The World Copper Factbook

International Copper Study Group

2009

About ICSG

The International Copper Study Group (ICSG) was formally established as an autonomous inter-governmental organization on 23 January 1992, following a series of Ad Hoc meetings sponsored by the United Nations (UNCTAD) in 1986 and 1987 to review the world situation of copper and discuss the need for such a body. ICSG serves to increase copper market transparency and promote international discussions and cooperation on issues related to copper. ICSG is the only forum solely dedicated to copper where industry, its associations and governments can meet and discuss common problems and objectives. The current members of ICSG are Belgium, Chile, China, the European Community, Finland, France, Germany, Greece, India, Italy, Japan, Luxembourg, Mexico, the Netherlands, Peru, Poland, Portugal, the Russian Federation, Serbia, Spain, Sweden and the United States.

In order to fulfill its mandate, the Study Group has three main objectives:

- Promote international cooperation on matters related to copper, such as health and the environment, research, technology transfer, regulations and trade.
- Provide a global forum where industry and governments can meet and discuss common problems/objectives. The ICSG is the only inter-government forum solely dedicated to copper.
- Increase market transparency by promoting an exchange of information on production, consumption, stocks, trade, and prices of copper, by forecasting production and consumption, and by assessing the present and future capacities of copper mines, plants, smelters and refineries.

The International Copper Study Group maintains activities in four core areas: Statistics; Environment and Health; Economics; and serving as an International Commodity Body. The ICSG maintains one of the world's most complete historical and current database providing access to production, consumption and trade data for copper, copper products and secondary copper, price series, and information on copper mines and plants. ICSG publishes the Copper Bulletin (monthly), the Statistical Yearbook (annual), the Directory of Copper Mines and Plants (semi-annual), and the Directory of Copper and Copper Alloy Fabricators – First Use (annual), as well as special studies on selected topics such as the copper scrap market, constraints on copper supply, regulatory developments, the impacts of the economic crisis on the copper industry and other topics.

As part of its mandate to provide a global forum where industry and governments can meet and discuss common problems and objectives, ICSG meetings are held twice per year, typically in the Spring and Fall at ICSG Headquarters in Lisbon, Portugal. The meetings of the Study Group are open to government members, their industry advisors and invited observers.

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Secretary	Ms Fatima Cascalho

Contacts:
International Copper Study Group
Rua Almirante Barroso, 38-6º
1000-013 Lisbon, Portugal
Tel: +351-21-351-3870
Fax: +351-21-352-4035
e-mail: mail@icsg.org

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Chapter 1: Copper and Society

Of all the materials used by humans, copper has had one of the most profound effects on the development of civilization. From the dawn of civilization until today, copper has made, and continues to make, a vital contribution to sustaining and improving society. What makes copper and copper-based products so valuable to us, and why do societies depend on them? Copper's chemical, physical and aesthetic properties make it a material of choice in a wide range of domestic, industrial and high technology applications. Copper is ductile, corrosion resistant, malleable and an excellent conductor of heat and electricity. Alloyed with other metals, such as zinc (to form brass), aluminum or tin (to form bronzes), or nickel, for example, it can acquire new characteristics for use in highly specialized applications. In fact, society's infrastructure is based, in part, on copper. For instance, copper is used for:

- conducting electricity and heat
- communications
- transporting water and gas
- roofing, gutters and downspouts
- protecting plants and crops, and as a feed supplement and
- making statues and other forms of art.

Copper has been in use for at least 10,000 years, yet it is still a high technology material, as evidenced by the development of the copper chip by the semi-conductors industry.

Photo: Liberty Bell (70% copper), Philadelphia, Pennsylvania, USA. Photo courtesy of National Park Service Digital Image Archives.

Copper in History

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Archaeological evidence demonstrates that copper was one of the first metals used by humans and was used around 10,000 years ago for items such as coins and ornaments in western Asia. During the prehistoric Chalcolithic Period (derived from *chalkos*, the Greek word for copper), man discovered how to extract and use copper to produce ornaments and implements. As early as the 4th to 3rd millennium BC, workers extracted copper from Spain's Huelva region.

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The discovery that copper, when alloyed with tin, produces bronze, led to the Bronze Age, c. 2,500 BC. Israel's Timna Valley provided copper to the Pharaohs (an Egyptian papyrus records the use of copper to treat infections and to sterilize water). Cyprus supplied much of the Phoenician, Greek and Roman needs for copper. "Copper" is derived from the latin *Cyprium*, literally Cyprian metal. The Greeks of Aristotle's era were familiar with brass as a valued copper alloy. In South America, the pre-Columbian Maya, Aztec and Inca civilizations exploited copper, in addition to gold and silver. During the Middle Ages, copper and bronze works flourished in China, India and Japan.

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The discoveries and inventions relating to electricity and magnetism of the late 18th and early 19th centuries by scientists such as Ampere, Faraday and Ohm, and the products manufactured from copper, helped launch the Industrial Revolution and propel copper into a new era.

Today, copper continues to serve society's needs.

Photos courtesy of the British Museum: 1.Copper Jug, about 1500-1300 BC, probably from the Peloponnese, Greece; 2. Bronze Lions Foot, late 8th century BC, from eastern Anatolia (modern Turkey); 3. Bronze Helmet, 9th-8th century BC, probably from north-west Iran; 4. Bronze shield, 1200-1000 BC; from the River Thames, London, England; 5. Copper Axe, From Ur, southern Iraq, about 2600-2400 BC; 6. Copper Ingot in the form of an oxhide; from Cyprus, about 1225-1150 BC.

Copper: Natural, Recyclable and Essential

Copper occurs naturally in the Earth's crust in a variety of forms. It can be found in sulfide deposits[1] (as chalcopyrite, bornite, chalcocite, covellite), in carbonate deposits[2] (as azurite and malachite), in silicate deposits[3] (as chrysycolla and dioptase) and as pure "native" copper.

Copper is one of the most recycled of all metals. It is our ability to recycle metals over and over again that makes them a material of choice. Recycled copper (also known as secondary copper) cannot be distinguished from primary copper (copper originating from ores), once reprocessed. Recycling copper extends the efficiency of use of the metal, results in energy savings and contributes to ensuring that we have a sustainable source of metal for future generations.

Copper also occurs naturally in humans, animals and plants. Organic life forms have evolved in an environment containing copper. As a nutrient and essential element, copper is vital to maintaining health. Life sustaining functions depend on copper.

[1] Bound with sulfur.
[2] Bound with carbon and oxygen.
[3] Bound with silicon and oxygen.
Photo courtesy of European Copper Institute.

From Ores to Products



Geologists look for signs and/or anomalies that would indicate the presence of a mineral deposit. Under the right geological, economic, environmental and legal conditions, mining can proceed.

Primary copper production starts with the extraction of copper-bearing ores. There are three basic ways of copper mining: surface, underground mining and leaching. Open-pit mining is the predominant mining method in the world.

After the ore has been mined, it is crushed and ground followed by a concentration by flotation. The obtained copper concentrates typically contain around 30% of copper, but grades can range from 20 to 40 per cent. In the following smelting process, sometimes preceded by a roasting step, copper is transformed into a "matte" containing 50-70% copper. The molten matte is processed in a converter resulting in a so-called blister copper of 98.5-99.5% copper content. In the next step, the blister copper is fire refined in the traditional process route, or, increasingly, re-melted and cast into anodes for electro-refining.

The output of electro-refining is refined copper cathodes, assaying over 99.99% of copper.

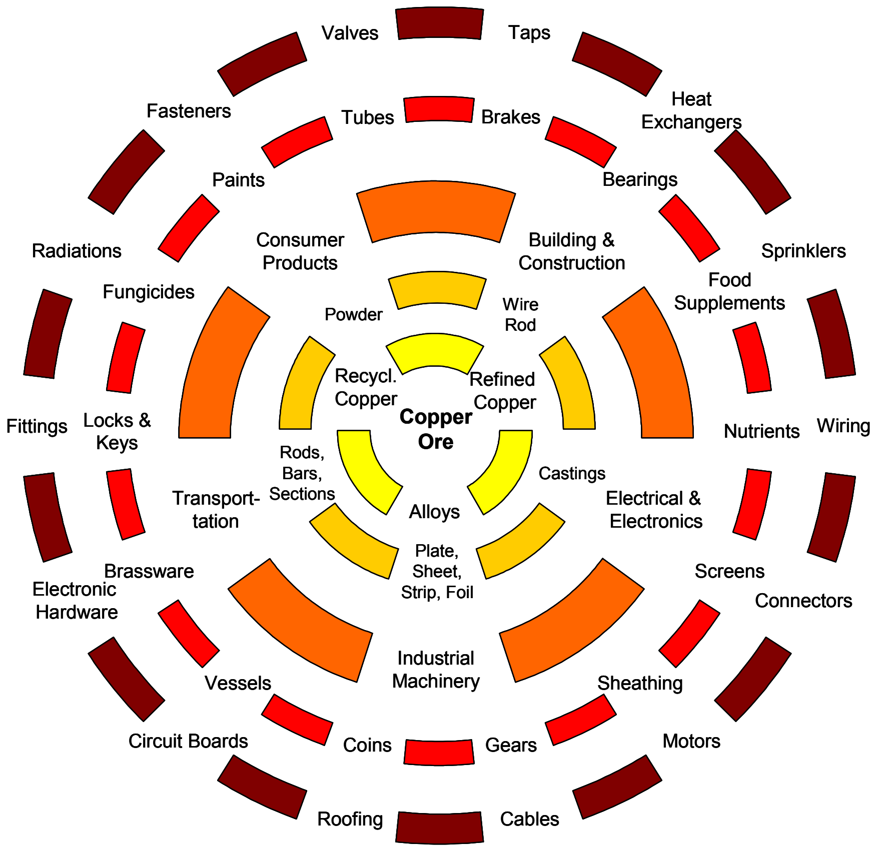
Alternatively, in the hydrometallurgical route, copper is extracted from mainly low grade oxide ores and also some sulphide ores, through leaching (solvent extraction) and electrowinning (SX-EW process). The output is the same as through the electro-refining route - refined copper cathodes. ICSG estimates that in 2008, refined copper production from SX-EW represented 17% of total copper refined production.

Refined copper production derived from mine production (either from metallurgical treatment of concentrates or SX-EW) is referred to as "primary copper production", as obtainable from a primary raw material source. However, there is another important source of raw material which is scrap. Copper scrap derives from either metals discarded in semis fabrication or finished product manufacturing processes ("new scrap") or obsolete end-of-life products ("old scrap"). Refined copper production attributable to recycled scrap feed is classified as "secondary copper production". Secondary producers use processes similar to those

Photos: Luis Hernán Herreros from www.visnu.cl, © Copyright Anglo American (Faena Los Bronces y Mantos Blancos – Chile).

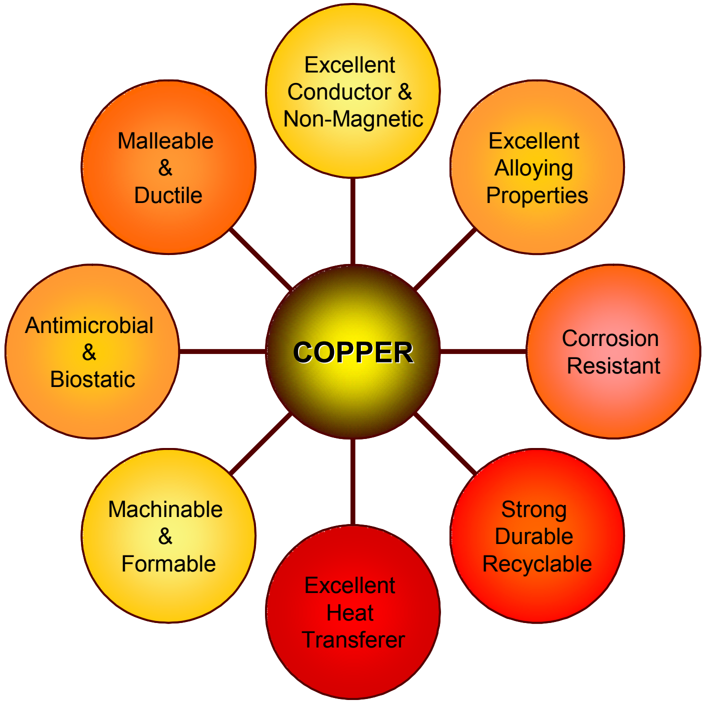
employed for primary production. ICSG estimates that in 2008, at the refinery level, secondary copper refined production reached around 15% of total copper refined production.

Copper is shipped to fabricators mainly as cathode, wire rod, billet, cake (slab) or ingot. Through extrusion, drawing, rolling, forging, melting, electrolysis or atomization, fabricators form wire, rod, tube, sheet, plate, strip, castings, powder and other shapes. These copper and copper-alloyed products are then shipped for final manufacturing, or distribution, to meet society's needs.



Properties of Copper

Chemical Symbol	Cu
Atomic number	29
Atomic weight	63.54
Density	8960 kg m^{-3}
Melting point	1356 K
Specific Heat c_p (at 293 K)	0.383 kJ kg^{-1} K^{-1}
Thermal conductivity	394 W m^{-1} K^{-1}
Coefficient of linear expansion	16.5 x 10^{-6} K^{-1}
Young's Modulus of Elasticity	110 x 10^{9} N m^{-2}
Electrical Conductivity (% IACS[1])	100 %
Electrical Resistivity	1.673 x 10^{-8} ohm-m
Crystal Structure	Face-Centered Cubic



[1] International Annealed Copper Standard.

Major Uses of Copper: Electrical

Copper is the best non-precious metal conductor of electricity as it encounters much less resistance compared with other commonly used metals. It sets the standard to which other conductors are compared.

Copper is also used in power cables, either insulated or uninsulated, for high, medium and low voltage applications.

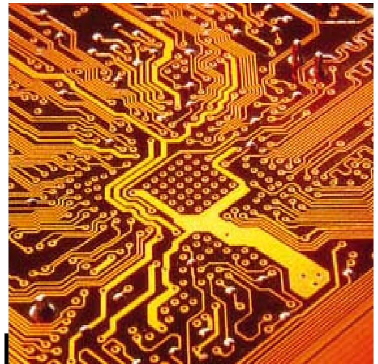
In addition, copper's exceptional strength, ductility and resistance to creeping and corrosion makes it the preferred and safest conductor for commercial and residential building wiring.

Copper is an essential component of energy efficient generators, motors, transformers and renewable energy production systems. Renewable energy sources such as solar, wind, geothermal, fuel cells and other technologies are all heavily reliant on copper due to its excellent conductivity.

ICSG, in partnership with the Common Fund for Commodities, the International Copper Association and the International Copper Promotion Council (India), is supervising the Transfer of Technology for High Pressure Copper Die Casting in India project. The project is designed to facilitate the transfer of technology related to the manufacture of rotors, motors and motor systems using more energy efficient high pressure copper die castings.

Photo courtesy of the European Copper Institute.

Major Uses of Copper: Electronics and Communications




Copper plays a key role in worldwide information and communications technologies. HDSL (High Digital Subscriber Line) and ADSL (Asymmetrical Digital Subscriber Line) technology allows for high-speed data transmission, including internet service, through the existing copper infrastructure of ordinary telephone wire.

Copper and copper alloy products are used in domestic subscriber lines, wide and local area networks, mobile phones and personal computers.

Semiconductor manufacturers have launched a revolutionary "copper chip." By using copper for circuitry in silicon chips, microprocessors are able to operate at higher speeds, using less energy. Copper heat sinks help remove heat from transistors and keep computer processors operating at peak efficiency. Copper is also used extensively in other electronic equipment in the form of wires, transformers, connectors and switches.


Photos courtesy of the Copper Development Association and European Copper Institute.

Major Uses of Copper: Construction

Copper and brass are the materials of choice for plumbing, taps, valves and fittings. Thanks in part to its aesthetic appeal, copper and its alloys, such as architectural bronze, is used in a variety of settings to build facades, canopies, doors and window frames.

Unlike plastic tubing, copper does not burn, melt or release noxious or toxic fumes in the event of a fire. Copper tubes also help protect water systems from potentially lethal bacteria such as legionella. Copper fire sprinkler systems are a valuable safety feature in buildings.

The use of copper doorknobs and plates exploits copper's biostatic properties to help prevent the transfer of disease and microbes.

Copper roofing, in addition to being attractive, is well known for its resistance to extreme weather conditions. Major public buildings, commercial buildings and homes use copper for their rainwater goods and roofing needs.

The telltale green patina finish, that gives copper the classic look of warmth and richness, is the result of natural weathering.

Photos courtesy of the Copper Development Association and European Copper Institute.

Major Uses of Copper: Transportation

All major forms of transportation depend on copper to perform critical functions.

Copper-nickel alloys are used on the hulls of boats and ships to reduce marine biofouling, thereby reducing drag and improving fuel consumption.

Automobiles and trucks rely on copper motors, wiring, radiators, connectors, brakes and bearings. Today, the average mid-size automobile contains about 22.5 kg (50 lbs) of copper, while luxury cars on average contain around 1,500 copper wires totaling about 1.6 km (1 mile) in length.[1] Electric and hybrid vehicles can contain even higher levels of copper. Copper's superior thermal conductivity, strength, corrosion resistance and recyclability make it ideal for automotive and truck radiators. New manufacturing technologies, processes and innovative designs are resulting in lighter, smaller and more efficient radiators.

Copper is also used extensively in new generation airplanes and trains. New high-speed trains can use anywhere from 2 to 4 tonnes of copper, significantly higher than the 1 to 2 tonnes used in traditional electric trains.

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[1] Source: International Copper Association.
Photos: Courtesy of the Copper Development Association (top and center) and International Copper Association (and bottom).

Major Uses of Copper: Industrial Machinery and Equipment

Wherever industrial machinery and equipment is found, it is a safe bet that copper and its alloys are present. Due to their durability, machinability, and ability to be cast with high precision and tolerances, copper alloys are ideal for making products such as gears, bearings and turbine blades.

Copper's superior heat transfer capabilities and ability to withstand extreme environments makes it an ideal choice for heat exchange equipment, pressure vessels and vats.

The corrosion resistant properties of copper and copper alloys (such as brass, bronze, and copper-nickel) make them especially suitable for use in marine and other demanding environments.

Vessels, tanks, and piping exposed to seawater, propellers, oil platforms and coastal power stations, all depend on copper's corrosion resistance for protection.

Photos: Courtesy of the Copper Development Association.

Major Uses of Copper: Consumer and General Products

From the beginning of civilization copper has been used by various societies to make coins for currency.

Today, countries are replacing lower denomination bills with copper-based coins, as these coins last 10, 20 and even 50 times longer.

In the United States, one cent coins and five cent coins contain 2.5% and 75% copper, respectively, while other U.S. coins contain a pure copper core and 75% copper face.[1] In the recently expanded European Union, the Euro coins, first introduced in 2002, also contain copper.

Copper and copper-based products are used in offices, households and workplaces. Computers, electrical appliances, decorative brassware, and locks and keys are just some of the products exploiting copper's advantages.

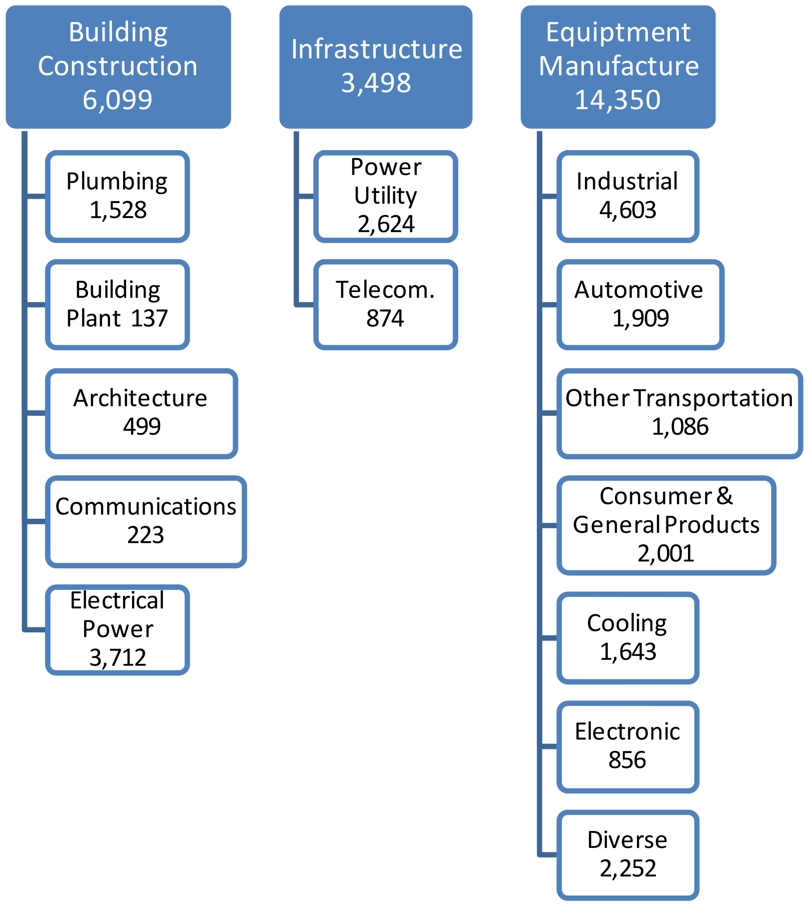
In addition, in areas known to be copper deficient, copper is used by farmers to supplement livestock and crop feed.

