Zinc...A Sustainable Material
Zinc is Essential for Sustainable Development

**Zinc is Natural**
Zinc is a natural component of the earth’s crust and an integral part of our environment. Zinc is present in rock and soil, air, water and the biosphere.

**Zinc is Essential for the Environment**
Zinc is a natural element and plays an essential role in the biological processes of all humans, animals and plants.

**Zinc is Durable**
One of zinc’s most important characteristics is its ability to protect steel against corrosion. The life and durability of steel are greatly improved when coated with zinc. No other material can provide such efficient and cost-effective protection for steel.

**Zinc is Recyclable**
Zinc can be recycled infinitely without loss of properties and quality. While the recycling rate of zinc depends mainly on the collection rate of zinc-containing products at their end of life, over 90% of these collected products are recycled.

**Zinc is Essential for Human Health**
Zinc is an essential nutrient for human health, and every human needs zinc to survive. Ensuring adequate levels of zinc intake is a key component in efforts to reduce child illness, enhance physical growth and decrease mortality in developing countries.

**Zinc is Essential for Crops**
Adding zinc to soils and crops can make a significant contribution towards goals of increased food security and human health in a sustainable manner.

**Zinc is a Sustainable Source of Energy**
Zinc-based energy systems have tremendous advantages including high specific energy, recyclability, safety, low cost and zero emissions.

**Zinc is a Sustainable Resource**
Zinc, with its key attributes of essentiality, durability and recyclability, is well positioned as a material of choice for a sustainable society.

**Zinc Industry Sustainable Development Activities**
Assessing the sustainability of zinc and zinc products through the development of sound scientific information.
Introduction: Zinc and Sustainable Development

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 and environmental releases associated with upstream metal production operations, 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 steel products) and through end-of-life recycling (e.g. by utilizing recycled zinc to create new products).

The International Zinc Association (IZA), working on behalf of the global zinc industry, is committed to continually assessing the sustainability of zinc and zinc products through the development of sound scientific information, and communicating this information to the key markets and stakeholders. This report represents a brief overview of the numerous sustainable attributes of zinc and its contributions to a sustainable society.

Zinc and its uses

Zinc is naturally present in rock, soil, water and air and is essential to human, animal and crop health and well-being. When the supply of zinc is inadequate, crop yields and crop quality are frequently impaired. Dietary zinc deficiency is a critical problem that affects hundreds of millions of people throughout the world.

A very versatile material, zinc also plays a key role in a variety of industrial and product applications. A major use of zinc is to protect steel from corrosion – making steel more durable by lasting longer. Less corrosion also means less cost and less environmental impact arising from maintenance. At the end of their useful lives, zinc products can also be recycled, and zinc content can be recovered without loss of properties or quality.

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. Because of zinc’s durability and recyclability, zinc can help save natural resources and improve sustainability performance.

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 based alloys, mainly for use by the die casting industry. Significant amounts are also utilized for compounds such as zinc oxide and zinc sulfate and zinc sheet applications including roofing, gutters and down-pipes.

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

Zinc is a natural component of the earth’s crust and an integral part of our environment. Zinc is present in rock and soil, air, water and the biosphere.
Zinc is constantly transported around our environment by nature through a process called natural cycling. Rain, snow, ice, solar heat and wind erode zinc-containing rocks and soil. Wind and water carry minute amounts of zinc to lakes, rivers and the sea, where it collects as sediment or is transported further. Natural phenomena such as volcanic eruptions, forest fires, dust storms and sea spray all contribute to the continuous cycling of zinc through nature.

During the course of evolution, all living organisms have adapted to the zinc in their environment and have used it for specific metabolic processes.

The amount of zinc present in the natural environment varies from place to place and from season to season. For example, the amount of zinc in the earth's crust ranges between 10 and 300 milligrams per kilogram, and zinc in rivers varies from less than 10 micrograms per liter to over 200 micrograms. Even falling leaves in autumn lead to a seasonal increase in zinc levels in soil and water.

The zinc industry has supported numerous studies in aquatic, terrestrial and atmospheric systems to further the understanding of the natural variations of zinc in the environment. Consideration of background zinc concentrations has assisted environmental risk assessment efforts by providing a context for biological acclimation and adaptation.

