# THE WORLD COPPER FACTBOOK 2020

INTERNATIONAL COPPER STUDY GROUP

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# 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.

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

- 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.
- 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.

The current members of ICSG are:

| | |
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| DR Congo | Poland |
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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.

## ICSG Officers and Secretariat

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**Acknowledgements and Copyright:**

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## ICSG Publications

- **COPPER BULLETIN (monthly).** The ICSG Copper Bulletin includes annual and monthly statistics on copper and copper products, their production, usage and trade by country, as well as stocks and exchange prices, providing a global view of supply and demand. Subscribers to the Copper Bulletin receive the Yearbook as part of their annual subscription.
- **ICSG STATISTICAL YEARBOOK.** The ICSG Copper Bulletin yearbook includes annual statistics on copper and copper products, their production, usage and trade by country, as well as stocks and exchange prices, providing a global view of supply and demand for the past 10 years. The Yearbook serves as a useful tool for consultations and analysis on the longer term evolution of world copper production, usage, stocks and prices. Subscribers to the Copper Bulletin receive the Yearbook as part of their annual subscription.
- **DIRECTORY OF COPPER MINES AND PLANTS.** The Directory of Copper Mines and Plants highlights current capacity and provides a five year outlook of forecasted capacity for over 1,000 existing and planned copper mines, smelters and refineries on a country by country basis, including separate tables for SX-EW plants. Salient data and information for each mine, smelter and refinery are included and the Directory separates operations between Operating, Developing, Feasibility and Exploration stages. The Directory is published twice per year.
- **ICSG STATISTICAL DATABASE.** The ICSG maintains one of the world's most complete historical and current databases with statistics on copper production capacities, data on copper production, consumption, stocks, prices, recycling and trade for copper products. In 2012 ICSG launched its **online statistical database** that gives subscribers direct access to ICSG historical data. It also provides subscribers with specific extraction tools for downloading the data.
- **DIRECTORY OF COPPER & COPPER ALLOY FABRICATORS (FIRST USE).** This directory provides a global overview of companies and plants involved in the first use of copper.

- **EUROPEAN SEMI MANUFACTURED COPPER PRODUCTS CAPACITY (2019).** A study focusing on providing a complete picture of fabrication and copper use in Europe.
- **SOLID WASTES IN COPPER, LEAD, ZINC AND NICKEL MINING, SMELTING AND REFINING (2019).** The study examines mine, smelter and refinery solid wastes and assesses a range of issues related to these wastes.
- **SMELTING AND HYDROMETALLURGY TREATMENT FOR COPPER SULPHIDE ORES AND CONCENTRATES (2019).** This study focuses on key issues related to plants processing copper sulphide ores and concentrates of different complexity.
- **COPPER USE IN FABRICATION IN JAPAN, KOREA, TAIWAN (CHINA) AND VIETNAM (2018).** A study focusing on providing a complete picture of fabrication and copper use in the Japan, Korea, Taiwan and Vietnam.
- **INDUSTRIAL USE OF REFINED COPPER AND SCRAP IN FABRICATION IN CHINA (2017).** A study focusing on providing a complete picture of fabrication and copper use in China.
- **MANUFACTURE AND USE OF SEMI-FABRICATED COPPER IN LATIN AMERICA/CANADA (2017).** A study focusing on providing a complete picture of fabrication and copper use in Latin America and Canada.
- **CHINA COPPER MINING INDUSTRY.** A study focusing on providing a complete picture of the copper mining industry in China.

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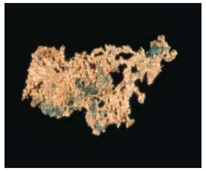
# Chapter 1: Cu Basics

## What is Copper?



Copper is a malleable and ductile metallic element that is an excellent conductor of heat and electricity as well as being corrosion resistant and antimicrobial. Copper occurs naturally in the Earth’s crust in a variety of forms. It can be found in sulfide deposits (as chalcopyrite, bornite, chalcocite, covellite), in carbonate deposits (as azurite and malachite), in silicate deposits (as chrysycolla and dioptase) and as pure "native" copper.