[1] Source: U.S. Department of the Treasury.
Photos: The British Museum (top left), International Copper Association (bottom left), and the Copper Development Association (top and bottom right).

Major Uses of Copper: Usage by End-Use Sector and Region, 2008

Basis: copper content, thousand metric tonnes
Source: International Copper Association

	2008 tonnes 000
China	6,937
Japan	1,622
South Korea	768
India	882
ASEAN	892
Taiwan	521
Region: Asia	11,622
North America	3,171
Rest of World	2,186
Latin America	1,533
Region: All others	6,890
Western Europe	3,984
Eastern Europe	1,451
Region: Europe	5,435
World	**23,947**



Chapter 2: Copper and the Environment

Copper and Health

1. Copper is essential to plant, animal and human health. Deficiencies, as well as excesses, can be detrimental to health.

2. In 1996, a World Health Organization associated agency, the International Program on Chemical Safety, concluded that "there is greater risk of health effects from deficiency of copper intake than from excess copper intake."

3. Copper is important in: the maintenance of the immune function and bone strength; the development of red and white blood cells; cholesterol and glucose metabolism; homeostasis; protection against oxidative and inflammatory damage; maintaining a healthy heart; transport and adsorption of iron; and brain development.

4. Certain enzymes that are critical to the function of our body depend on copper.

5. Copper deficiency can cause problems. In children, copper deficiency can result in physical, metabolic and developmental problems.

6. Population groups particularly at risk of having a copper deficiency are those with poor diets.

7. People with rare genetic disorders such as Menke's Disease (where the body has difficulty absorbing copper it needs), Wilson's Disease (where the body has difficulty getting rid of copper it does not need) and Idiopathic Copper Toxicosis (similar to the effects of Wilson's Disease) are susceptible to copper deficiencies or excesses.

8. In areas that benefit from copper tubing as a means to transport water, copper may be introduced in safe and minuscule amounts into the water. This amount of copper can contribute to meeting dietary requirements.

9. Copper can kill or inhibit health threatening fungi, bacteria, and viruses, including water-borne organisms.

Photos courtesy of the International Copper Association.

Copper and the Environment

Copper is present naturally in the environment in a wide variety of forms and humans, animals and plants require copper for healthy development. However, the relationships between copper, copper production and the environment can be complex. An overview of some key environmental attributes of copper and issues related to copper production is provided below.

Pros:

- **Recycling**. Copper is one of the most recycled of all metals. Virtually all products made from copper can be recycled. Industry uses recycled copper (also known as secondary copper) as a major source of raw material. In some instances, recycled copper can be remelted and directly used without any further processing. In effect, copper can be considered as renewable since it can be recycled over and over again without losing any of its chemical or physical properties.
- **Energy Efficiency**. Copper can improve the efficiency of energy production and distribution systems. Electricity conducted by copper encounters much less resistance compared with any other commonly used metal. This is the reason why copper is found in wires and cables, as well as in generators, motors, transformers, and renewable energy production systems. Household electrical appliances, electronic and telecommunications devices also contain significant quantities of copper.
- **Antimicrobial Properties**. Due to copper's antimicrobial properties, numerous applications of copper and copper alloy products are currently being explored in the healthcare and public sanitation fields to eliminate pathogens, reduce the spread of diseases and produce clean water.

Cons:

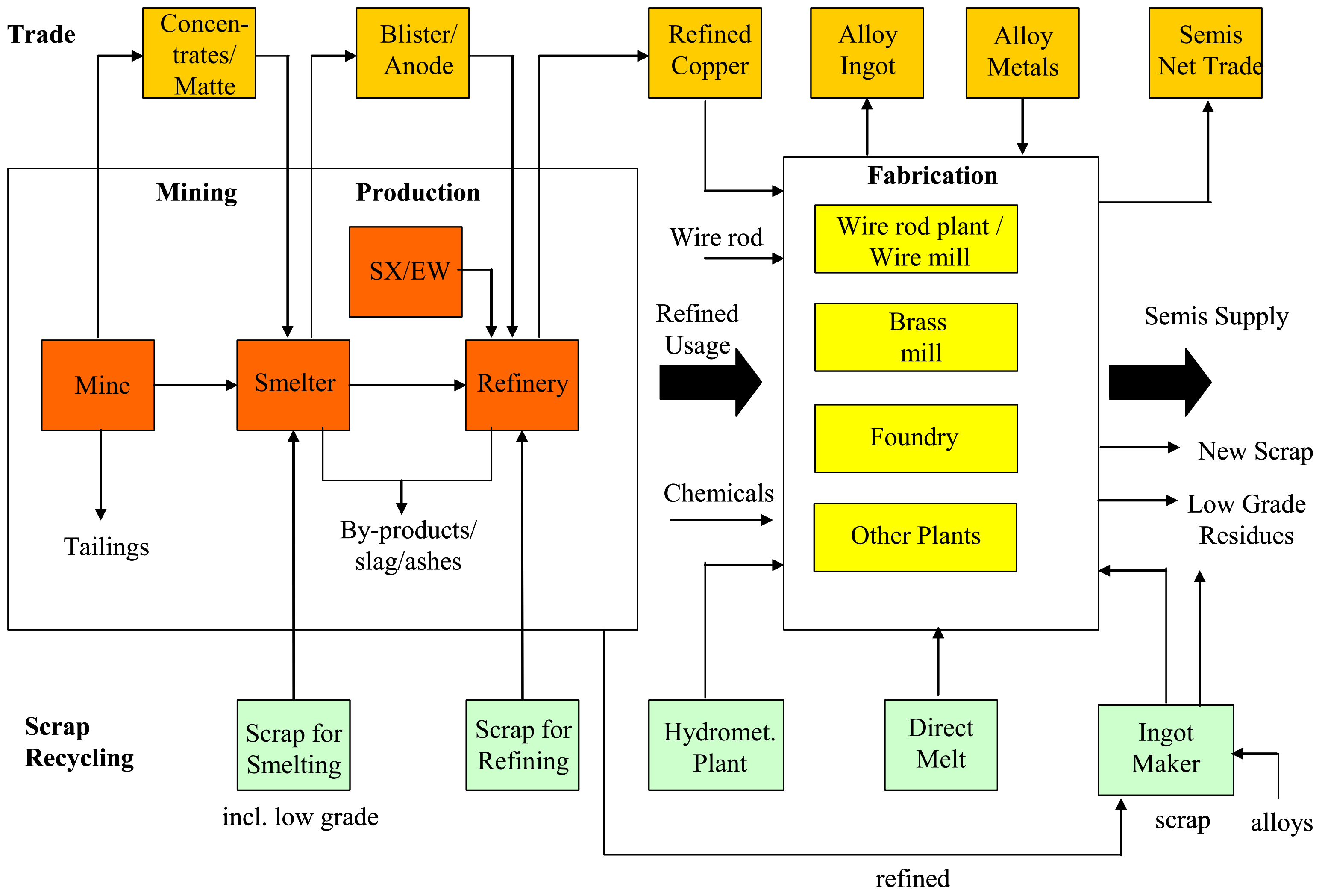
- **Water pollution.** Water pollution from mine waste rock and tailings may need to be managed after mine closure. In particular, acid mine drainage is becoming a key issue in some areas. As new mining technologies are able to handle more rock and ore material, more solid and liquid waste is expected to be disposed of and treated properly.
- **Emissions.** Atmospheric emissions of sulphur dioxide and heavy metals on fine particles may occur in the smelting and refining processes. While there have been significant improvements in copper mining, smelting and refining procedures and practices in recent years, reducing the environmental impacts of copper production remains an important issue for the industry.

Copper Recycling

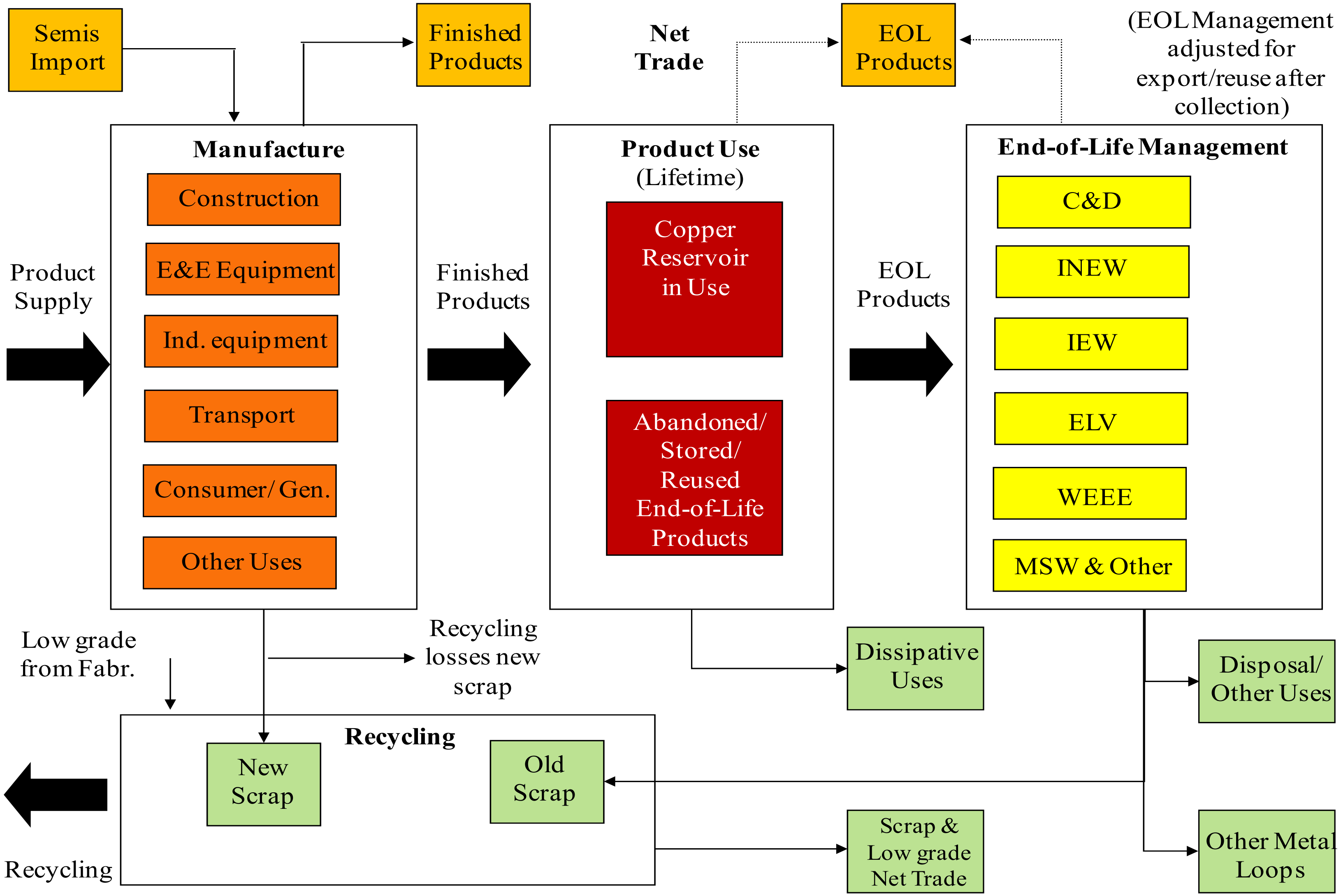
Copper is among the few materials that do not degrade or lose their chemical or physical properties in the recycling process. Considering this, the existing copper reservoir in use can well be considered a legitimate part of world copper reserves. In the recent decades, an increasing emphasis has been placed on the sustainability of material uses in which the concept of reuse and recycling of metals plays an important role in the material choice and acceptance of products. If appropriately managed, recycling has the potential to extend the use of resources, and to minimize energy use, some emissions, and waste disposal. Closing metal loops through increased reuse and recycling enhances the overall resource productivity and therefore represents one of the key elements of society's transition towards more sustainable production and consumption patterns. It is widely recognized that recycling is not in opposition to primary metal production, but is a necessary and beneficial complement.

In 2007, ICSG estimates that 35% of copper consumption came from recycled copper. Some countries' copper requirements greatly depend on recycled copper to meet internal demands. However, recycled copper alone cannot meet society's needs, so we also rely on copper produced from the processing of mineral ores.

Copper Recycling Flows



Copper Recycling Flows (cont.)



Copper Recycling Rate Definitions

The recycling performance of copper-bearing products can be measured and demonstrated in various ways – depending, among other things, on objectives, scope, data availability and target audience. The three International Non-Ferrous Metal Study Groups in conjunction with various metal industry associations agreed on the common definitions of the three following metal recycling rates:

- The **Recycling Input Rate** (RIR) measures the proportion of metal and metal products that are produced from scrap and other metal-bearing low-grade residues. The RIR is mainly a statistical measurement for raw material availability and supply rather than an indicator of recycling efficiency of processes or products. The RIR has been in use in the metals industry for a long time and is widely available from statistical sources. Major target audiences for this type of "metallurgical" indicator are the metal industry, metal traders and resource policy makers. However, given structural and process variables, it may have limited use as a policy tool.

- The **Overall Recycling Efficiency Rate** (Overall RER) indicates the efficiency with which end of life (EOL) scrap, new scrap, and other metal-bearing residues are collected and recycled by a network of collectors, processors, and metal recyclers. The key target audiences of this particular indicator are metal industry, scrap processors and scrap generators.

- The **EOL Recycling Efficiency Rate** (EOL RER) indicates the efficiency with which EOL scrap from obsolete products is recycled. This measure focuses on end-of-life management performance of products and provides important information to target audiences such as metal and recycling industries, product designers, life cycle analysts, and environmental policy makers.

Global Copper Recyclables Use, 2001-2007

Thousand metric tonnes

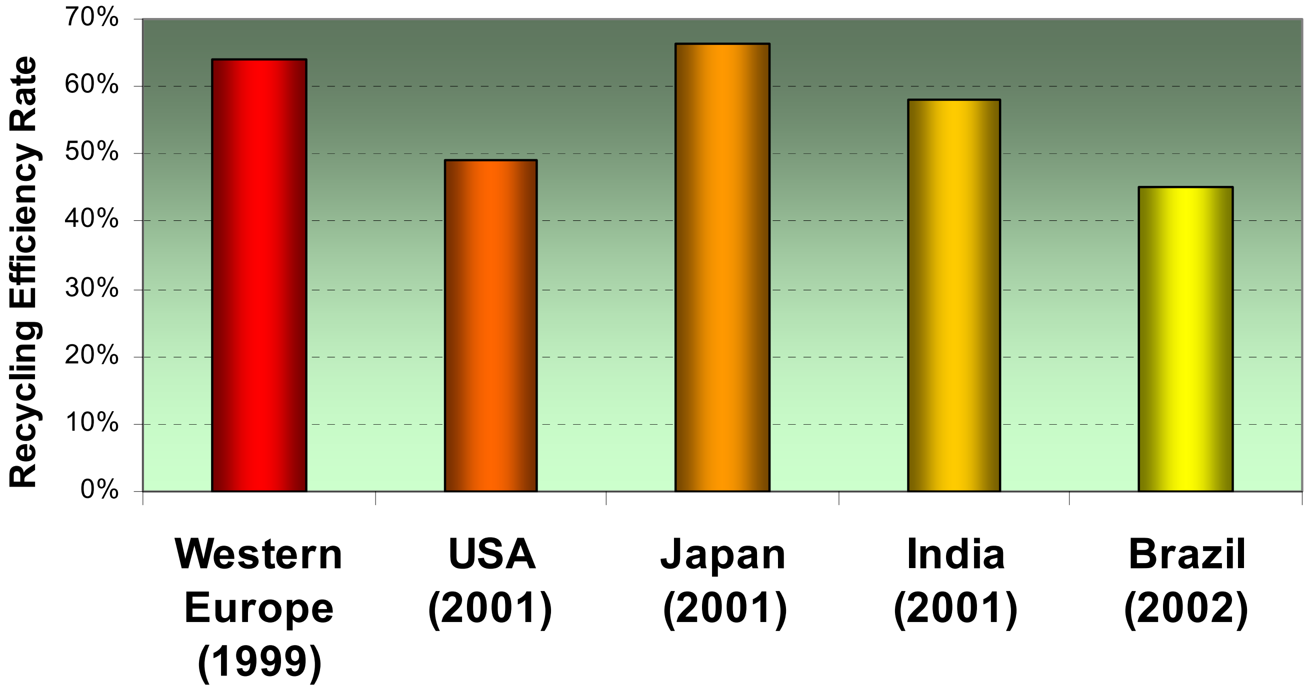
Source: ICSG

	2001	2002	2003	2004	2005	2006	2007
Americas	1,329	1,296	1,198	1,252	1,339	1,419	1,427
Asia	2,724	2,780	2,918	3,398	3,541	4,011	4,179
Europe	2,761	2,713	2,530	2,595	2,455	2,650	2,546
Africa & Oceania	87	70	54	51	55	48	60
World Total	**6,905**	**6,864**	**6,704**	**7,301**	**7,399**	**8,133**	**8,220**
Total scrap use year-on-year		-0.6%	-2.3%	8.9%	1.3%	9.9%	1.1%
Secondary refined production	1,892	1,898	1,786	2,069	2,161	2,613	2,743
Cu content of Direct Melt	5,013	4,966	4,918	5,232	5,238	5,520	5,477
Refined Usage	14,946	15,231	15,716	16,839	16,673	17,043	18,163
Total copper usage	19,959	20,197	20,634	22,071	21,911	22,563	23,640
Recycling Input Rate (RIR)	**34.6%**	**34.0%**	**32.5%**	**33.1%**	**33.8%**	**36.0%**	**34.8%**

Recycling Input Rate	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
Asia	32.8%	30.7%	30.3%	32.2%	32.9%	36.3%	33.7%
Europe	44.0%	44.5%	41.6%	41.3%	41.4%	41.1%	41.0%
North America	29.0%	29.8%	28.4%	27.7%	29.5%	32.3%	32.8%
Rest of the World	15.0%	15.4%	13.8%	14.3%	16.9%	16.9%	19.7%
Total World	34.6%	34.0%	32.5%	33.1%	33.8%	36.0%	34.8%

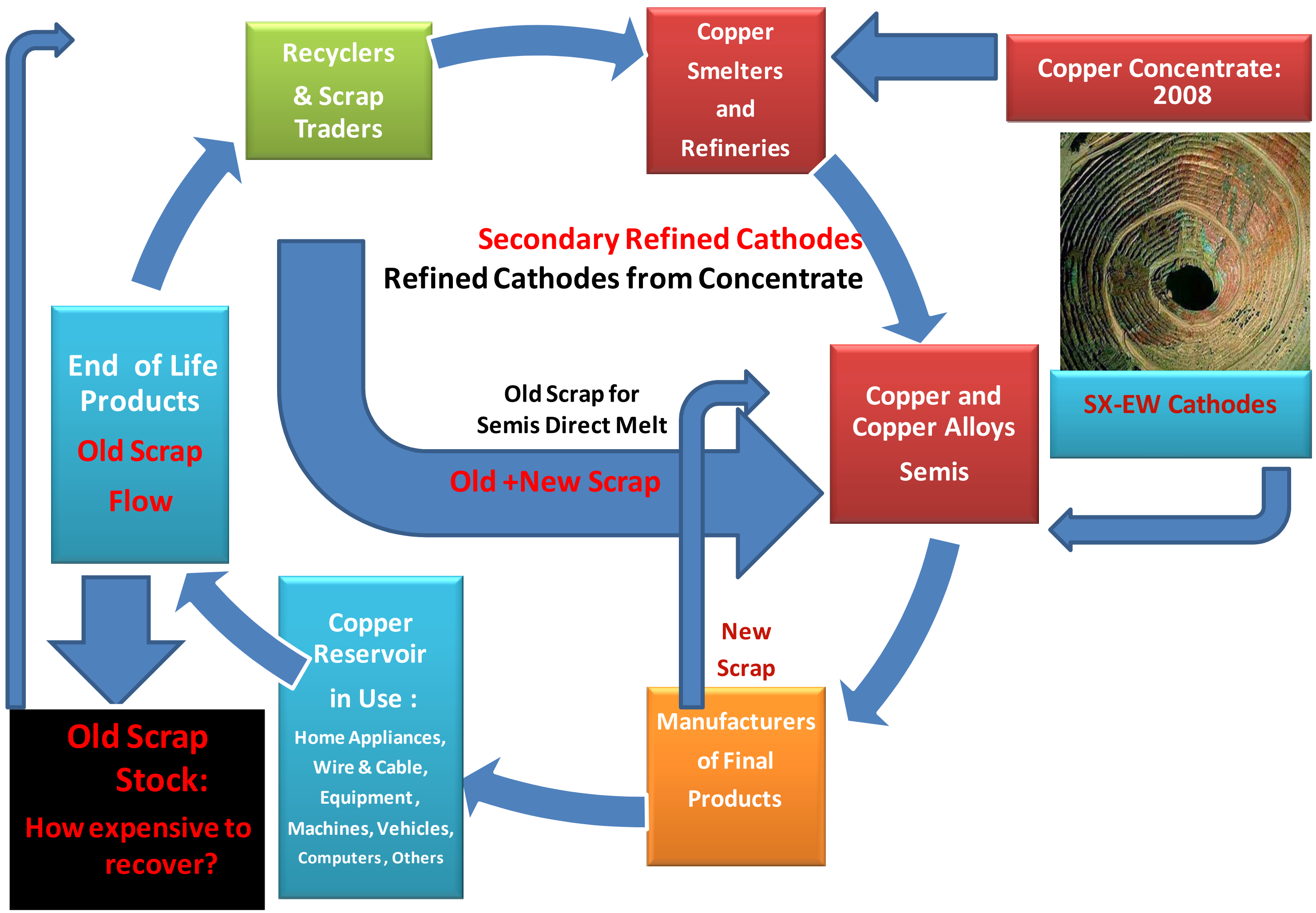
ICSG Copper Flow Model

The ICSG Secretariat developed some years ago the Copper Flow Model (CFM) as a tool for understanding copper flows in a particular country and determining the efficiency of recycling of copper from end-of-life products. It was first applied for Western Europe and afterwards for the USA and Brazil. Comparable flow studies were published by other organizations in the context of projects commissioned by the ICSG and/or other governmental organizations (including China, India and Japan). The CFM aims to calculate balances at different stages of the copper flow and to cross check these with collected data. For instance, different approaches for estimating recycling efficiency of a particular product group can be applied and crosschecked. The chart below shows a comparison of the calculated Recycling Efficiency Rates for the different regions.



