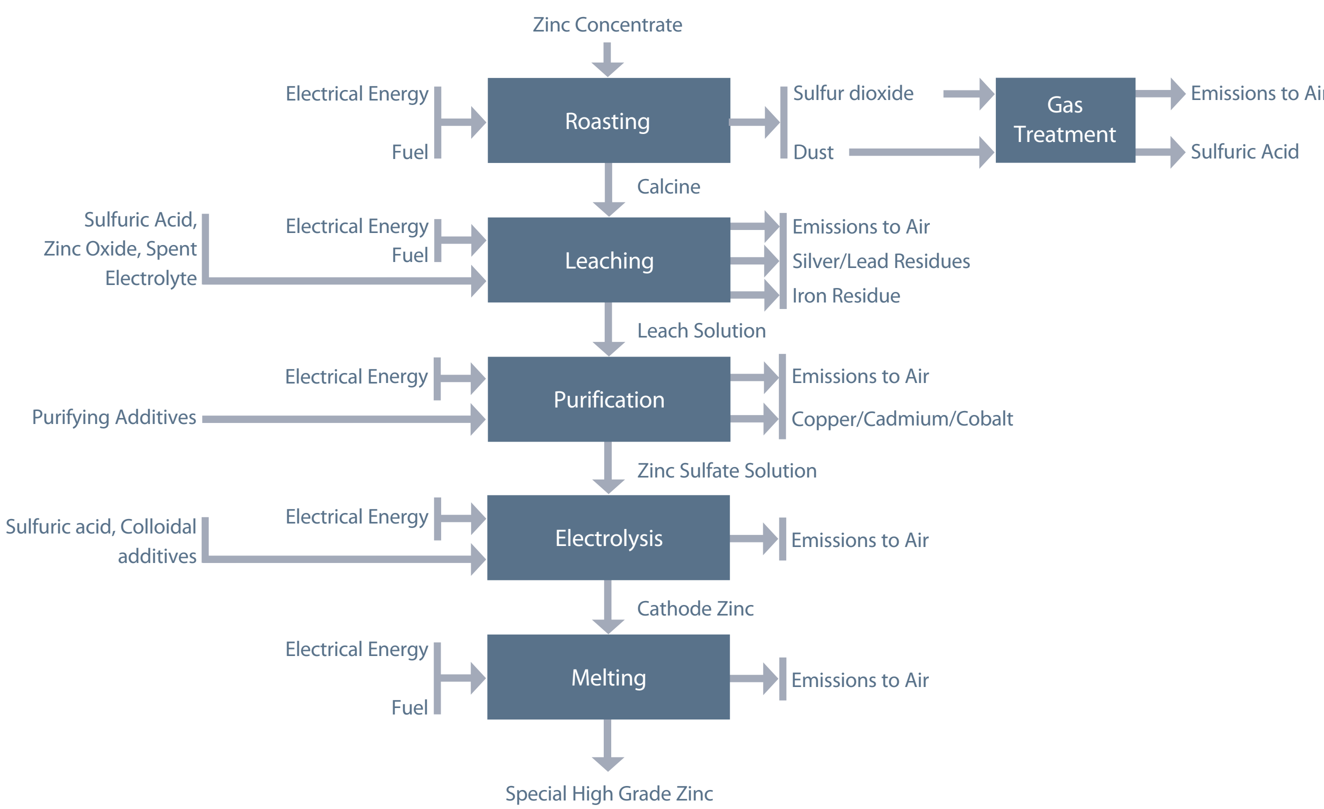


Figure 2: Schematic illustration of zinc metal production

Life Cycle Assessment

LCA is a decision-making tool used to identify environmental burdens and evaluate the environmental consequences of a material, product, process or service over its life cycle from cradle-to-gate (typical for basic raw materials and commodities) or cradle-to-grave (typical for products and services). LCA has been standardized by the International Organization for Standardization (ISO) and forms the conceptual basis for a number of management approaches and standards that consider the life cycle impacts of product systems (e.g. emerging carbon footprint protocols).