**Zinc Emissions to the Environment**

Sea salt and the movement of soil dust particles in the air are the principal sources of natural zinc emissions in the atmosphere. Forest fires and volcanoes also contribute in a minor way to zinc's natural cycling. It is estimated that these natural emissions of zinc amount to 5.9 million metric tonnes each year.

By comparison, anthropogenic emissions of zinc to the atmosphere – those that result from man's activities, such as metal production, waste disposal and fossil fuel combustion - are estimated at only 57,000 metric tonnes each year.
Zinc is Essential for the Environment

Zinc is a natural element and plays an essential role in the biological processes of all humans, animals and plants.
All life on earth has evolved in the presence of natural levels of zinc. Due to its general availability to organisms and unique characteristics, zinc has an essential role in various biological processes. As such, zinc is an essential element for all forms of life, from the smallest micro-organisms to man.

**The Natural Cycling of Zinc**
Organisms take up the essential elements they need from their environment, which means directly from air, water, soil, or from food. When their cellular requirements for these elements are satisfied, growth and development are optimized.

**The zinc industry is continually funding research to develop information and state-of-the-science methodologies which allow zinc’s bioavailability to be predicted in a range of environmental conditions, such as in water and sediments.**

**Zinc in the Environment**
The environmental impact of zinc – and of all essential elements – cannot be assessed in the same way as man-made chemical compounds. Because zinc occurs naturally, eliminating it from the environment would not be possible. Moreover, because zinc is essential, achieving such a goal would ultimately lead to detrimental effects throughout an ecosystem. In other words, “less” is not necessarily “better”.

Elevated levels of zinc in the environment occur because of various man-made activities, and sources of emissions include municipal and industrial effluents, historical impurity, mining activities, geology and diffuse sources (unintentional sources that are not directly connected with zinc production or manufacturing). An extensive risk assessment of zinc in Europe concluded that “the current uses of zinc and zinc compounds do not [by themselves] lead to the elevated regional levels found in surface water and sediment”. The distribution, transport and effects (bioavailability) of zinc in water, sediment and soil depend largely on the site-specific chemical and physical characteristics of the environment and an organism’s condition (e.g. age, size, prior history of exposure, etc.). For these reasons, environmental assessment of zinc must take these factors into account to be meaningful.
Zinc is Durable

One of zinc’s most important characteristics is its ability to protect steel against corrosion. The life and durability of steel are greatly improved when coated with zinc. No other material can provide such efficient and cost-effective protection for steel.
One of zinc’s most exceptional qualities is its natural capacity to protect steel from corrosion. When left unprotected, steel will corrode in almost any environment. Zinc coatings protect steel by providing a physical barrier as well as cathodic protection for the underlying steel, allowing its service life to be extended indefinitely.

Damage caused by corrosion leads to costly and time consuming repairs and has been estimated to cost at least four percent of a country’s gross domestic product (GDP). By protecting steel from corrosion, zinc performs an invaluable service. It helps to save natural resources by significantly prolonging the life of steel goods and capital investments, such as homes, cars, bridges, port facilities, power lines and water distribution, telecommunications and transport.

The long-term durability provided by galvanizing is achieved at relatively low environmental burden in terms of energy and other globally relevant impacts, especially when compared to the energy value of the steel it is protecting.

**IZA’s Galvanized Autobody Partnership (GAP) has successfully made galvanized automotive steel more durable and corrosion resistant, more fuel efficient through reduced weight and more competitive against other materials due to these sustainability aspects. This success occurred through technical innovations resulting from the strong collaboration between IZA and the steel and automotive industries.**

Numerous studies have shown the high economic and environmental costs associated with repeated maintenance painting of steel structures. These burdens can be significantly reduced by an initial investment in zinc-coated steel.

Lack of optimal corrosion protection can leave a damaging economic legacy of repeated maintenance costs. In social housing projects, future maintenance costs will be borne by the local authorities. In public infrastructure projects, use of galvanized steel leads to lower maintenance budgets, releasing public funds for other purposes.
Zinc is Recyclable
Zinc can be recycled infinitely without loss of properties and quality. While the recycling rate of zinc depends mainly on the collection rate of zinc-containing products at their end of life, over 90% of these collected products are recycled.
Approximately 60% of the zinc produced worldwide originates from mined ores and the remaining 40% from recycled or secondary zinc. The level of recycling increases each year, in step with progress in zinc production and recycling technology.