Preliminary ICSG Research on the Global Use of Recycled Copper Flows

Source: ICSG



ICSG Copper Scrap Project

Recent Reports

- Japan Scrap Market Report
- China Scrap Usage Survey
- China Domestic Scrap Generation 2010-2015
- India Scrap Market
- Russia Scrap Market Report
- China Scrap Market Report

Some Preliminary Research Findings

Copper scrap is a concept that hides many different metals and end of life products containing copper.

- Global copper scrap supply of high copper content is less sensitive to prices/spread changes, and driven by first use industry activity.
- Low quality scrap supply reacts faster to price/spread incentives and is strongly affected by consumer behaviour.
- Domestic scrap generation must be growing below total copper use growth in economies with high manufactured exports/GDP.
- More research to estimate copper content in international trade of manufactured products by country should be considered to improve national availability estimations.
- More research should be considered on the composition of alloying metals in copper brass mills and other first Cu users outside the United States.
- Updated copper content in end of life vehicles, construction, industrial, municipal scrap and WEEE by country needs to be part of national statistics.
- Domestic copper scrap generation is growing fast in developing countries, in particular in electric and electronic waste.
- But not enough information on collection and recovery rates is widely available in most of developing countries and in some developed economies.
- We found that the study of copper content in the scrap trade was very rewarding to understand the global market behaviour. New methodologies and sampling related research should be implemented at the country level.
- The analysis of trade value revealed numerous gaps in the declarations of exporters and importers of the same scrap flow.

Based on interest expressed by ICSG member countries, ICSG launched the copper scrap market project in 2007 in order to provide greater transparency on an increasingly vital component of the world copper market at a time when globalization is reshaping the copper scrap and copper alloy recycling business. Below are some selected preliminary results and areas for future research.

Copper and Sustainable Development

Copper and copper-based alloys are used in a variety of applications that are necessary for a reasonable standard of living. Its continued production and use is essential for society's development. How society exploits and uses its resources, while ensuring that tomorrow's needs are not compromised, is an important factor in ensuring society's sustainable development.

The demand for copper will continue to be met by the discovery of new deposits, technological improvements, efficient design, and by taking advantage of the renewable nature of copper through reuse and recycling. As well, competition between materials, and supply and demand principles, contribute to ensuring that materials are used efficiently and effectively.

Copper is an important contributor to the national economies of mature, newly developed and developing countries. Mining, processing, recycling and the transformation of metal into a multitude of products creates jobs and generates wealth. These activities contribute to building and maintaining a country's infrastructure, and create trade and investment opportunities. This is particularly important for lesser-developed countries seeking to improve their living standards.

Copper will continue to contribute to society's development well into the future.

Copper is distributed in the earth's crust and oceans in various forms and concentrations, which form the overall resource-base for copper.

Often, there are references to "world reserves" of a metal. Reserves indicate the amount of material that can be economically extracted or produced at the time of determination. Improved extraction techniques and technologies, new discoveries, depletion and changes in economic conditions are some of the factors that alter reserve levels. For instance, world copper reserves have jumped from 90 million tonnes in 1950 to an estimated 550 million tonnes in 2008.[1]

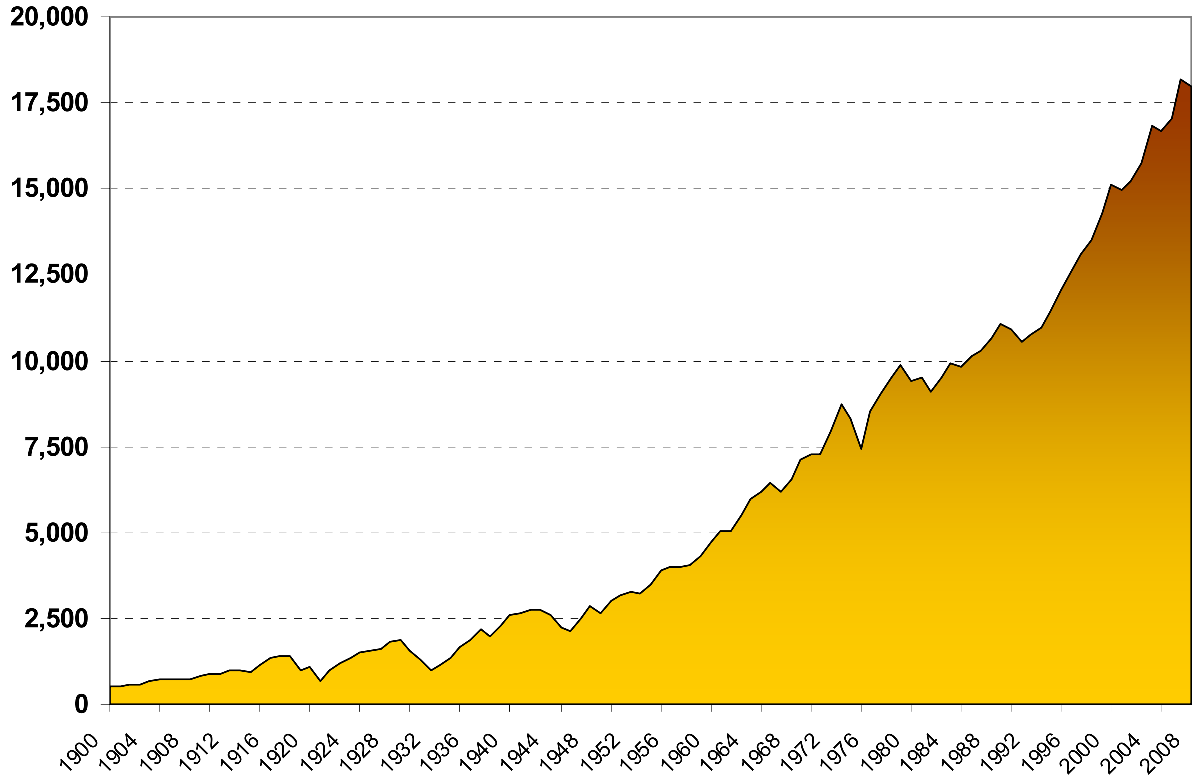
[1]Source: United States Geological Survey.

Chapter 3: World Copper Usage

World Copper Usage, 1900-2008

Thousand metric tonnes

Source: ICSG

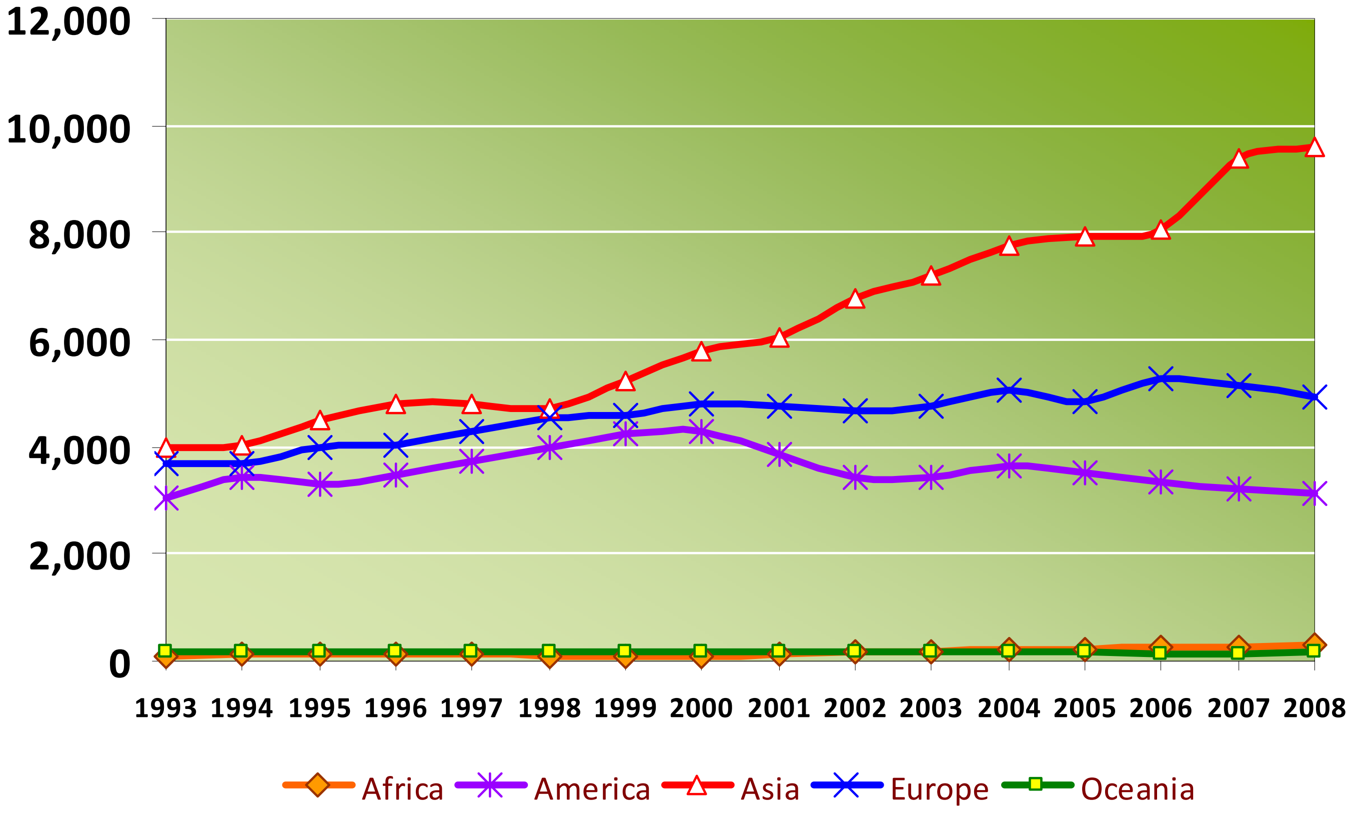


Since 1900, demand for refined copper increased from less than 500 thousand tonnes to around 18 million metric tonnes in 2008 as demand over the period grew by an average of 4% per year.

Refined Copper Usage by Region, 1993-2008

Thousand metric tonnes

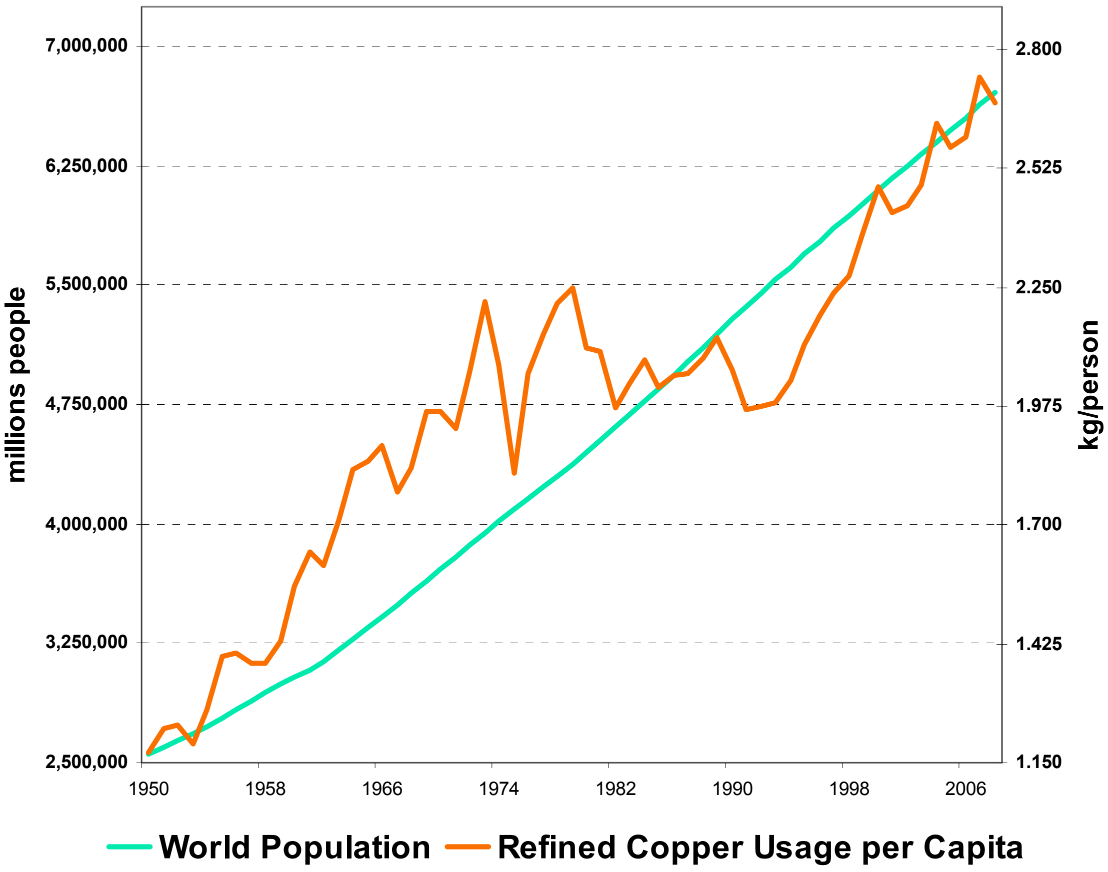
Source: ICSG



Recent growth in refined copper usage has been especially strong in Asia, where demand more than doubled over the 15-year period ending in 2008.

World Refined Usage per Capita, 1950-2008[1]

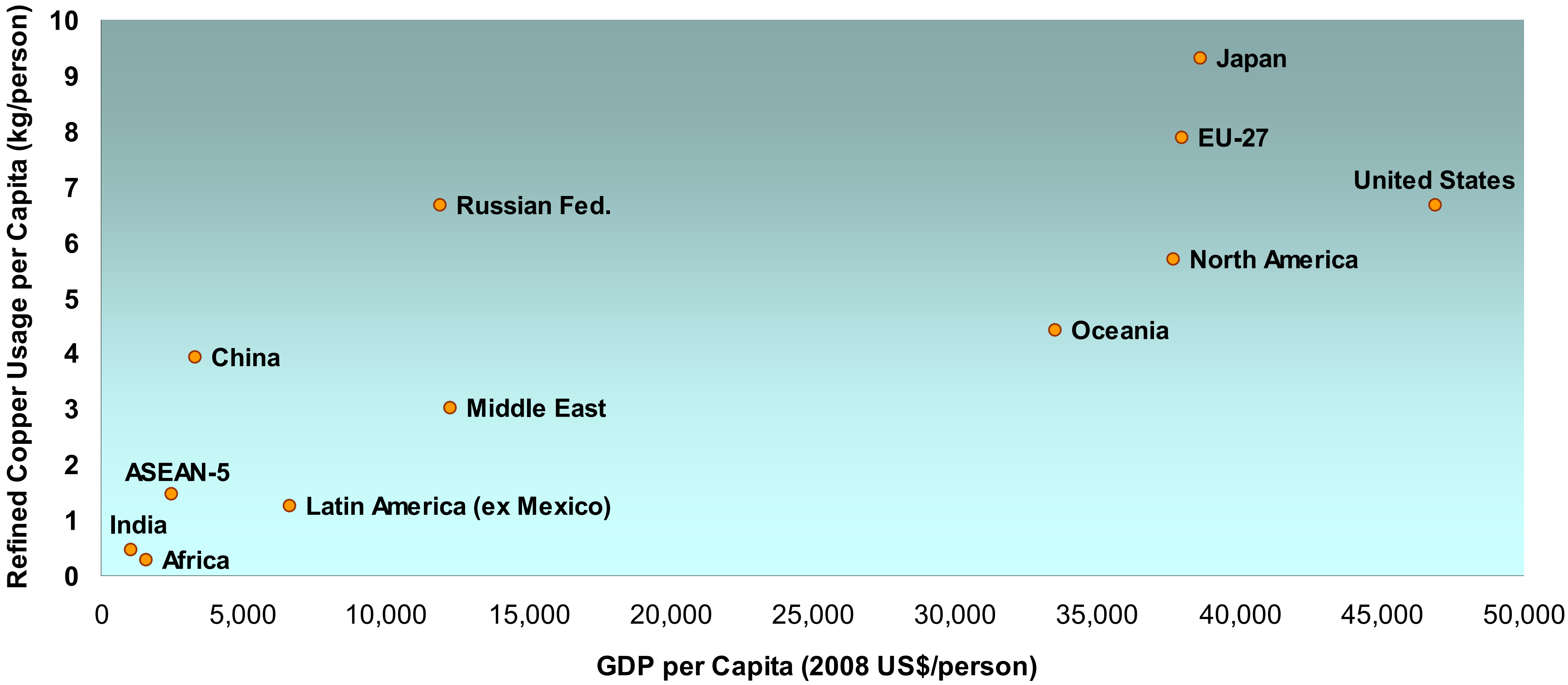
Sources: ICSG and U.S. Census Bureau



[1] Note: Refined copper is consumed by semis fabricators or the "first users" of refined copper, including ingot makers, master alloy plants, wire rod plants, brass mills, alloy wire mills, foundries and foil mills. As a result, per capita consumption of refined copper refers to the amount of copper consumed by industry divided by the total population and does not represent consumption of copper in finished products per person.

Intensity of Refined Copper Use, 2008[1]

Sources: ICSG, International Monetary Fund, U.S. Census Bureau

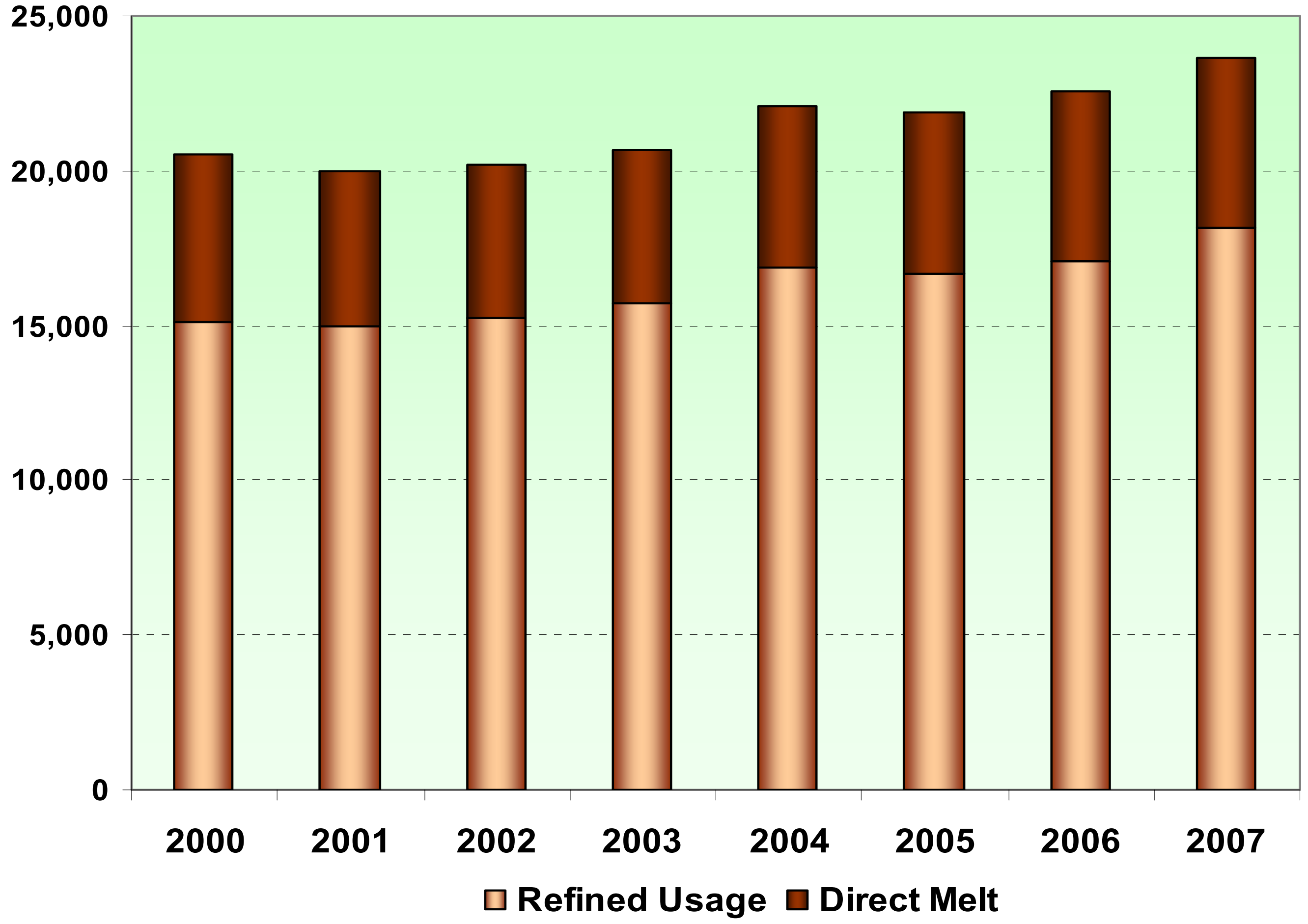


[1] Note: Refined copper is consumed by semis fabricators or the "first users" of refined copper, including ingot makers, master alloy plants, wire rod plants, brass mills, alloy wire mills, foundries and foil mills. As a result, per capita consumption of refined copper refers to the amount of copper consumed by industry divided by the total domestic population and does not represent consumption of copper in finished products per person.