There are four components to a typical LCA study:

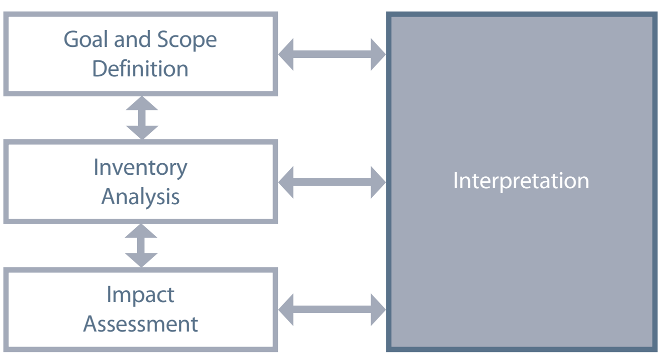
Goal and Scope – where the reference units, scope and boundaries, audience and uses of the study are confirmed;

Life Cycle Inventory – where the physical system is modeled and data is collected on all relevant inputs and outputs to the system;

Life Cycle Impact Assessment – where potential impacts associated with the system being studied are assessed; and

Interpretation – where the results are interpreted to help decision-makers understand where the greatest impacts are and to determine the implications of changes to the system (e.g. what if a different energy supply option or industrial process was used).

Life Cycle Assessment Framework



How is LCA used?

Typically LCA is used to evaluate the environmental implications of materials and products (although services have also been studied using this tool). According to the ISO Standard on LCA, it can assist in:

- Identifying opportunities to improve the environmental aspects of product systems at various points in the life cycle;
- Decision-making in industry, governmental or non-governmental organizations (e.g. strategic planning, priority setting, product or process design or redesign);
- Selecting relevant indicators of environmental performance, including measurement techniques; and
- Marketing (e.g. an environmental claim, eco-labeling scheme or environmental product declaration).

Various software tools and databases are available that enable the user to track materials flows, energy flows and pollution from any industrial system. Typically the databases provide generic information on materials, energy supply options, transportation options and end-of-life management.

A product manufacturer (typically an engineer or product designer) can add in data and put together a comprehensive set of information on the entire product system. Then scenario analysis can be conducted to determine the implications of changes to the systems (e.g. what if a different material, energy supply option or manufacturing process was used). In some cases, short screening level studies are done that can quickly help the user understand where potential "hot spots" in the product system are.

Zinc for Life

The International Zinc Association launched "Zinc for Life" to provide scientific information about the sustainability performance attributes of zinc and to position it as a material of environmental choice for engineers, architects and other individuals involved in the specification of materials. The two complementary components of Zinc for Life are:

- Methodology and data generation: which is focused on providing up-to-date and scientifically sound life cycle data on zinc and zinc products, as well as examining and contributing to methodology aspects of life cycle assessment of relevance to zinc (e.g. treatment of recycling).
- Outreach: which involves analyzing sector-specific environmental information needs/requirements and expectations in zinc consuming industries, as well as from other key stakeholders; and establishing appropriate outreach and communication strategies to address these needs.

A key component of the methodology and data generation component of the Zinc for Life Program is the generation of robust and representative life cycle data on primary zinc as well as key first tier applications such as zinc sheet. The remainder of this profile provides the results of the primary zinc life cycle inventory study, which is the foundation study for current and future efforts to examine the life cycle profile of zinc and zinc-containing products.

Primary zinc LCA overview

The specific goal for this life cycle project was to gather up-to-date data for primary zinc (mine to ingot at refinery gates) to be made available to LCA practitioners and end-use markets and to support LCA projects on zinc-containing projects.
A cradle-to-gate analysis, this study provides life cycle inventory (LCI) data for primary zinc (ingot at refinery gate). Figure 3 illustrates the gate-to-gate and the cradle-to-gate systems of primary zinc production.

Data for the study was provided by IZA members responsible for 614Mt of ore and 4.2Mt of zinc concentrate production. For smelting, approximately 3.38Mt of refined zinc was represented in the study.

This data coverage represented 44% of the global zinc mine production and 32% of the global zinc production volume for the reference year 2005. This number is considered high for a global study conducted for the first time, and therefore the resulting final LCI on primary zinc production is considered representative of the industry.