For the zinc and steel industries, recycling of zinc-coated steel provides an important new source of raw material. Historically, the generation of zinc-rich dusts from steel recycling was a source of loss from the life-cycle (landfill); however, today technologies exist which provide incentive for steel recyclers to minimize waste. Thus, the recycling loop is endless - both zinc and steel can be recycled again and again without any loss of their physical or chemical properties.

Zinc is recycled at all stages of production and use, including scrap that arises during the production of galvanized steel sheet, scrap generated during manufacturing and installation processes and from end-of-life products. The presence of zinc coating on steel does not affect steel’s recyclability, and all types of zinc-coated products are recyclable. Similarly, the presence of zinc in alloys does not affect its recyclability; the alloys are remelted and used to manufacture new products of the same alloy.

Because many zinc products have a long, useful life, typical recycling indicators are difficult to apply. IZA has developed a Zinc Industry Recycling Rates Calculator (ZIRRC) to allow efficient calculation of zinc recycling rates by end-use application and/or sector.

The amount of zinc available for recycling varies, due to the generally long, useful life of zinc-containing products, which is variable and can range from 15-plus years for the zinc-coated steel panels used in cars or household appliances - to over 100 years for zinc sheet used for roofing. Galvanized steel used in public infrastructure applications, such as street lighting columns and transmission towers, are often in service for 50 years or more. All of these products tend to be replaced due to obsolescence, not because the zinc has ceased to protect the underlying steel or building.
Zinc is Essential for Human Health

Zinc is an essential nutrient for human health, and every human needs zinc to survive. Ensuring adequate levels of zinc intake is a key component in efforts to reduce child illness, enhance physical growth and decrease mortality in developing countries.
Zinc is an essential micronutrient for human health. It is vital for activating growth and physical and neurological development in infants, children and teenagers. Zinc is found in all parts of the body. It is a component in more than 300 enzymes and influences hormones. Zinc also accelerates cell division and enhances the immune system. Zinc is vital in protecting the body from illnesses and fighting infections, and it can reduce the duration and severity of a common cold or halt diarrhea.

**Global Zinc Deficiency in Humans**
Zinc deficiency in humans is a widespread and global issue with about one-third of the world’s population receiving insufficient zinc through their diets.

Over 450,000 children die each year due to zinc deficiency. The zinc industry, through IZA, launched the Zinc Saves Kids initiative in support of UNICEF’s global micronutrient supplementation program to address zinc deficiency for at-risk children.

Two billion people worldwide are not getting enough zinc through their diets. Zinc deficiency is a major health problem in developing countries, especially among young children. Zinc deficiency weakens their immune system and leaves them vulnerable to conditions such as diarrhea, pneumonia and malaria. Zinc deficiency is also accountable for impairing physical and intellectual development, preventing children from reaching their full potential. UNICEF estimates that diarrhea accounts for nearly two million deaths in children every year. Diarrhea is preventable and treatable, but in developing countries, only 35% of children with diarrhea receive the recommended treatment of oral rehydration salts and zinc supplements.

In 2008, the Copenhagen Consensus, a group of internationally acclaimed economists, including five Nobel Laureates, concluded that combating the world’s malnutrition problem through the provision of vitamin A and zinc was ranked the highest among the various cost-effective solutions to the world’s pressing problems.
Zinc is Essential for Crops
Adding zinc to soils and crops can make a significant contribution towards goals of increased food security and human health in a sustainable manner.
Zinc deficiency in food crops reduces yields and quality, and it lowers the nutritional value of the crops. According to a study by the Food and Agricultural Organization (FAO), an estimated 50% of the world’s agricultural soils devoted to cereal production are deficient in zinc. Zinc is also widely recognized as the most critical micronutrient deficiency in crops, being one of eight trace elements that plants need for normal growth and reproduction. Although required in small but critical concentrations, zinc plays a vital role in several key functions including: membrane structure, photosynthesis, protein synthesis and defense against drought and disease.

Despite these facts, zinc deficiency is unrecognized, underestimated or untreated in many countries and regions of the world. Thus, there is an urgent need to address zinc deficiency to contribute to crop production and food security in these countries and to improve human health. Applying zinc fertilizer to soils and/or onto plant leaves is a simple and highly effective solution to this critical problem.