Total Copper Use (Including Direct Melt Scrap), 2000-2007

Thousand metric tonnes

Source: ICSG

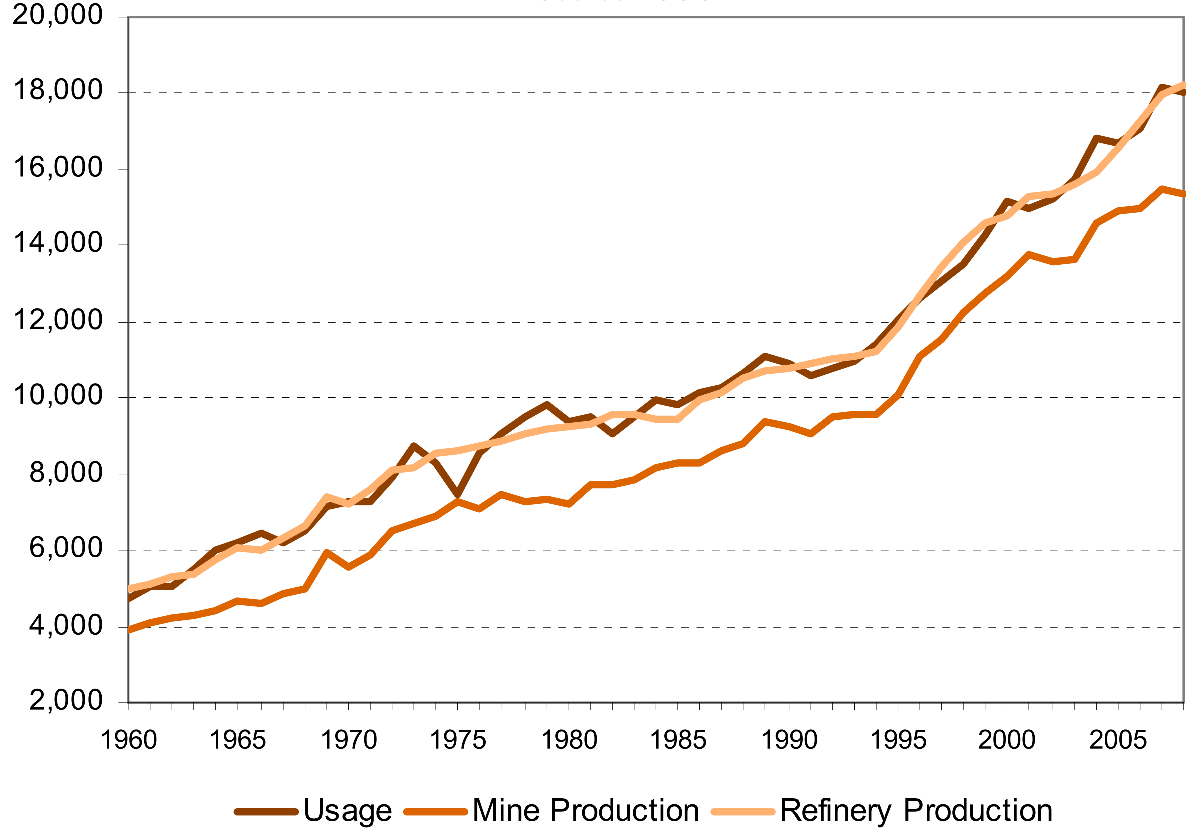


Chapter 4: Copper Products Along the Value Chain

World Copper Production and Consumption, 1960-2008

Thousand metric tonnes

Source: ICSG



Economic, technological and societal factors influence the supply and demand of copper. As society's need for copper increases, new mines and plants are introduced and existing ones expanded. In times of market surplus, existing operations can be scaled back or closed down, while planned expansions can be delayed or canceled. See next page for detailed supply constraints.

Recent ICSG Research on Constraints on Copper Supply Coming On Stream: Selected Operational and Financial Constraints

- Falling Ore Grades: a serious issue in developed copper areas such as the USA and Chile
- Project finance: cost of capital is a central factor. High interest rates may reduce supply significantly
- Capital cost overruns, in the past underestimations of US dollar inflation was source of many cost overruns
- Tax & investment regimes: recent research indicates these are less important than geological endowments
- Water supply: a critical issue in dry mining districts
- Energy: coal is the fuel chosen to power main copper mines and processes, climate change may increase costs.
- Shipping costs: not an issue for copper...now
- Sulphuric acid supply and price: 16% cost factor for SX-EW projects
- Skilled labor: open labor markets would help address this constraint
- Labor strikes: tend to increase when refined prices are high and GDP is growing faster, but tend to be longer and less frequent in cool economic times and also when copper prices are down
- High domestic costs if there is “dutch disease” (resulting in higher exchange rates due in part to strong exports)
- Rate between imported inputs and domestic input costs affected by the currency strength of the producer
- Market power/concentration: risks have moved to the import demand side versus export supply side in recent years
- Peace and security is also a key factor to avoid supply constraints from emerging exporters (relevant for low income economies such as the Democratic Republic of the Congo, Afghanistan and Pakistan, but also for Indonesia)

Copper Production and Usage by Country, 2008

Thousand metric tonnes

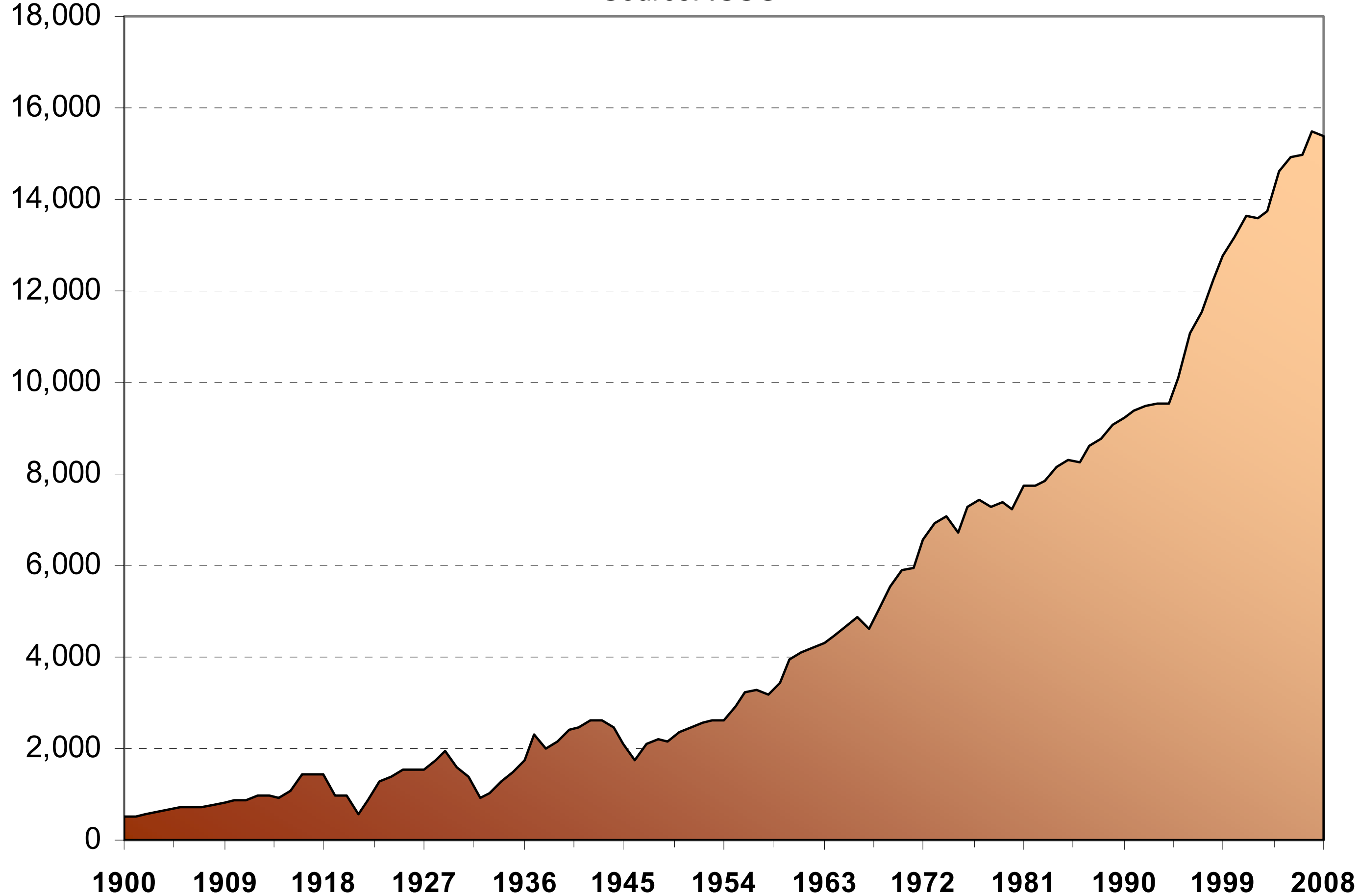
Source: ICSG

	Mine Production	Refined Production	Refined Usage		Mine Production	Refined Production	Refined Usage		Mine Production	Refined Production	Refined Usage
Argentina	157	16	30	**Iran**	248	201	135	**Poland**	429	527	247
Australia	883	502	151	**Italy**		24	635	**Portugal**	89		2
Austria		107	33	**Japan**		1,540	1,184	**Romania**	5	15	36
Belgium		396	285	**Kazakhstan**	420	398	56	**Russian Fed.**	705	862	650
Botswana	29			**Korea, North**	12	15	15	**Saudi Arabia**	1		192
Brazil	212	223	375	**Korea, South**		531	780	**Serbia**	19	34	37
Bulgaria	105	127	59	**Laos**	89	64		**South Africa**	109	93	86
Canada	607	442	197	**Malaysia**			177	**Spain**	7	319	385
Chile	5,328	3,058	103	**Mauritania**	33			**Sweden**	57	228	170
China	951	3,791	5,198	**Mexico**	247	295	325	**Taiwan (China)**			582
Colombia	1	10	10	**Mongolia**	129	3		**Tanzania**	4		
Congo, Dem Rep	214	64		**Morocco**	5			**Thailand**		0	240
Czech Republic			6	**Myanmar**	0	0		**Turkey**	83	88	360
Egypt		4	170	**Namibia**	9			**Ukraine**		20	20
Finland	13	131	67	**Netherlands**			22	**United Arab Emirates**			36
France			410	**Norway**		37		**United Kingdom**			54
Germany		690	1,398	**Oman**	20	25	15	**United States**	1,335	1,282	2,020
Greece			75	**Pakistan**	20		41	**Uzbekistan**	80	90	48
Hungary			8	**Papua New Guinea**	160			**Vietnam**	11	2	102
India	28	662	520	**Peru**	1,268	464	55	**Zambia**	547	417	29
Indonesia	651	254	195	**Philippines**	21	175	39	**Zimbabwe**	3	7	10

Copper Mine Production, 1900-2008

Thousand metric tonnes (copper content)

Source: ICSG

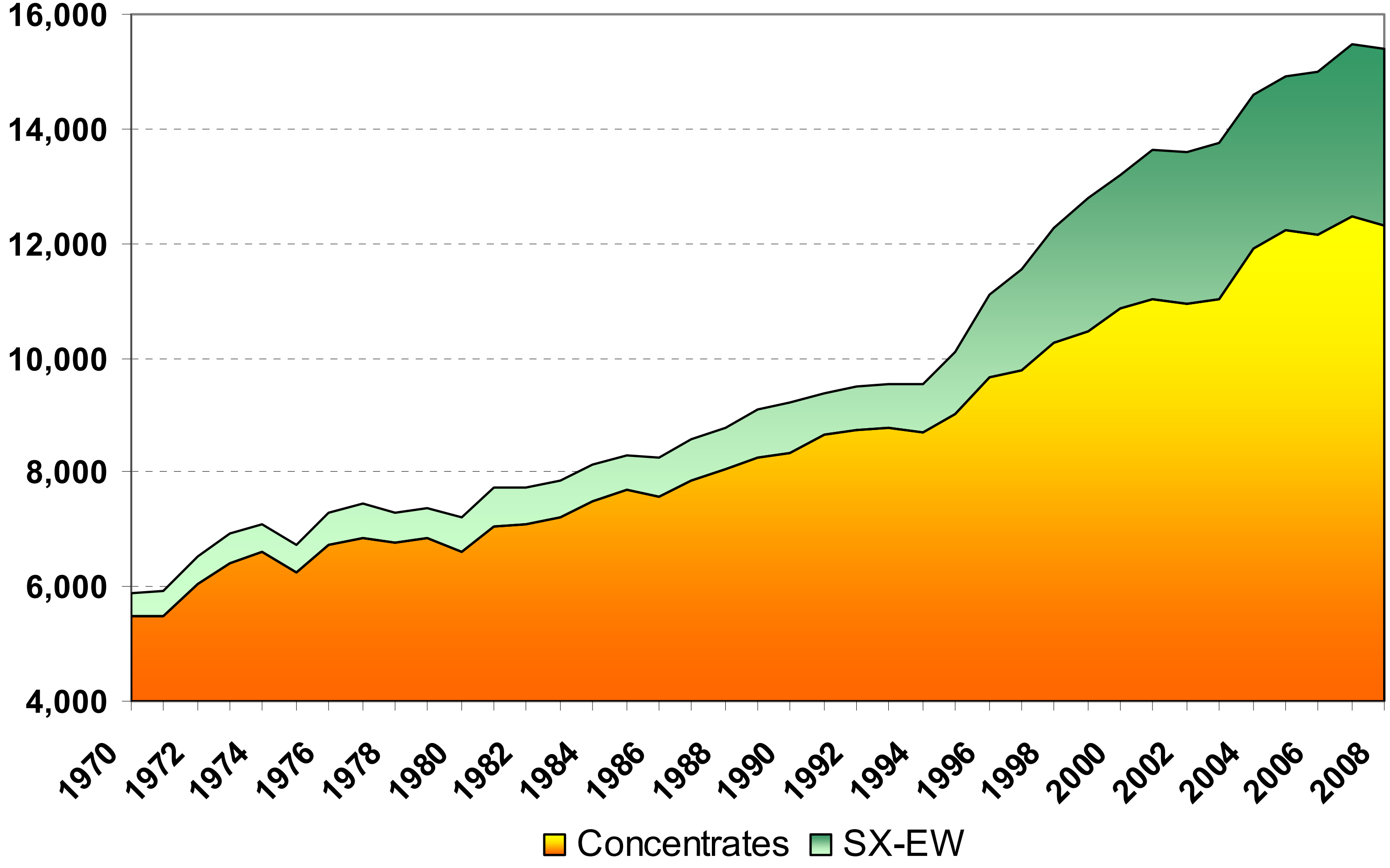


World production: 1900: 495 thousand metric tonnes; 2008: over 15 million metric tonnes
Average annual growth rate since 1900: 4%

Copper Mine Production by Process, 1970-2008

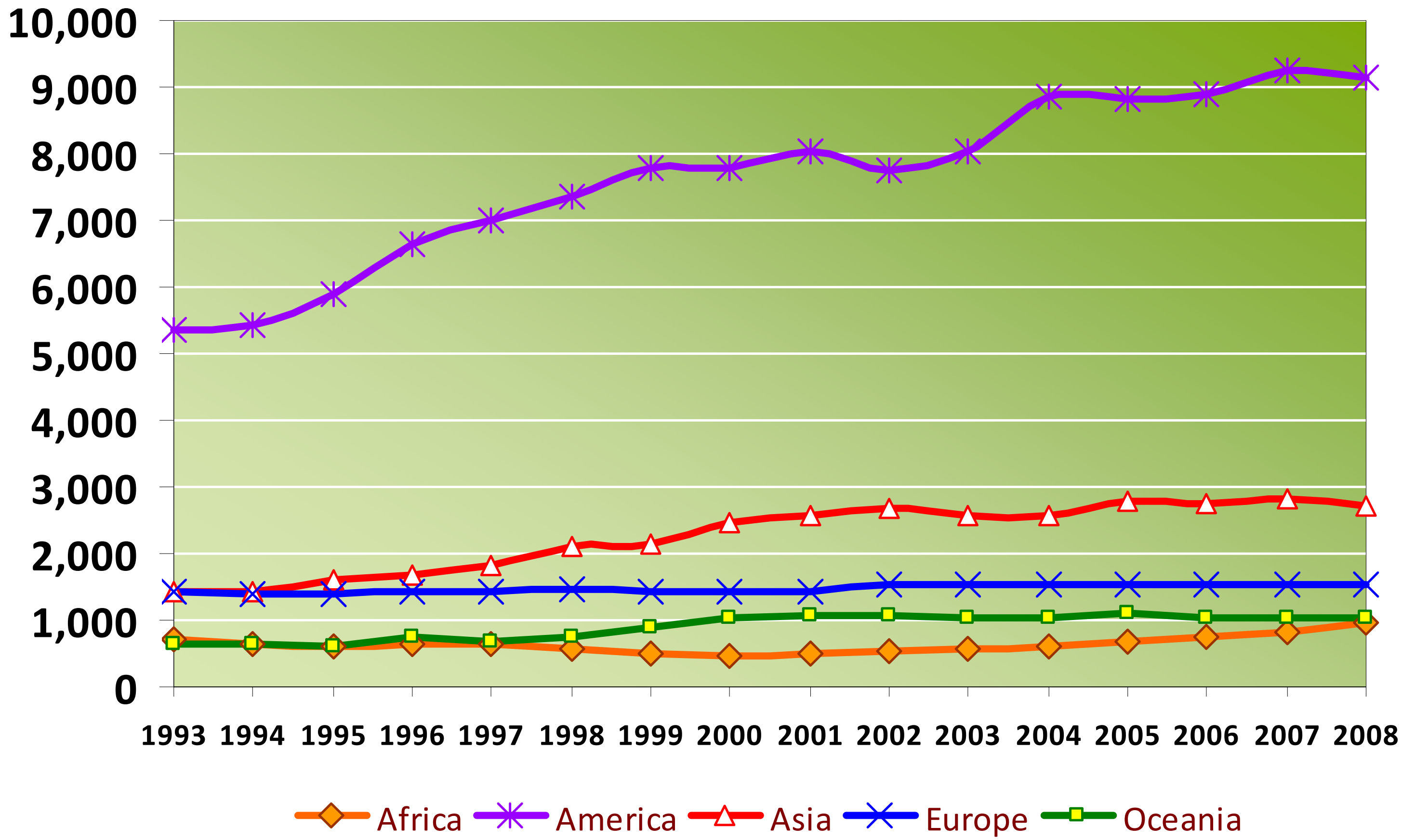
Thousand metric tonnes (copper content)

Source: ICSG

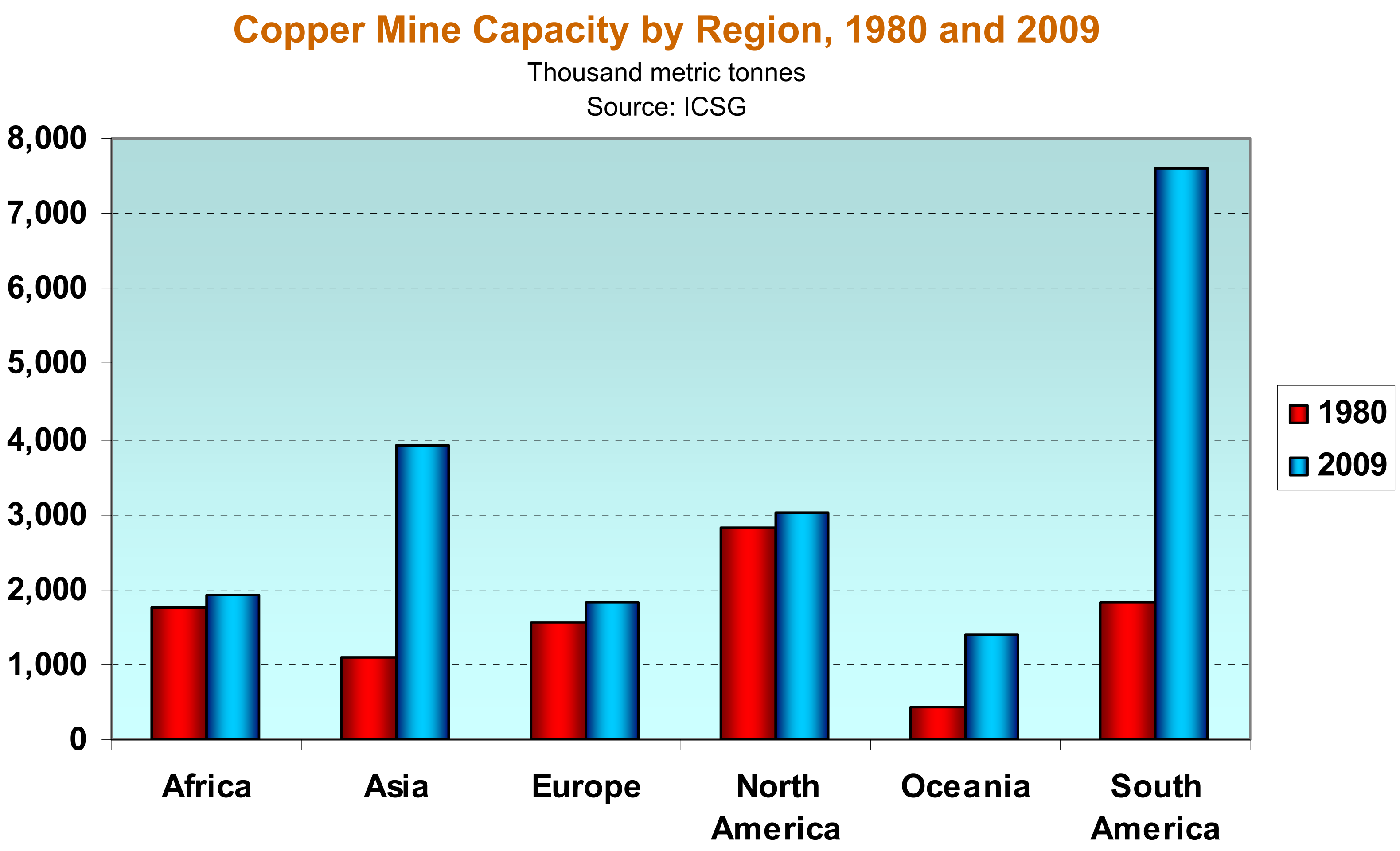


Copper Mine Production by Region

Thousand metric tonnes
Source: ICSG



Chile is by far the largest producer of mined copper in the world, with mine production of over 5.3 million metric tonnes in 2008.