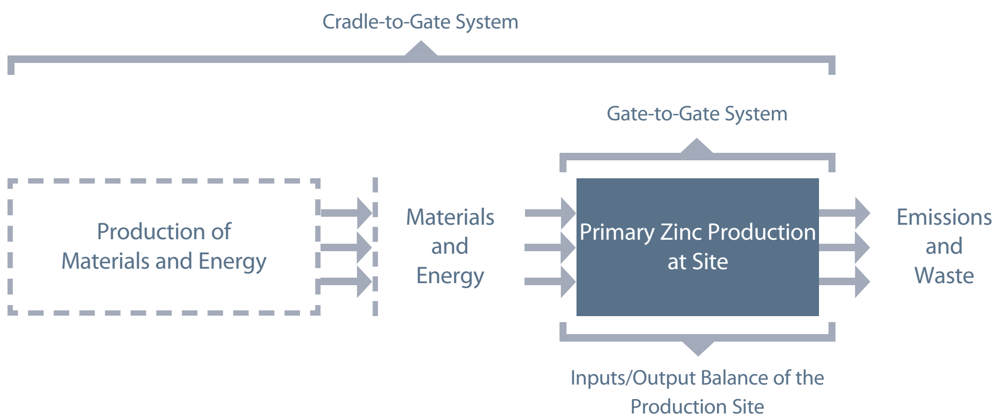


Figure 3: Schematic illustration of the gate-to-gate and the"cradle-to-gate systems of primary zinc production

Study results

To support the study, IZA members provided data on energy use, materials use and environmental releases from the extraction of the zinc ore at the mine site to the production of primary zinc and shipment of zinc ingot from the gate of facility where it is produced.

Primary data was used for the main unit processes of zinc production, and secondary data from a variety of sources was used to model upstream materials production (fuel, auxiliary materials, electricity, etc.).

The study also looked at five impact categories: primary energy consumption, global warming potential, acidification potential, eutrophication potential and photochemical oxidant creation potential (POCP).

The study found that primary energy demand ranged between 35,000MJ/t and 76,000MJ/t of special high-grade zinc.

Variations in the figure were influenced by three main factors: different characteristics of country specific power grid mixes (primary energy demand per kWh electricity generated); differences in energy efficiency for special high-grade zinc production; and differences at the production sites, with some being more integrated plants producing numerous co-products, or with zinc production not even being the major metal produced.

The carbon footprint of zinc was found to be approximately 3t of CO_2 equivalents per tonne of zinc produced. As with any material, the carbon footprint of zinc is best understood in relation to the products it is used in. For example, zinc's anti-corrosion properties can extend the life of a variety of steel products and reduce the overall impact of those products, therefore making them more sustainable.

Selected LCI Parameters of Special High Grade Zinc	Inventory Results per Metric Ton	Unit
Primary energy demand	49134	MJ
Non-renewable energy resources	41644	MJ
Renewable energy resources	7489	MJ
Carbon dioxide	3041	kg
Sulphur dioxide	9.2	kg
Selected LCIA Parameters Based on Impact Methodology CML 2001	**Inventory Results per Metric Ton of Special High Grade Zinc**	**Unit**
Global Warming Potential (GWP 100years)	3124	kg CO2 Equiv.
Acidification Potential (AP)	23.5	kg SO2-Equiv.
Eutrophication Potential (EP) [kg Phosphate-Equiv.]	2.45	kg Phosphate-Equiv.
Photochem. Ozone Creation Potential (POCP)	1.27	kg Ethane-Equiv.
Ozone Layer Depletion Potential (ODP, steady state)	0.0003	kg R11-Equiv.

Table 1: Illustration of the gate-to-gate and the cradle-to-gate systems of primary zinc production

More detailed information is available on the Zinc for Life website at www.zincforlife.org. The site also provides general information on sustainability and zinc, a sustainability report, information on key issues related the treatment of metals in life cycle studies (e.g. recycling), IZA's sustainability charter and guiding principles. The zinc data is also available from the European Commissions in the European Life Cycle Database at http://lca.jrc.ec.europa.eu/lcainfohub/datasetArea.vm.