The zinc industry is committed to alleviating zinc deficiency in soils, crops and humans and has to this end launched the Zinc Nutrient Initiative, a multi-year program aimed at increasing crop productivity and nutritional status by promoting the use of zinc-containing fertilizers to help address food security and human malnutrition.

Global Zinc Deficiency in Crops
Zinc deficiency is a widespread and global problem affecting more than half of the world’s agricultural soils, with potentially significant impacts on crop productivity, nutritional quality and health in these areas.

By ensuring that crops have an adequate supply of zinc, crop productivity, food security and nutritional quality can be improved, thus providing significant health, social and economic benefits.
Zinc is a Sustainable Source of Energy

Zinc-based energy storage systems have tremendous advantages including high specific energy, recyclability, safety, low cost and zero emissions.
**Enhancing Energy’s Value: A Sustainable Source of Energy**

Zinc-based energy systems have tremendous advantages including high specific energy, recyclability, safety, low cost and zero emissions.

Zinc is used in the manufacture of a variety of battery chemistries, both primary and rechargeable, consumer and industrial. The most well known of these chemistries are the primary zinc-carbon and alkaline batteries, which together dominate the standard AAA, AA, C and D size consumer battery market.

Zinc-air and zinc-silver “button cell” batteries are also widely used in the electronics industry to power items such as hearing aids, wrist watches and calculators. Industrial zinc-silver and zinc-nickel batteries are of critical importance in a variety of aeronautic and military applications; while larger zinc-air cells have been developed to power electric vehicles and Remote Area Power Supply (RAPS) installations.

IZA co-funded the largest zinc air fuel cell demonstration project in the world which was implemented by AEDC in the village of Guyuni, South Africa. 300 dwellings now have lights, and a vegetable garden uses waste zinc oxide - created by the fuel cells during energy production - as high value fertilizer, providing food security.

---

**Zinc-Air Batteries**

Zinc-air batteries are built of layers of flat “plates” of zinc, a catalyst, an electrolyte and a porous membrane that, when packaged, make a compact flat cell.

The zinc air cell is a particularly interesting technology because it acts as a partial fuel cell using the \( O_2 \) from air as the cathode. There are portable primary zinc/air batteries and industrial primary zinc/air batteries. There are also electrically rechargeable zinc/air batteries that use a bifunctional oxygen electrode for charge and discharge and mechanically rechargeable zinc/air batteries that require the replacement of discharged anodes.

What is compelling about zinc-air is that it represents three times the energy density of the current state-of-the-art battery (lithium-ion) at a fraction of the cost.
Zinc is a Sustainable Resource
Zinc, with its key attributes of essentiality, durability and recyclability, is well positioned as a material of choice for a sustainable society.
Natural Reserves of Zinc

The world is naturally abundant in zinc. It is estimated that the first mile of the earth’s crust under land contains 224,000,000 million tonnes of zinc. There are a further 15 million tonnes of zinc in the seabed, and each cubic mile of seawater is estimated to contain one tonne of zinc. Such estimates, however, fail to consider whether or not it is economic, or environmentally acceptable, to exploit these resources.

Reserves of zinc – like those of any natural resource – are not a fixed amount stored in nature. Reserves are determined by geology and the interaction of economics, technology and politics. The term “reserves” denotes only what has been mapped and measured today and what can be mined, economically, using current technology. Zinc reserves have increased significantly since the 1950s, as large new ore bodies have been discovered in many areas of the world. The sustainability of zinc ore supplies cannot therefore be judged simply by extrapolating the combined mine life of today’s zinc mines.

An example of this can be illustrated by comparing United States Geological Survey (USGS) data on zinc reserves. In 1994, USGS reported that world zinc reserves were 140,000,000 tonnes, but by 2005, despite 11 additional years of consumption, the USGS reported world zinc reserves of 220,000,000 tonnes, a 57% increase over 1994 levels.

During the 1990s, commodity prices were relatively stable at low levels, causing production to stagnate and limiting the creation of exploration and mining operations. In recent years, prices have become more volatile, with large increases followed by rapid declines. Exploration and production have likewise risen and stabilized or declined.