World copper mine capacity in 1980: 9,512 kt; in 2009: 19,680 kt

Major International Trade Flows of Copper Ores and Concentrates[1]

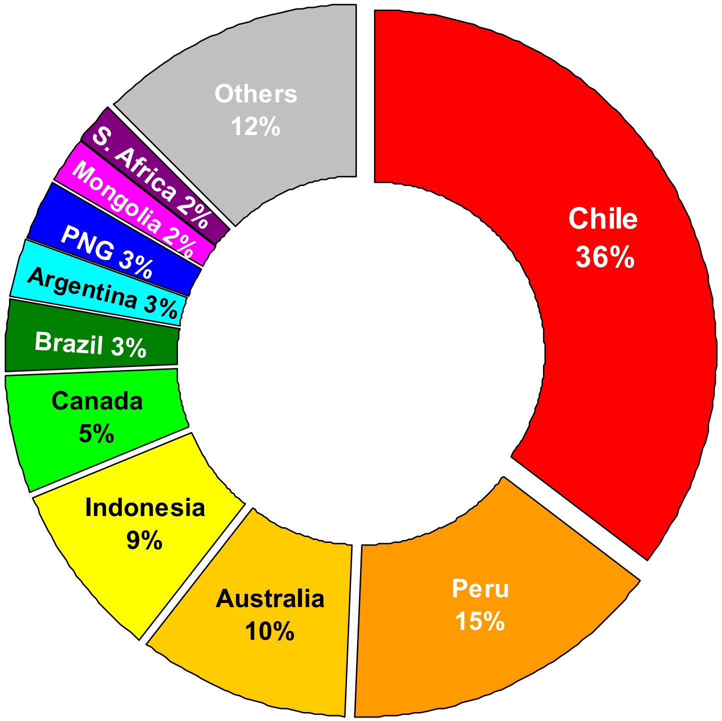
[1] Figure is intended to illustrate trade flows but not actual trade routes.

Leading Exporters and Importers of Copper Ores and Concentrates, 2008

Percentage and thousand metric tonnes copper content

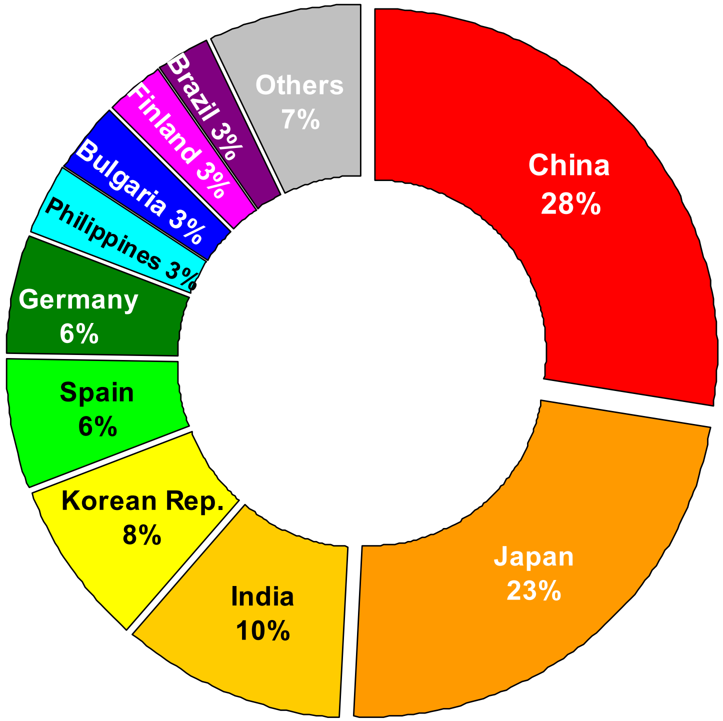
Source: ICSG

Exporters



World total: 5,718

Importers



World total: 5,652

Top 20 Copper Mines by Capacity, 2009

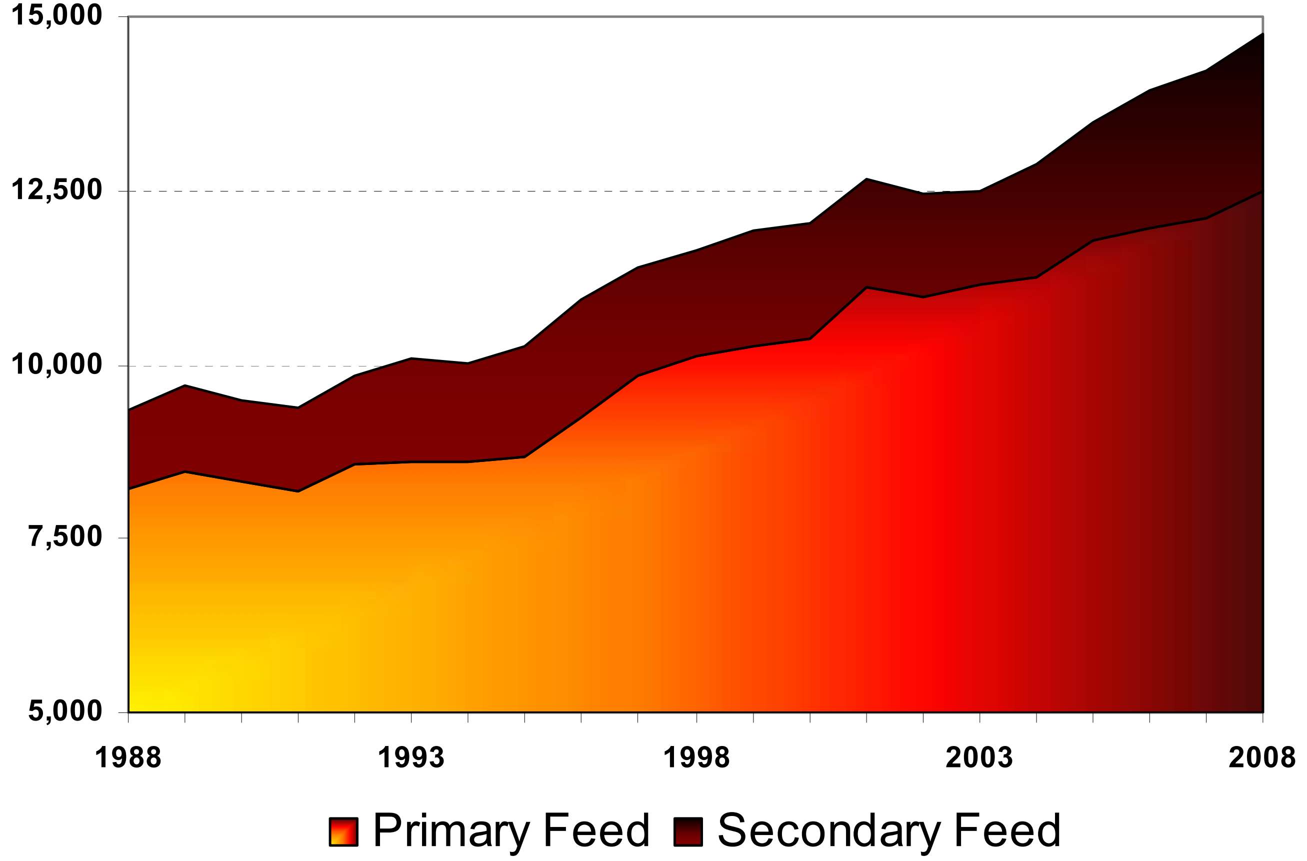
Thousand metric tonnes

Source: ICSG

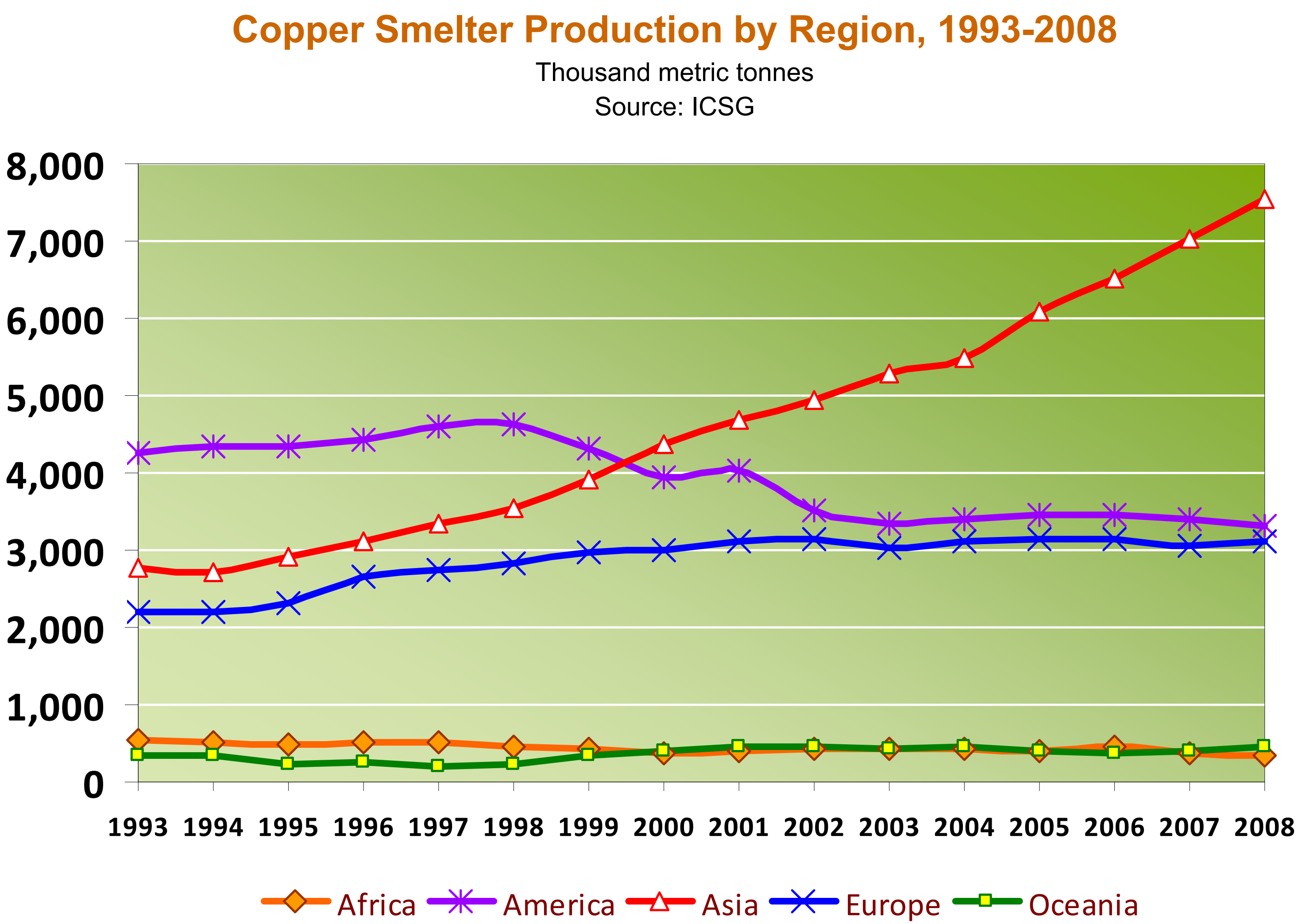
Rank	Mine	Country	Owner(s)	Source	Capacity
1	Escondida	Chile	BHP Billiton (57.5%), Rio Tinto Corp. (30%), Japan Escondida (10%), IFC (2.5%)	Concs & SX-EW	1,330
2	Codelco Norte	Chile	Codelco	Concs & SX-EW	900
3	Grasberg	Indonesia	P.T. Freeport Indonesia Co. (PT-FI), Rio Tinto	Concentrates	750
4	Collahuasi	Chile	Anglo American (44%), Xstrata plc (44%), Mitsui + Nippon (12%)	Concs & SX-EW	498
5	El Teniente	Chile	Codelco Chile	Concentrates	440
6	Taimyr Peninsula (Norilsk/ Talnakh Mills)	Russia	Norilsk Nickel	Concentrates	430
7	Antamina	Peru	BHP Billiton (33.75%), Teck (22.5%), Xstrata plc (33.75%), Mitsubishi (10%)	Concentrates	420
8	Morenci	United States	Freeport-McMoRan Copper & Gold Inc./Sumitomo	SX-EW	400
9	Los Pelambres	Chile	Antofagasta Holdings (60%), Nippon Mining (25%), Mitsubishi Materials (15%)	Concentrates	360
10	Bingham Canyon	United States	Kennecott	Concentrates	280
10	Batu Hijau	Indonesia	PT Pukuafu Indah (20%), Newmont (45%), Sumitomo Corp. (27.5%), Sumitomo Metal Mining (5%), Mitsubishi Materials (2.5%)	Concentrates	280
12	Kansanshi	Zambia	First Quantum Minerals Ltd (80%), ZCCM (20%)	Concs & SX-EW	270
13	Andina	Chile	Codelco Chile	Concentrates	250
14	Zhezkazgan Complex	Kazakhstan	Kazakhmys (Samsung)	Concentrates	230
15	Los Bronces	Chile	Anglo American (100%)	Concs & SX-EW	228
16	Olympic Dam	Australia	BHP Billiton	Concs & SX-EW	225
17	Rudna	Poland	KGHM Polska Miedz S.A.	Concentrates	220
18	Cananea	Mexico	Grupo Mexico	Concs & SX-EW	210
19	Sarcheshmeh	Iran	National Iranian Copper Industry Co.	Concs & SX-EW	204
20	Bajo de la Alumbrera	Argentina	Xstrata plc 50%, Goldcorp Inc 37.5%, Yamana Gold 12.5%	Concentrates	200

Copper Smelter Production, 1988-2008

Thousand metric tonnes
Source: ICSG



Smelting is the pyrometallurgical process used to produce copper metal. Recently, the trend to recover copper directly from ores through leaching processes has been on the increase. Primary smelters use mine concentrates as their main source of feed (although some use copper scrap as well).Secondary copper smelters use copper scrap (mainly low grade) as their feed.

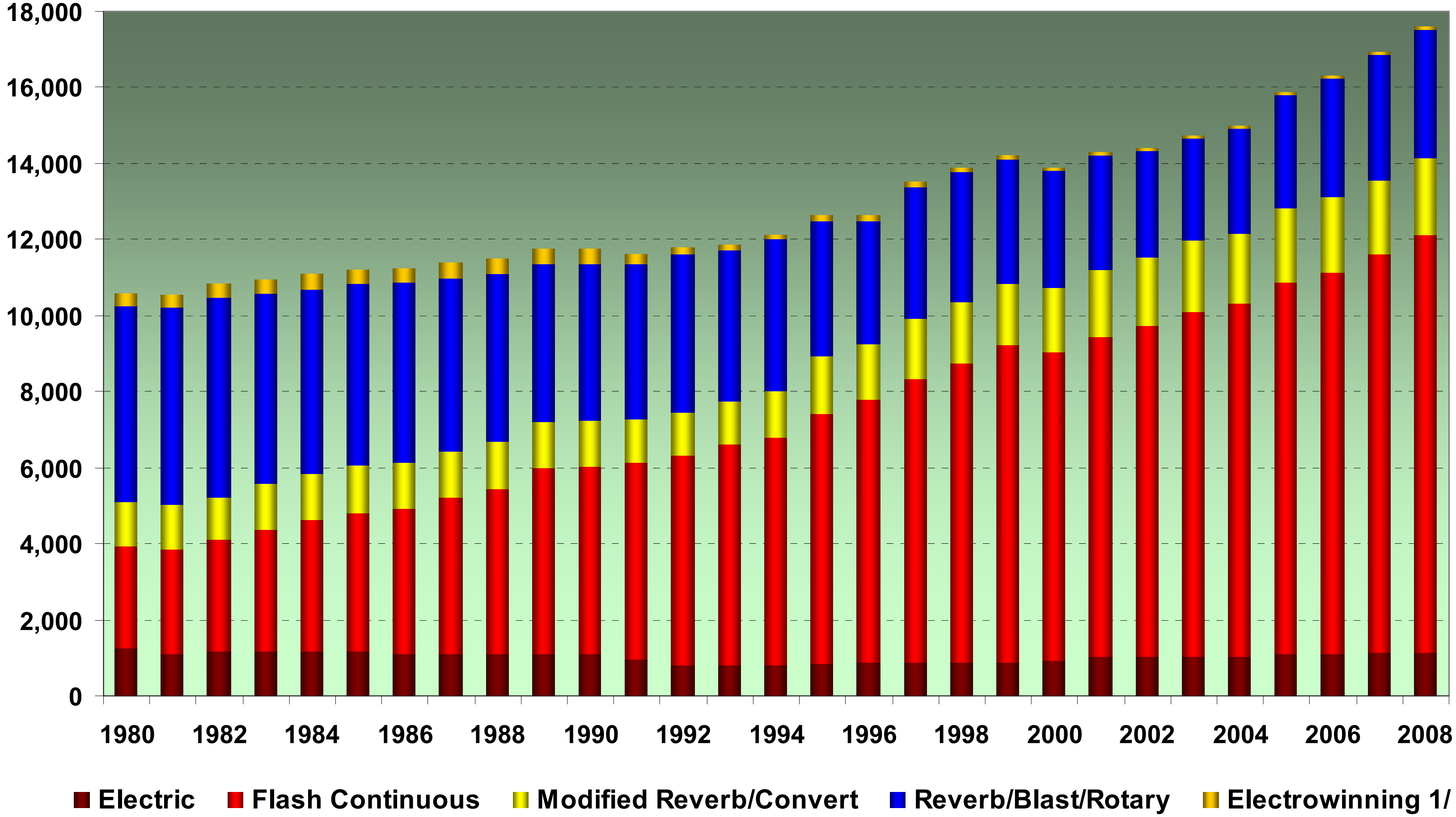


In 2008, China accounted for around 23% of world copper smelter output.

Trends in Copper Smelting Capacity, 1980-2008

Thousand metric tonnes

Source: ICSG

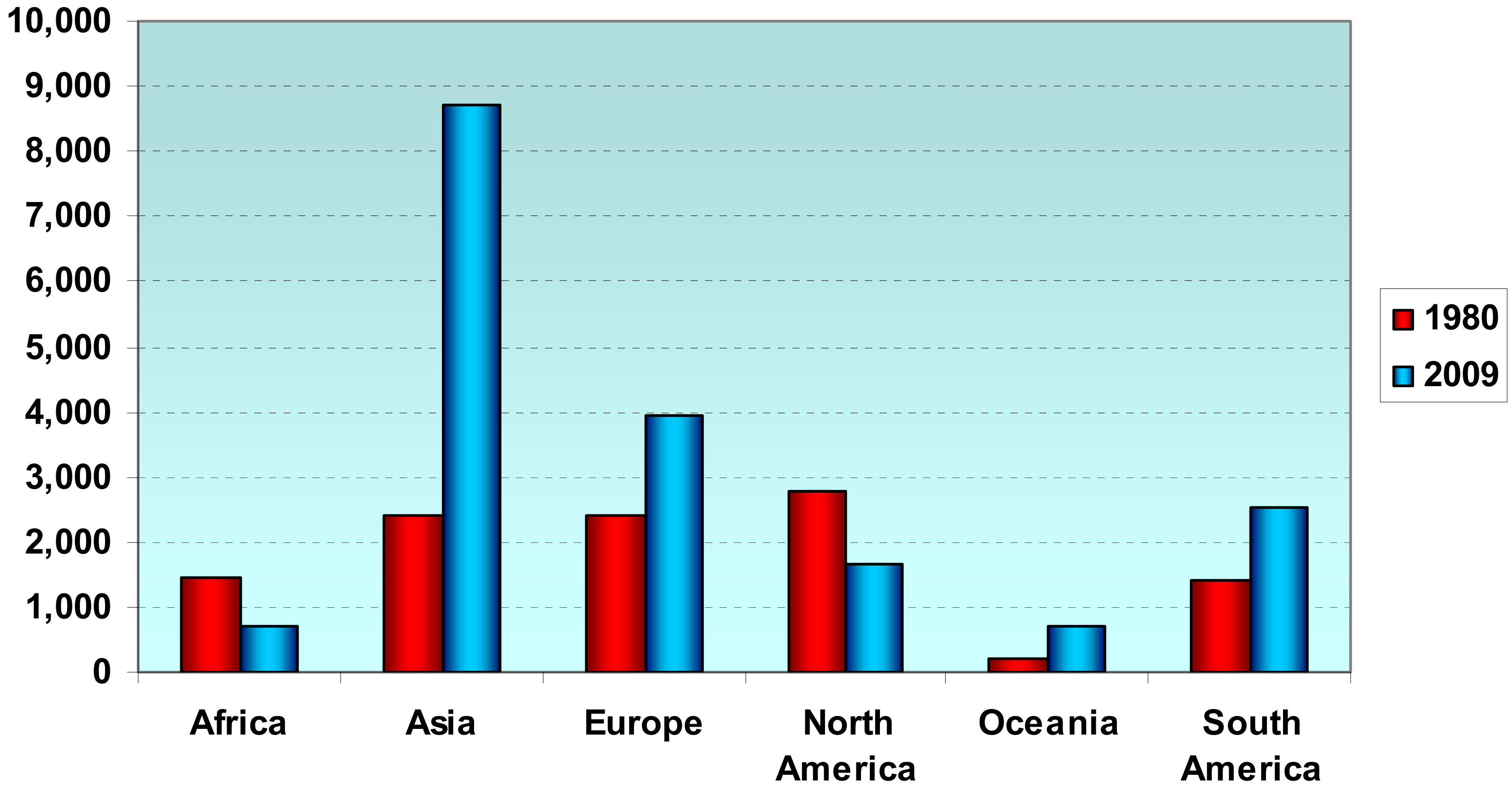


1/ Low grade copper to be re-refined.

Copper Smelter Capacity, 1980 and 2009

Thousand metric tonnes

Source: ICSG



World copper smelter capacity in 1980: 10,678 kt; in 2009: 18,186 kt

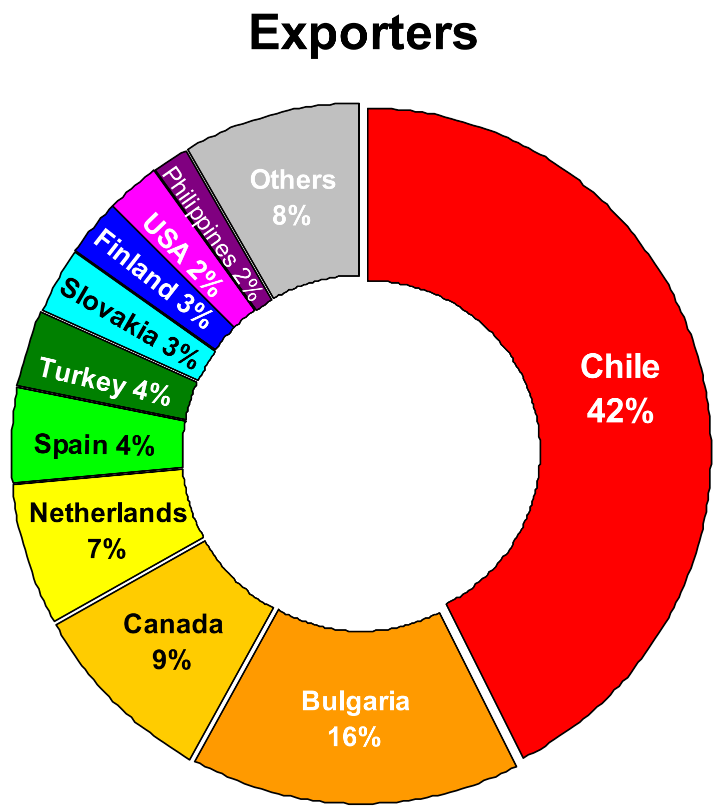
Major International Trade Flows of Copper Blister and Anodes[1]

[1] Figure is intended to illustrate trade flows but not actual trade routes.

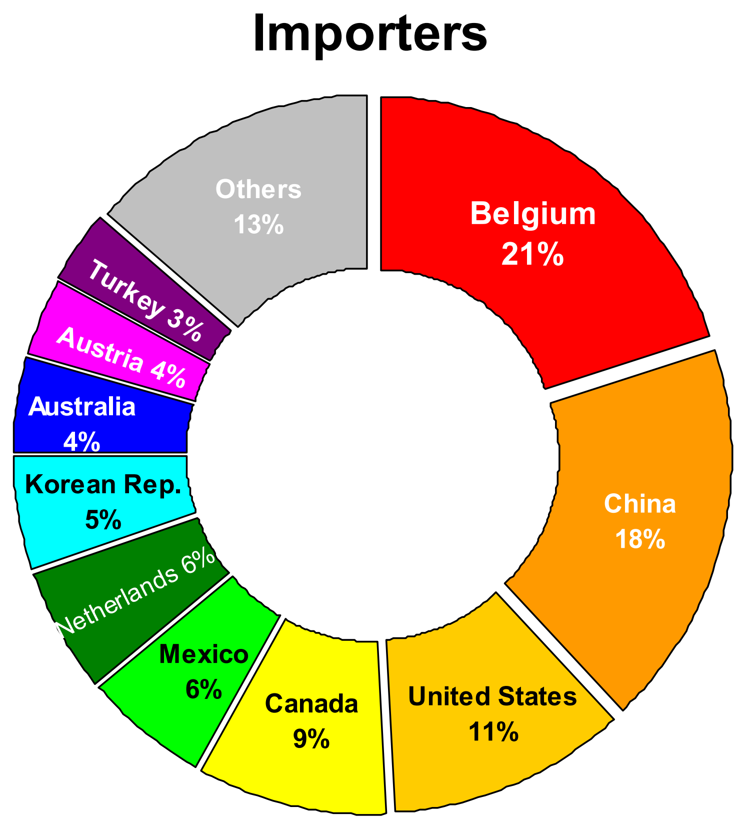
Leading Exporters and Importers of Copper Blister and Anodes, 2008

Percentage and thousand metric tonnes

Source: ICSG



World total: 962



World total: 1,100

Top 20 Smelters by Capacity, 2009

Thousand metric tonnes

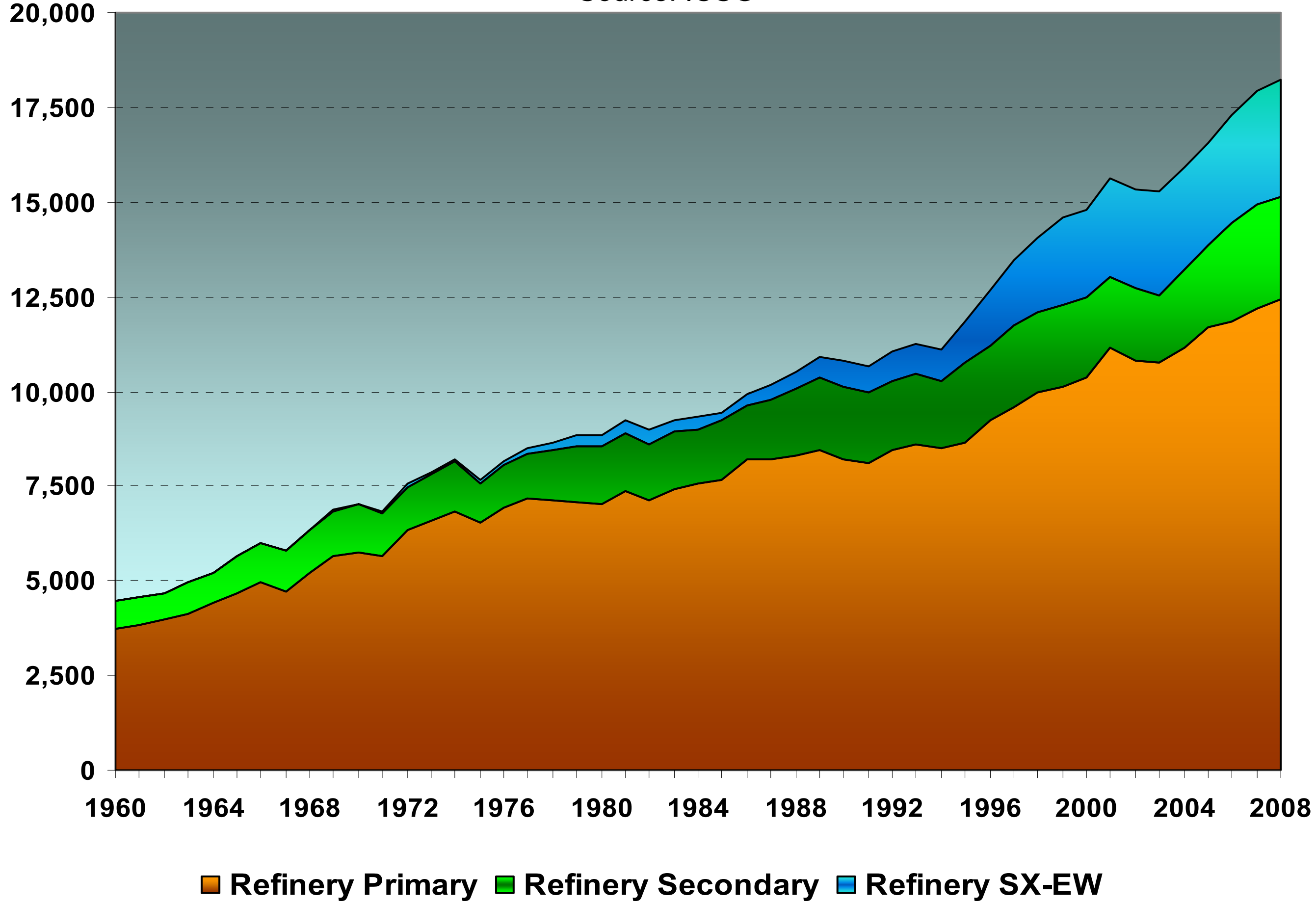
Source: ICSG

Rank	Smelter Name	Capacity	Process	Country	Owner(s)
1	Guixi	900	Outokumpu Flash	China	Jiangxi Copper Corp.
2	Birla Copper (Dahej)	500	Outokumpu Flash, Ausmelt, Mitsubishi Continuous	India	Birla Group
3	Codelco Norte	460	Outokumpu/Teniente Converter	Chile	Codelco
4	Hamburg	450	Outokumpu, Contimelt, Electric	Germany	Aurubis
4	Saganoseki/ Ooita	450	Outokumpu Flash	Japan	Pan Pacific Copper Co. Ltd
4	Besshi/ Ehime (Toyo)	450	Outokumpu Flash	Japan	Sumitomo Metal Mining Co. Ltd.
7	Norilsk (Nikelevy, Medny)	400	Reverb, Electric, Vanyukov	Russia	Norilsk G-M
7	El Teniente (Caletones)	400	Reverberatory/ Teniente Conv.	Chile	Codelco Chile
7	Jinchuan	400	Reverberatory/ Kaldo Conv.	China	Jinchuan Non- Ferrous Metal Co.
10	Altonorte (La Negra)	390	Noranda Continuous	Chile	Xstrata plc
11	Sterlite Smelter (Tuticorin)	380	Isasmelt Process	India	Vedanta
12	Ilo Smelter	360	Isasmelt Process	Peru	Southern Copper Corp. (Grupo Mexico)
13	Yunnan	350	Isasmelt Process	China	Yunnan Copper Industry Group (Local Government)
14	Onsan II	325	Mitsubishi Continuous	Korea Republic	LS-Nikko Co. (LS, Nippon Mining)
15	Onahama/ Fukushima	322	Reverberatory	Japan	Mitsubishi Materials Corp., Dowa Metals & Mining Co. Ltd., Furukawa Metals & Resources Co. Ltd.
16	Huelva	320	Outokumpu Flash	Spain	Atlantic Copper S.A. (Freeport McMoran)
16	Garfield	320	Kennecott/ Outokumpu	United States	Kennecott (Rio Tinto)
18	Naoshima/ Kagawa	306	Mitsubishi Continuous	Japan	Mitsubishi Materials Corp.
19	La Caridad	300	Outokumpu/ Teniente Converter	Mexico	Mexicana de Cobre S. A. (Grupo Mexico)
19	Mount Isa	300	Isasmelt Process	Australia	Xstrata plc

Refined Copper Production, 1960-2008

Thousand metric tonnes

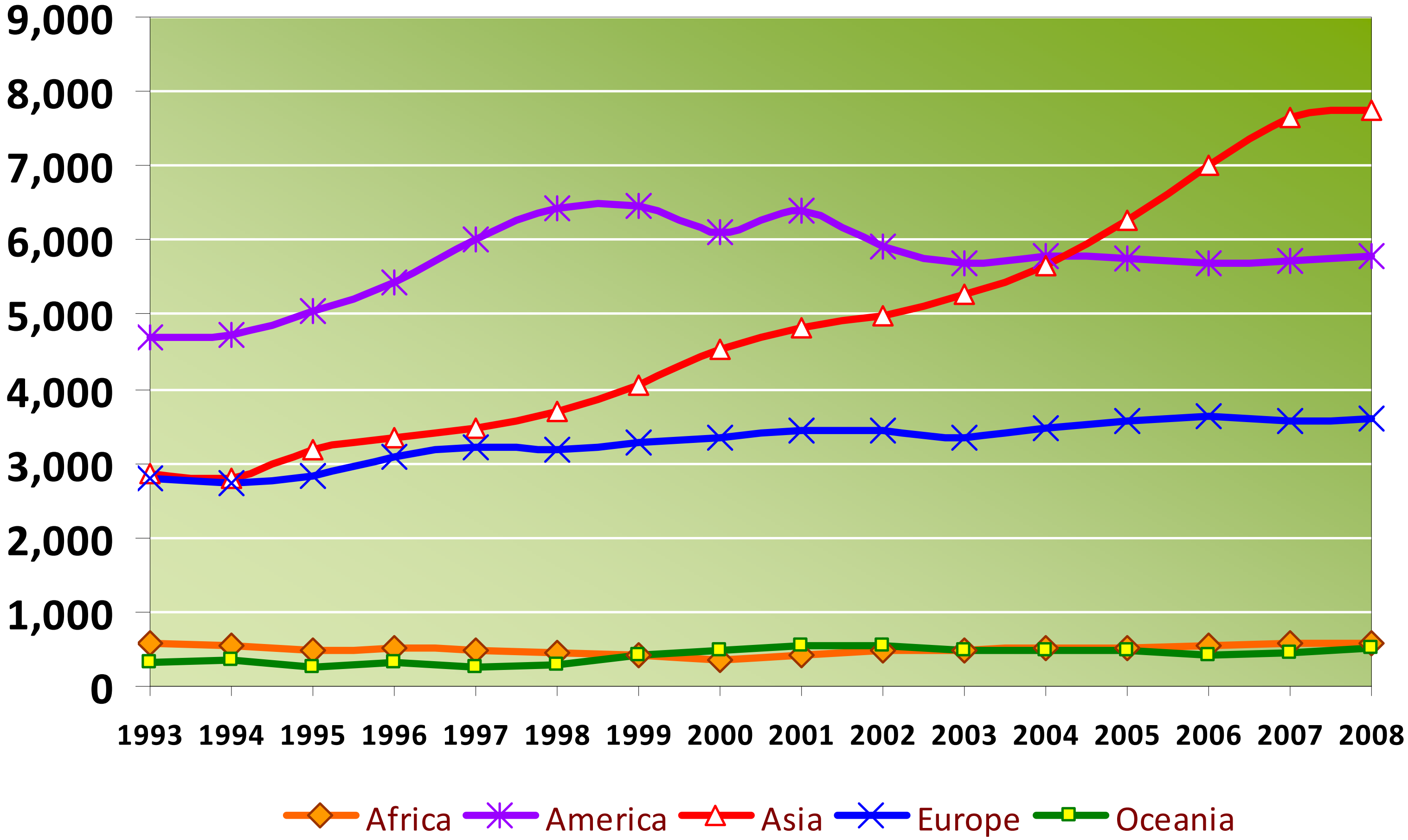
Source: ICSG



With the gradual emergence of solvent extraction-electrowinning (SX-EW) technology, refined copper produced from leaching ores has been on the rise and accounted for 17% of production in 2008. Recognizing the economic and environmental importance of recycling, secondary refined production sourced from scrap accounted for 15%.

Refined Copper Production by Region, 1993-2008

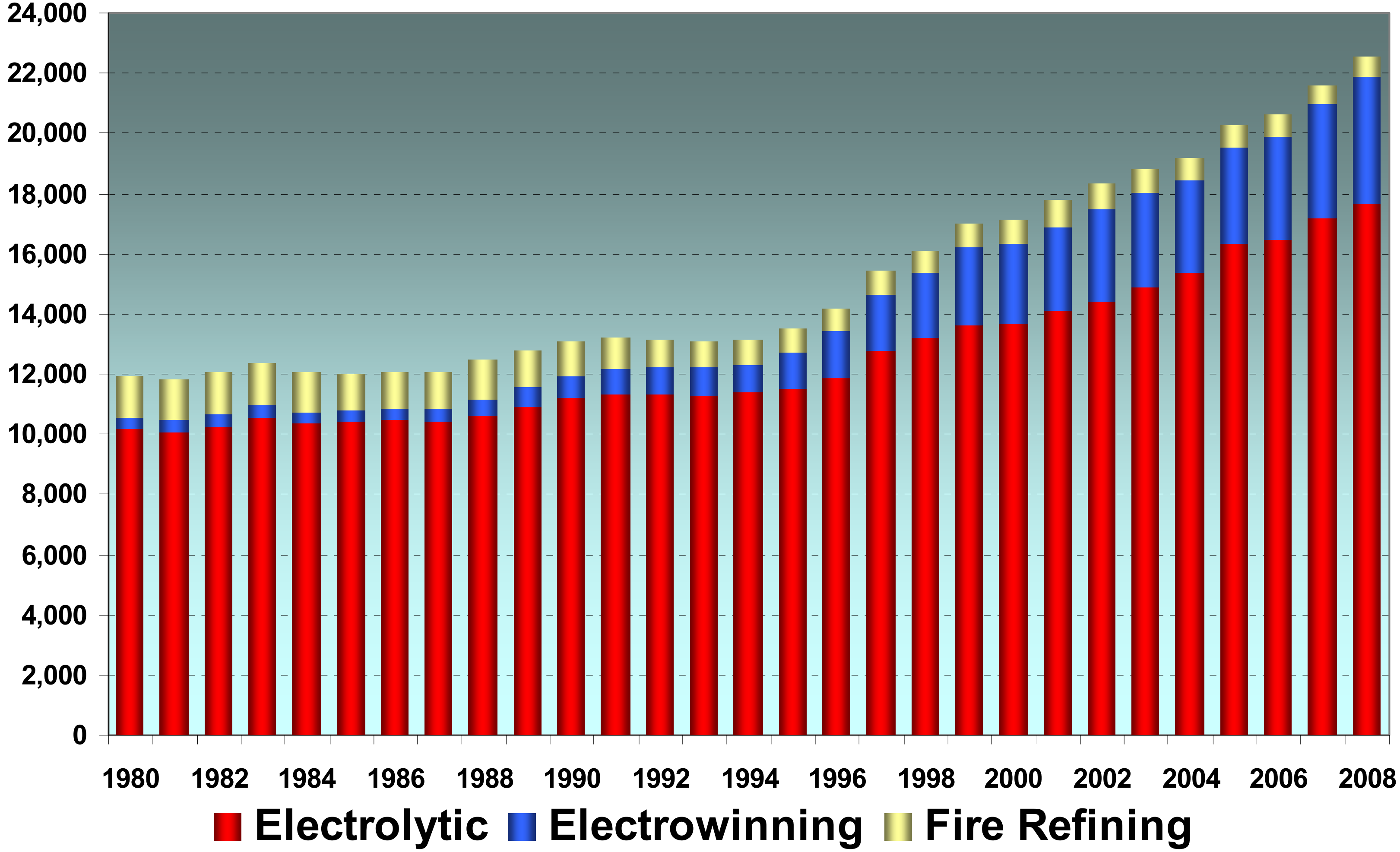
Thousand metric tonnes
Source: ICSG



Asia's share of world refined copper production in 1993: 25%; in 2008: 43%.