The mining industry is also investing in new technologies and techniques to increase the efficiency of zinc extraction and processing. Recycling of zinc products by the industry also provides an opportunity to help conserve the natural zinc reserves even more. The level of recycling increases each year, in step with the progress in zinc production and recycling technologies.
Zinc Industry Sustainable Development Activities
Assessing the sustainability of zinc and zinc products through the development of sound scientific information.
The concept of Sustainable Development encompasses the need for a careful balance of social, economic and environmental aspects considering both present and future needs. Recognizing this, the zinc industry has engaged in a long-running and growing Sustainable Development program which has had many key activities and achievements including:

- Creation of the IZA Sustainability Charter in 2001, adopted unanimously by the IZA Membership
- Development of nine Codes of Practice providing guidance, success stories and additional resources for critical issues including: Business Ethics, Employee Health & Safety, Mine Tailings and Residue Management, Community Consultation, Environmental Management, Managing Minor Elements, Sustainability Reporting, Mine Closure and Product Stewardship
- Sustainability Performance Assessment
- Zinc for Life initiative

Copies of the Sustainability Charter, Guiding Principles/Codes of Practice are available on the web at: www.zincforlife.org.

**IZA launched the Zinc for Life initiative to quantify scientific information about zinc’s sustainability and highlight its contributions to a sustainable society.**

**Sustainability Performance Assessment**

Five Winds International, a leading sustainability management consulting firm, recently conducted a comprehensive sustainability performance assessment which quantified overall sustainability activities of the zinc industry. This included assessing its strengths and weaknesses in environmental performance, social performance and governance.

With the average scores for the industry for each category being above 50%, which is considered excellent, the zinc industry proved to be highly active in sustainability practices.

The industry also performed well in comparison to some other major corporations and industry associations which are generally considered leaders in sustainability performance. The strong industry performance showed significant improvement in almost all areas assessed in the 2002 baseline performance assessment.
Properly demonstrating the sustainability of zinc requires data and information that enables users of zinc to evaluate its impact and benefits across the entire life cycle – from raw-material extraction to end-of-life recycling. IZA’s Zinc for Life initiative generated scientific information and made it available to the industry.

The Zinc for Life initiative was a comprehensive effort with twelve separate but linked areas of effort mainly focused on data generation (e.g. life cycle assessment studies (LCA)), methodology, sector-specific scheme assessments (e.g. LEED program) and communications. Key activities/achievements included:

- Completion of first global life-cycle inventory (LCI) for primary zinc
- LCI/LCA information for key zinc applications including zinc sheet, hot-dip galvanizing and die-casting
- Placement of primary zinc and zinc sheet LCI data on European and U.S. LCA databases
- Numerous publications in peer-reviewed and trade-journals highlighting the sustainable attributes of zinc and zinc products
- Environmental Profile reports on primary zinc and zinc sheet
- Refinement of key methodologies based on scientific principles
- Communication with downstream users and other stakeholders

More information on these items, including copies of the reports and publications, are available from the Zinc for Life website at: www.zincforlife.org.
A key aspect of the *Zinc for Life* initiative was working with downstream users of zinc, such as hot-dip galvanizers and the steel industry on developing and communication sustainable attributes of zinc products. Examples of this type of partnership were the publications, “Hot-Dip Galvanizing for Sustainable Design” and “Galvanizing and Sustainable Construction: A Specifiers’ Guide”, developed by the American Galvanizers Association (AGA) and the European General Galvanizers Association (EGGA), respectively, in collaboration with IZA.

Through the *Zinc for Life* initiative and other program activities, IZA will continue to develop and communicate information on the sustainability aspects of zinc and zinc products to meet the changing needs of the markets and stakeholders.
The International Zinc Association (IZA) was founded in 1990 and is a global non-profit organization based in Brussels, Belgium with offices in China, Europe, Latin America, North America and Southern Africa.

IZA is dedicated exclusively to the interests of zinc and its users and helps sustain the long-term global demand for zinc and its markets by promoting key end uses as corrosion protection for steel, diecasting, brass, oxide and sheet; and the essentiality of zinc in human health and crop nutrition. IZA’s main programs are Sustainability & Environment, Technology & Market Development and Communications.

For more information, please visit www.zinc.org.

© 2010 International Zinc Association