Trends in Refining Capacity, 1980-2008

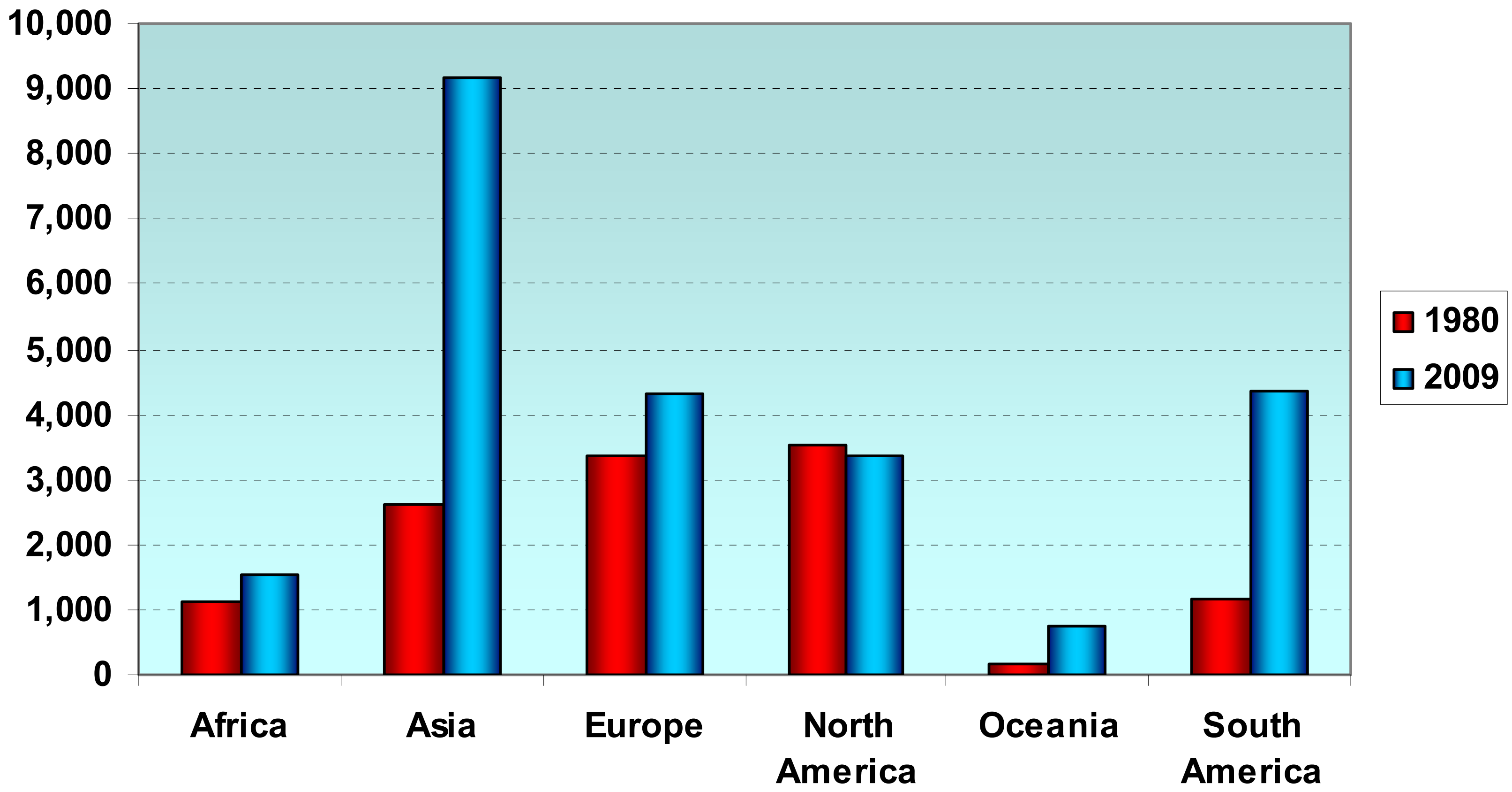
Thousand metric tonnes
Source: ICSG



Refined Copper Capacity by Region, 1980 and 2009

Thousand metric tonnes

Source: ICSG



World copper refinery capacity in 1980: 11,931 kt; in 2009: 23,449 kt

Major International Trade Flows of Refined Copper[1]

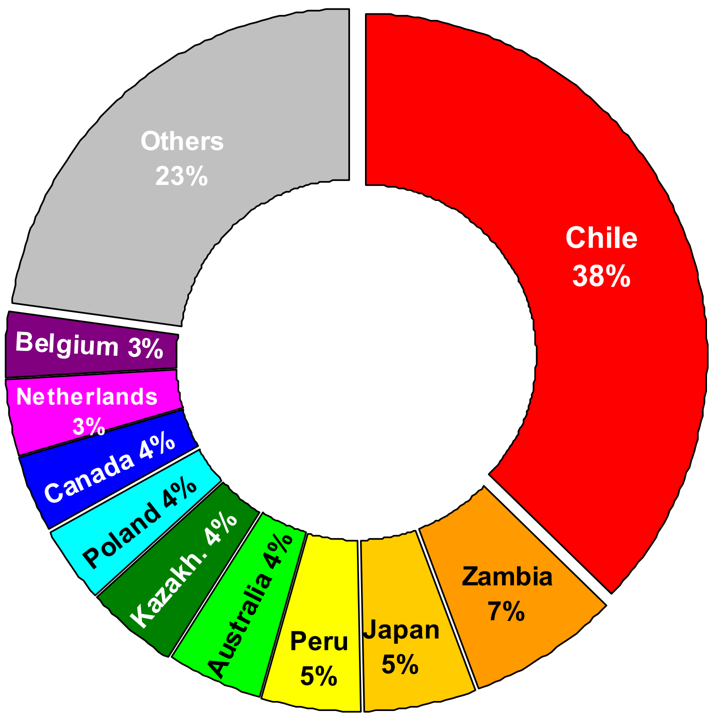
[1] Figure is intended to illustrate trade flows but not actual trade routes.

Leading Exporters and Importers of Refined Copper, 2008

Percentage and thousand metric tonnes

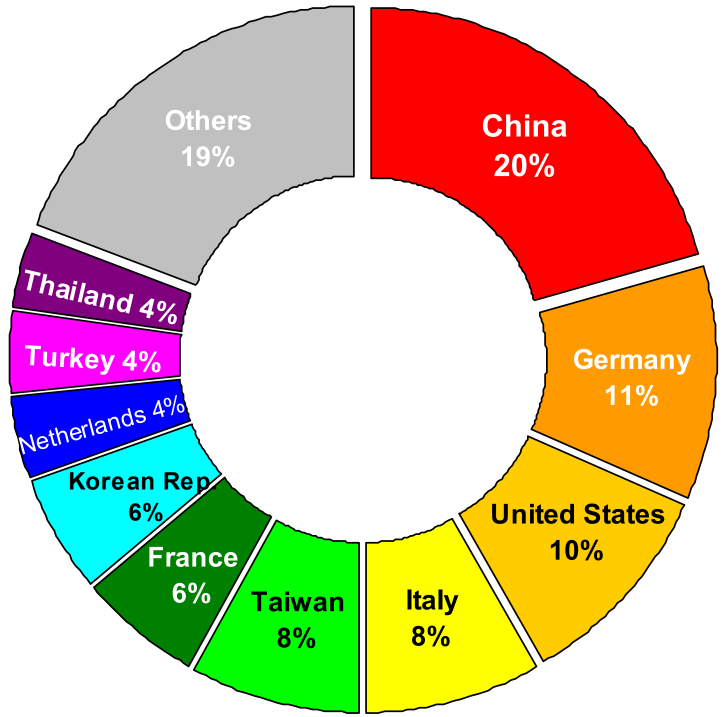
Source: ICSG

Exporters



World total: 8,037

Importers



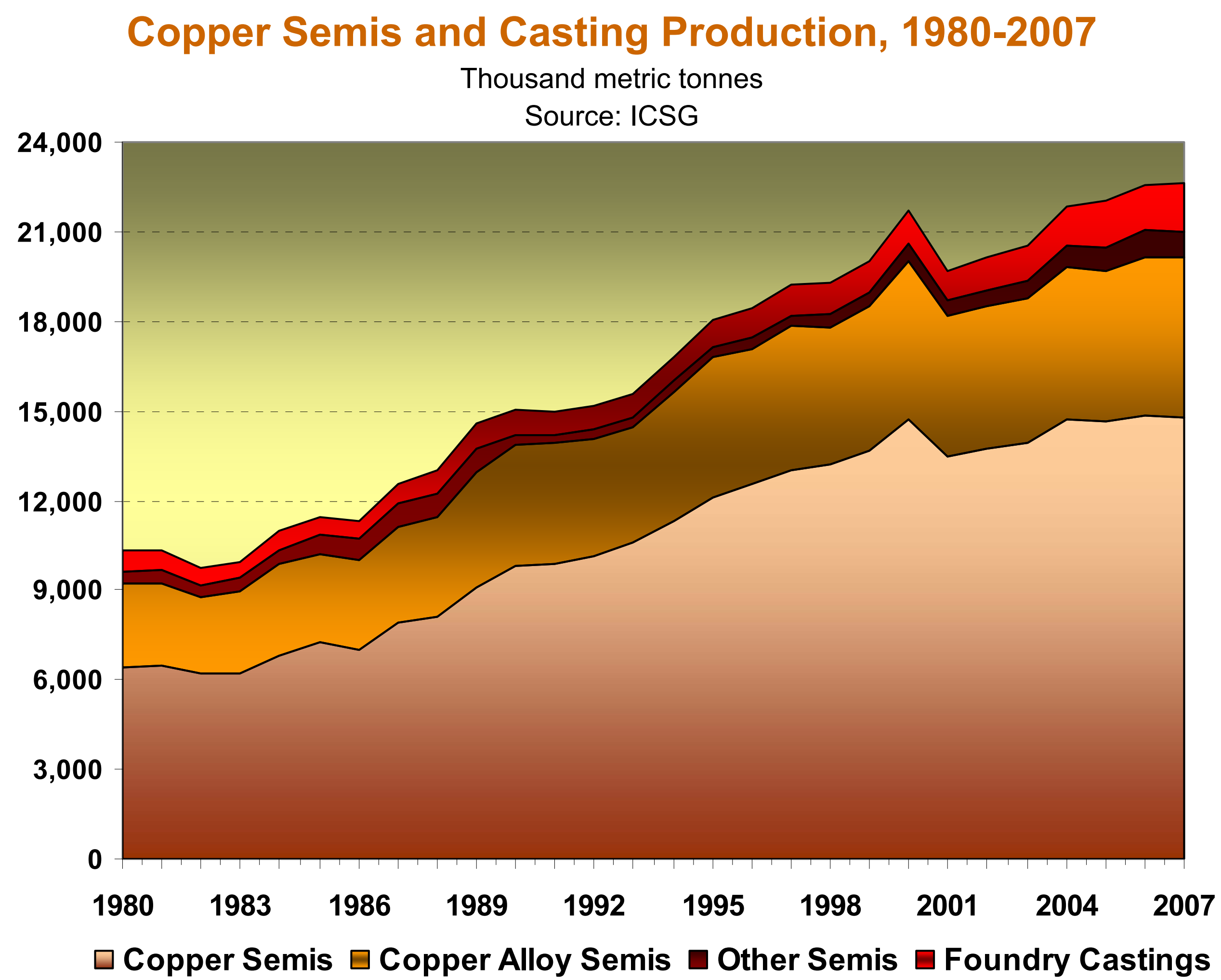
World total: 7,356

Top 20 Copper Refineries by Capacity, 2009

Thousand metric tonnes

Source: ICSG

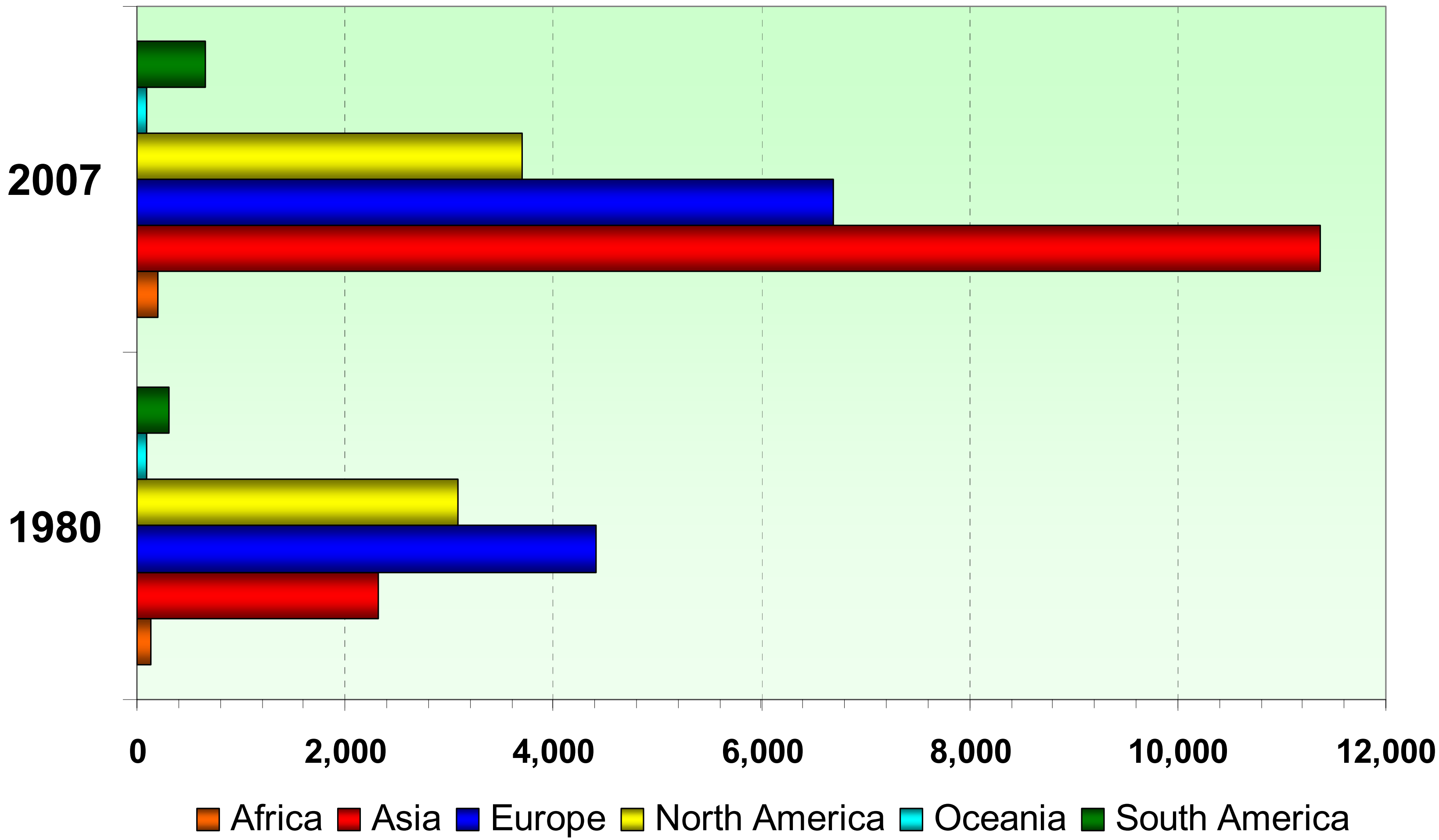
Rank	Refinery	Country	Owner(s)	Process	Capacity
1	Guixi	China	Jiangxi Copper Corporation	Electrolytic	900
2	Birla	India	Birla Group Hidalco	Electrolytic	500
3	Chuquicamata Refinery	Chile	Codelco	Electrolytic	490
4	Codelco Norte (SX-EW)	Chile	Codelco	Electrowinning	470
5	Toyo/Niihama (Besshi)	Japan	Sumitomo Metal Mining Co. Ltd.	Electrolytic	450
5	Amarillo	United States	Grupo Mexico	Electrolytic	450
6	El Paso (refinery)	United States	Freeport-McMoRan Copper & Gold Inc.	Electrolytic	415
7	Las Ventanas	Chile	Codelco	Electrolytic	400
8	Jinchuan	China	Jinchuan Non Ferrous Co.	Electrolytic	400
8	Morenci (SX-EW)	United States	Freeport-McMoRan Copper & Gold Inc./Sumitomo	Electrowinning	400
9	Hamburg (refinery)	Germany	Aurubis	Electrolytic	395
10	Pyshma Refinery	Russia	Uralelectromed (Urals Mining & Metallurgical Co.)	Electrolytic	390
11	CCR Refinery (Montreal)	Canada	Xstrata plc	Electrolytic	380
13	Escondida (SX-EW)	Chile	BHP Billiton (57.5%), Rio Tinto Corp. (30%), Japan Escondida (10%), IFC (2.5%)	Electrowinning	380
13	Sterlite Refinery	India	Vedanta	Electrolytic	380
14	Ilo Copper Refinery	Peru	Southern Copper Corp.	Electrolytic	360
15	Yunnan Copper	China	Yunnan Copper Industry Group (64.8%)	Electrolytic	350
17	Jinlong (Tongdu) (refinery)	China	Tongling NonFerrous Metal Corp. 52 %, Sharpline International 13%, Sumitomo Corp. 7.5%, Itochu Corp. 7.5%	Electrolytic	350
18	Olen	Belgium	Aurubis	Electrolytic	345
20	Onsan Refinery I	Korean Republic	LS-Nikko Co. (LS, Nippon Mining)	Electrolytic	330
20	Norilsk Refinery	Russia	Norilsk Copper	Electrolytic	330



Semis fabricators process refinery shapes such as cathodes, wire bar, ingot, billet slab and cake into semi-finished copper and copper alloy products using both unwrought copper materials and direct melt scrap as raw material feed. Semis fabricators are considered to be the "first users" of refined copper and include ingot makers, master alloy plants, wire rod plants, brass mills, alloy wire mills, foundries and foil mills.

Copper Semis and Casting Production by Region

Thousand metric tonnes
Source: ICSG

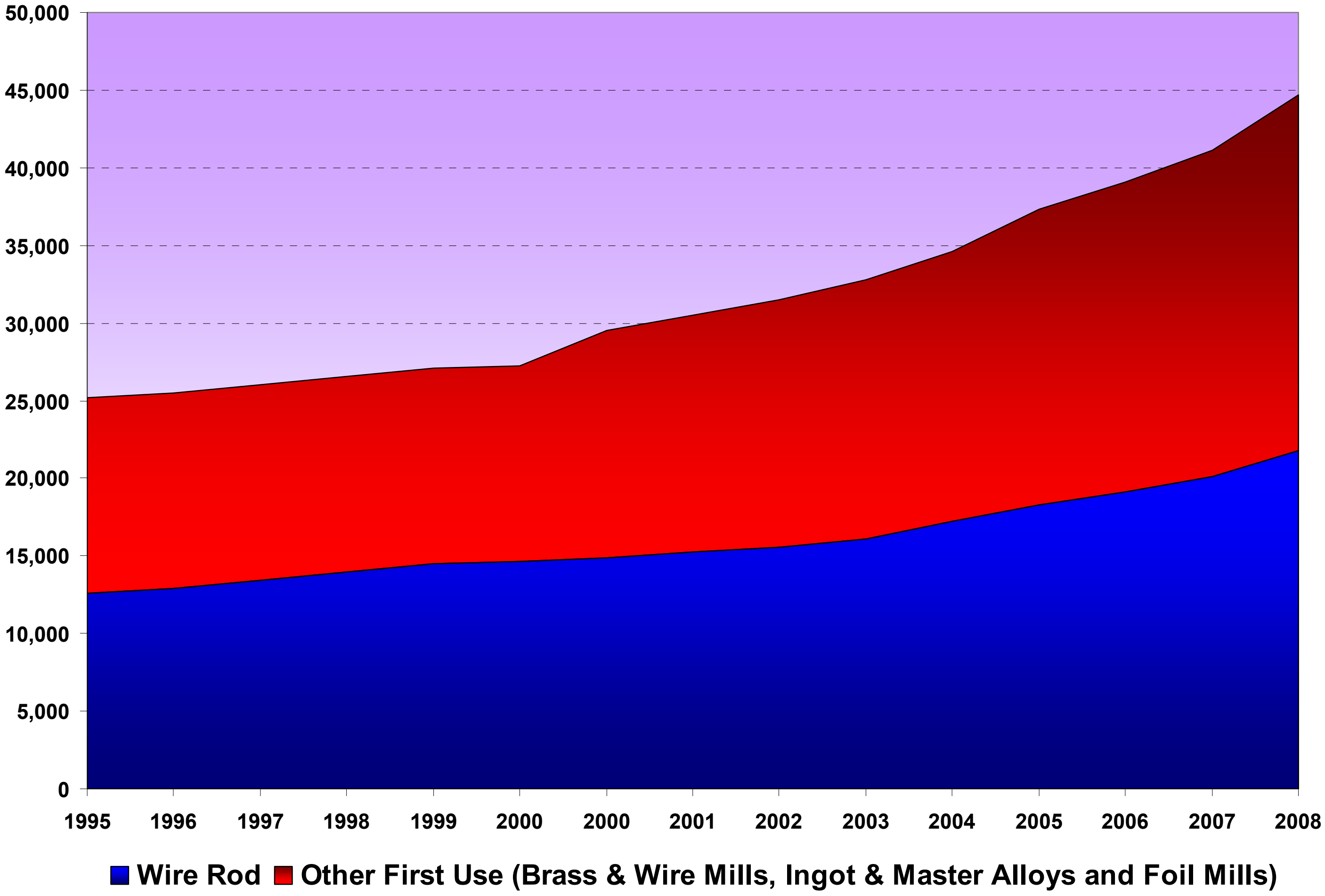


Asian countries accounted for 50% of semis production in 2007, or nearly 11.4 million metric tonnes, up from 22% in 1980.

Trends in First Use Capacity

Thousand metric tonnes

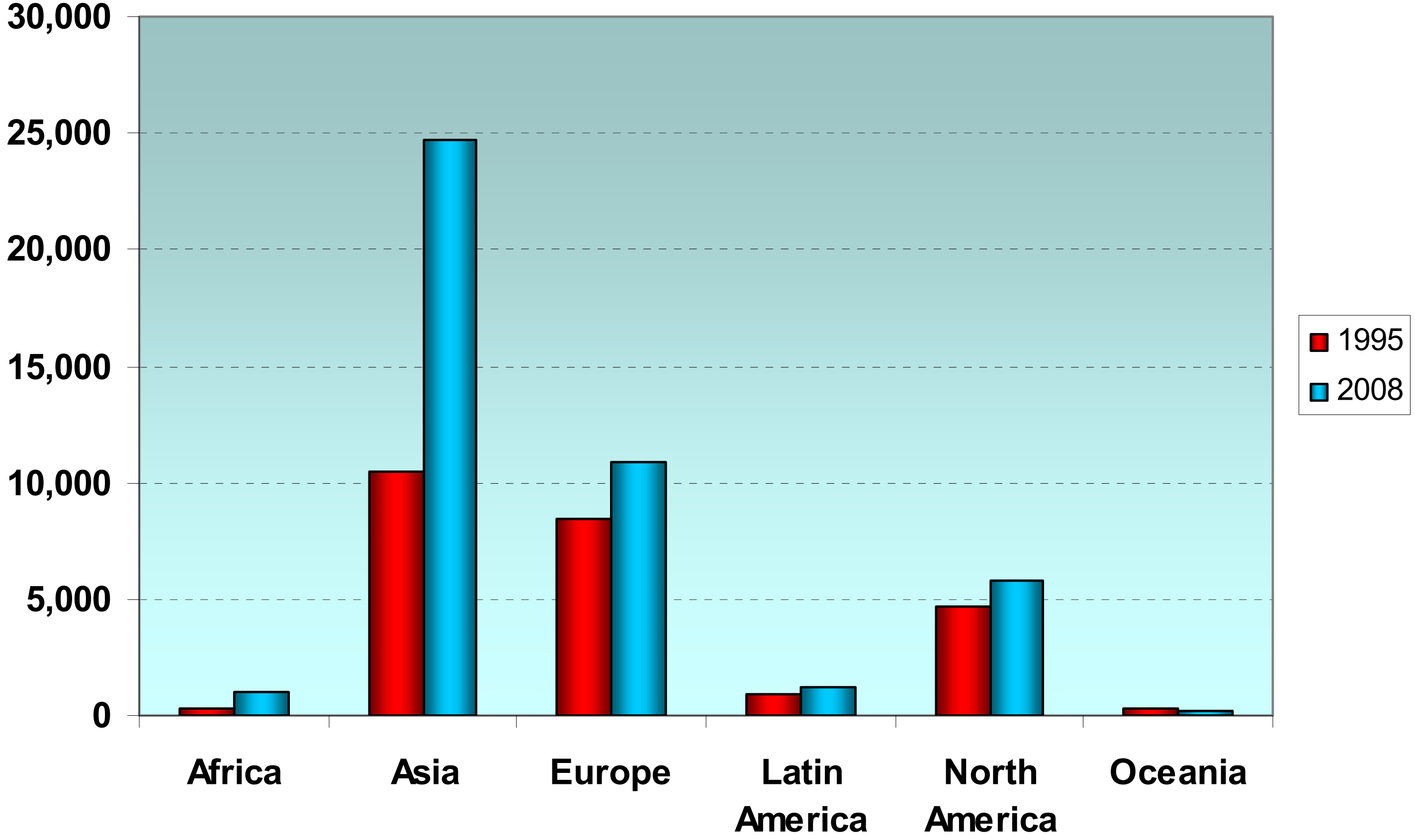
Source: ICSG



Wire rod plants are estimated to have accounted for just under half of all first use capacity in 2008.

First Use Capacity by Region

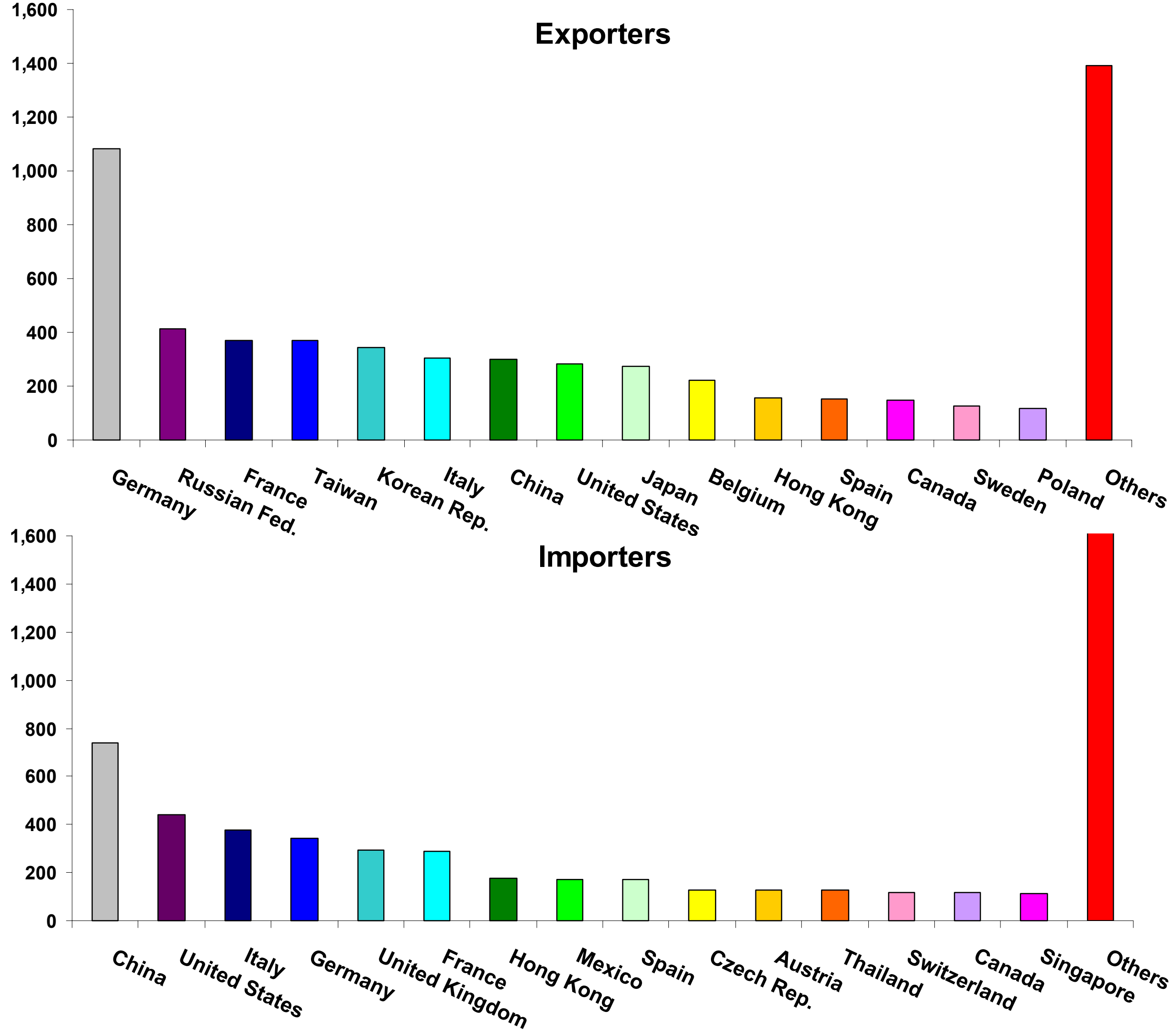
Thousand metric tonnes
Source: ICSG



First use capacity in Asia in 1995: just over 10,500 kt; in 2008: nearly 25,000 kt

Leadings Exporters and Importers of Semi-Fabricated Copper Products, 2008

Thousand metric tonnes, Source: ICSG



Top 20 Copper Fabricating Plants by Capacity, 2008

Thousand metric tonnes

Source: ICSG

Rank	Owners	Plant	Country	Plant Type	Capacity
1	Wieland Werke (Wieland Metals)	Vöhringen	Germany	Brass mill	360
2	Freeport McMoRan Copper & Gold Inc.	El Paso, TX	USA	Wire rod plant	355
2	Freeport McMoRan Copper & Gold Inc.	Norwich, CT	USA	Wire rod plant	355
4	Conticon (Condumex - Grupo Carso)	Celaya	Mexico	Wire rod plant	318
5	Southwire	Carollton, GA	USA	Wire rod plant	310
6	Jinagsu Jinhui Copper Group	Jinagsu Jinhui Copper Group	China	Wire rod plant	300
6	Nanjing Walsin Wire & Cable	Nanjing	China	Wire rod plant	300
6	SCCC - Societe de Coulee Continue de Cuivre (Nexans)	Chauny	France	Wire rod plant	300
6	Trafilierie Carlo Gnutti	Chiari, Brescia	Italy	Brass mill	300
10	Hitachi Wire Rod (Hitachi Cable 70%; Pan Pacific 20%)	Ibaraki-Ken	Japan	Wire rod plant	280
10	Cumerio (Aurubis)	Olen (Plant 1)	Belgium	Wire rod plant	280
12	Aurubis	Hamburg	Germany	Wire rod plant	275
13	Asarco (Grupo Mexico)	Amarillo, TX	USA	Wire rod plant	270
13	LS Cable	Gumi	Korea	Wire rod plant	270
15	Katur-Invest (Uralelektromed)	Verkhnaya Pyshma	Russia	Wire rod plant	265
16	Nexans Canada Inc. (Nexans 100%)	Montreal	Canada	Wire rod plant	260
17	Nanjin Walsin	Nanjin Walsin	China	Wire rod plant	250
17	Taihan Electric Wire	Anyang	Korea	Wire rod plant	250
19	Deutsche Giessdraht (Aurubis 60%, Codelco 40%)	Emmerich	Germany	Wire rod plant	250
19	MKM Mansfelder Kupfer & Messing (Kazakhmys)	Hettstedt	Germany	Brass mill	250

Chapter 5: The Commodity “Copper” in the Global Economy

Exchanges

Copper, as any other good or merchandise, is traded between producers and consumers. Producers sell their present or future production to clients, who transform the metal into shapes or alloys, so that downstream fabricators can transform these into different end-use products. One of the most important factors in trading a commodity such as copper is the settlement price for the present day (spot price) or for future days.

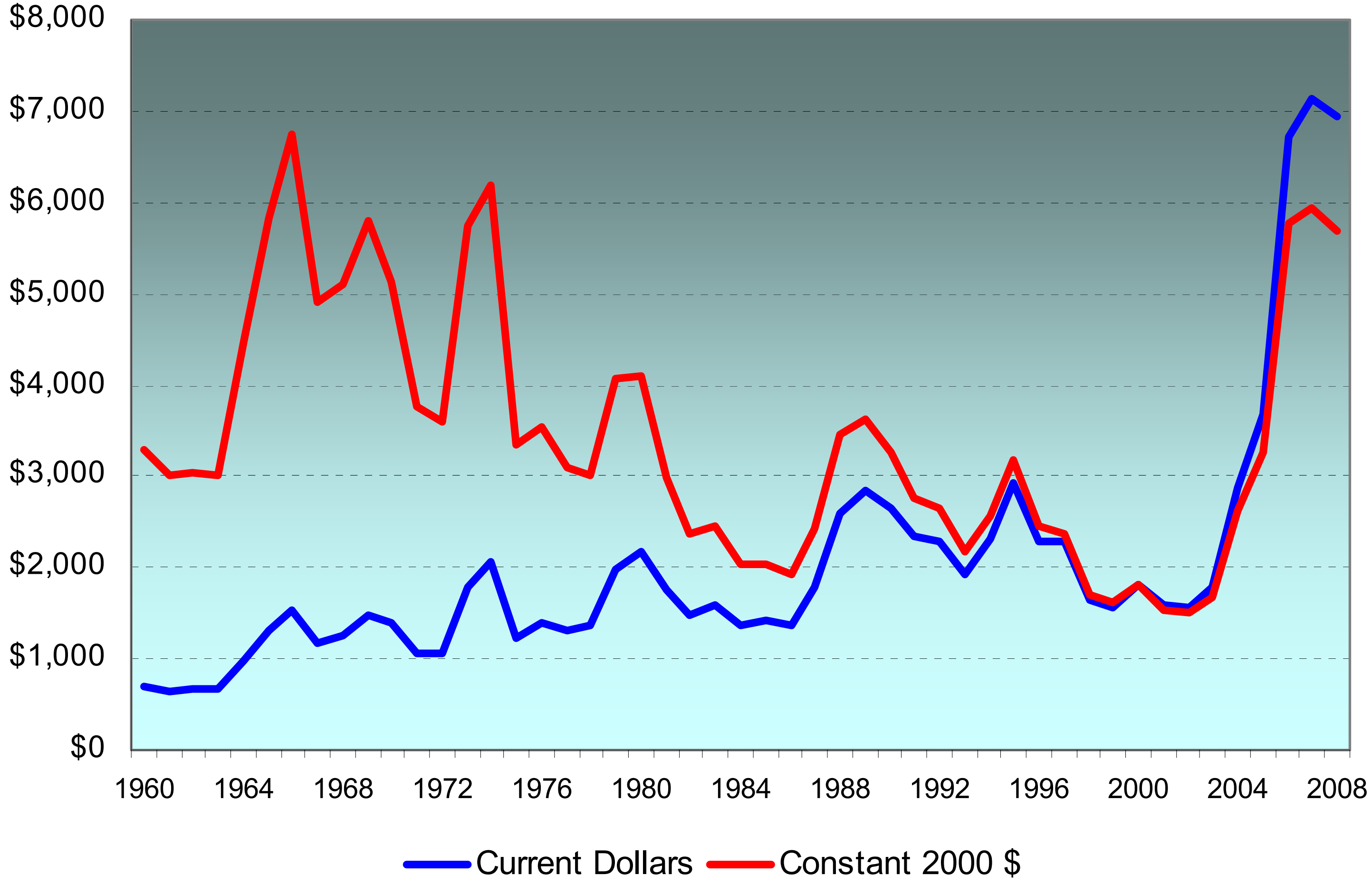
The role of a commodity exchange is to facilitate and make transparent the process of settling prices. Three commodity exchanges provide the facilities to trade copper: The London Metal Exchange (LME), the Commodity Exchange Division of the New York Mercantile Exchange (COMEX/NYMEX) and the Shanghai Metal Exchange (SHME). In these exchanges, prices are settled by bid and offer, reflecting the market's perception of supply and demand of a commodity on a particular day. On the LME, copper is traded in 25 tonne lots and quoted in US dollars per tonne; on COMEX, copper is traded in lots of 25,000 pounds and quoted in US cents per pound; and on the SHME, copper is traded in lots of 5 tonnes and quoted in Renminbi per tonne. More recently, mini contracts of smaller lots sizes have been introduced at the exchanges.

Exchanges also provide for the trading of futures and options contracts. These allow producers and consumers to fix a price in the future, thus providing a hedge against price variations. In this process the participation of speculators, who are ready to buy the risk of price variation in exchange for monetary reward, gives liquidity to the market. A futures or options contract defines the quality of the product, the size of the lot, delivery dates, delivery warehouses and other aspects related to the trading process. Contracts are unique for each exchange. The existence of futures contracts also allows producers and their clients to agree on different price settling schemes to accommodate different interests.

Exchanges also provide for warehousing facilities that enable market participants to make or take physical delivery of copper in accordance with each exchange's criteria.

Average Annual Copper Prices (LME, Grade A, Cash), 1960-2008

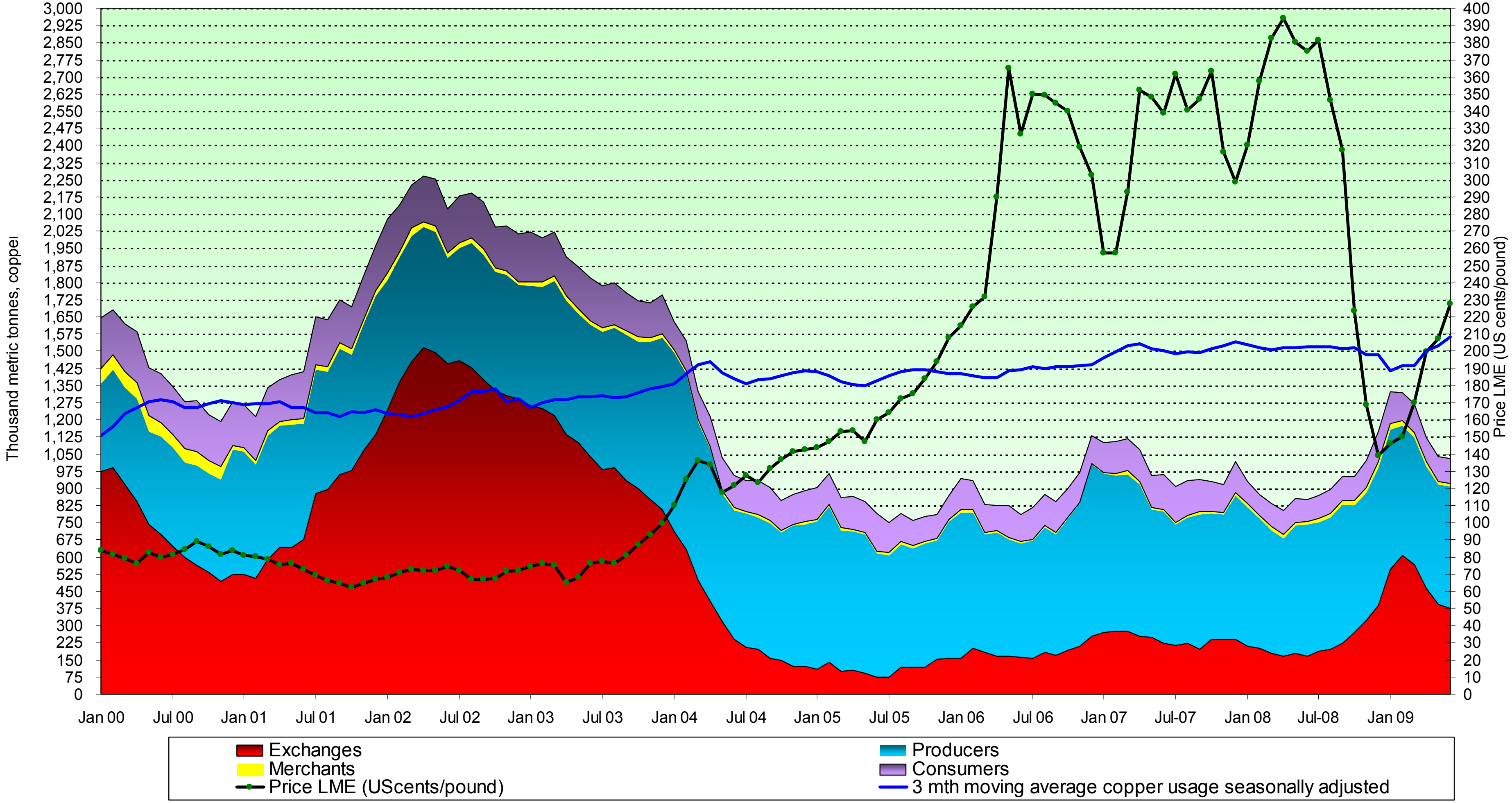
US$ per tonne
Source: ICSG



Copper Stocks, Prices and Usage

Thousand metric tonnes copper and US cents/pound

Source: ICSG



ANNEX

World Copper Production and Usage, 1960-2008

Thousand Metric Tonnes

Source: ICSG

	Mine Production	Refined Production	Refined Usage
1960	3,924	4,998	4,738
1961	4,081	5,127	5,050
1962	4,216	5,296	5,048
1963	4,286	5,400	5,500
1964	4,443	5,739	5,995
1965	4,647	6,059	6,193
1966	4,626	6,004	6,445
1967	4,872	6,324	6,195
1968	5,010	6,653	6,523
1969	5,941	7,404	7,137
1970	5,562	7,212	7,291
1971	5,900	7,592	7,296
1972	6,541	8,100	7,942
1973	6,735	8,187	8,740
1974	6,915	8,544	8,310
1975	7,289	8,632	7,445
1976	7,097	8,759	8,539
1977	7,444	8,884	9,057
1978	7,306	9,030	9,527
1979	7,371	9,200	9,848
1980	7,230	9,261	9,396
1981	7,745	9,319	9,522
1982	7,721	9,573	9,090
1983	7,843	9,541	9,510
1984	8,138	9,440	9,930
1985	8,288	9,455	9,798
1986	8,266	9,920	10,112
1987	8,592	10,148	10,293
1988	8,775	10,512	10,668
1989	9,372	10,687	11,081
1990	9,226	10,804	10,886
1991	9,084	10,908	10,565
1992	9,497	11,045	10,761
1993	9,549	11,124	10,981
1994	9,553	11,239	11,420
1995	10,084	11,832	12,059
1996	11,097	12,677	12,636
1997	11,537	13,478	13,098
1998	12,248	14,075	13,511
1999	12,775	14,578	14,294
2000	13,203	14,796	15,138
2001	13,757	15,273	14,946
2002	13,577	15,354	15,231
2003	13,633	15,638	15,716
2004	14,594	15,928	16,839
2005	14,924	16,573	16,673
2006	14,990	17,295	17,043
2007	15,463	17,944	18,168
2008p	15,388	18,232	18,006

International Copper Study Group

Rua Almirante Barroso 38 – 6th

1000-013 Lisbon, Portugal

Tel: +351-21-351-3870 Fax: +351-21-352-4035

e-mail: mail@icsg.org

Web site: www.icsg.org