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.

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.

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.

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

Images courtesy of the Copper Development Association.

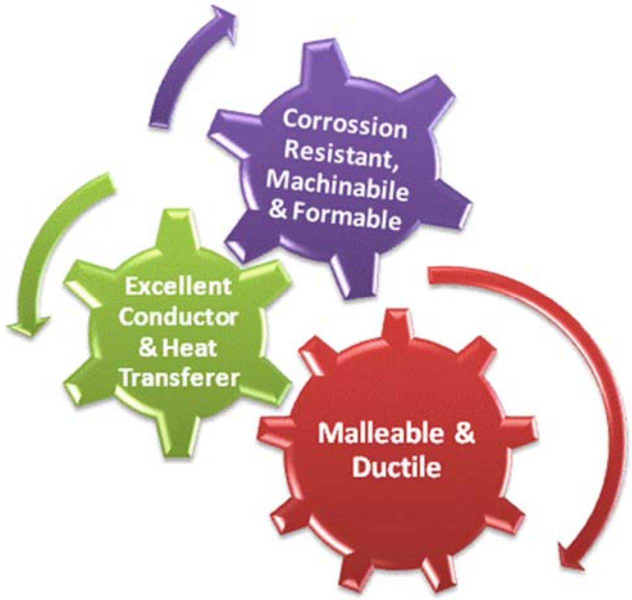
# Copper Properties and Benefits

| | |
|---|---|
| **Chemical Symbol** | **Cu** |
| **Atomic Number** | **29** |
| **Atomic Weight** | **63.54** |
| **Density** | **8960 kg $m^{-3}$** |
| **Melting point** | **1356 K** |
| **Specific Heat cp (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 109 N m-2** |
| **Electrical Conductivity (% IACS)** | **1.673 x $10^{-8}$ ohm-m** |
| **Crystal Structure** | **Face-Centered Cubic** |

Copper makes vital contributions to sustaining and improving society. Copper's chemical, physical and aesthetic properties make it a material of choice in a wide range of domestic, industrial and high technology applications.

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.

## Key Physical Properties of Copper




But copper's benefits extend beyond mechanical characteristics:

- Copper is **essential to the health** of plants, animal and humans. Deficiencies, as well as excesses, can be detrimental to health.
- **Antimicrobial Properties**. Due to copper's antimicrobial properties, copper and copper alloy products can be used to eliminate pathogens and reduce the spread of diseases.
- **Recycling**. Copper is one of the most recycled of all metals. Virtually all products made from copper can be recycled and recycled copper loses none of its chemical or physical properties.
- **Energy Efficiency**. Copper can improve the efficiency of energy production and distribution systems.

# Selected Copper Definitions

- **Anode.** The positive terminal in an electrolytic cell where electrons leave a device to enter the external circuit. A copper anode at 99 percent purity will dissolve.
- **Blister.** The product of a converting furnace. It is an intermediate, more concentrated (with respect to the desired metal) material than matte, from which it is made, and is usually transferred to another furnace for further concentration.
- **Cathode.** The negative terminal in an electrolytic cell where copper is plated during electrowinning or electrolytic refining. Copper so plated is referred to as "cathode" and is generally about 99.99 percent pure.
- **Contained Copper.** Contained copper is defined as the analytical amount of copper outputted in concentrates and precipitates.
- **Copper concentrate.** A product of flotation milling. It composes sulfide minerals and entrained material and contains one-third each copper, iron, and sulfur. It can be processed pyrometallurgically in a smelter to produce matte or hydrometallurgically (pressure leaching) to produce pregnant leach solution, both products requiring further processing to obtain copper metal.
- **Direct melt scrap.** Direct-melt, or re-melt scrap is secondary material that can be used directly in a furnace without cleanup through the use of fluxes and poling and re-refining.
- **Electrorefining.** An electrolytic refining process where less pure copper anode is dissolved and high-purity copper is plated at the cathode.
- **Electrowinning.** An electrolytic refining process where the anode is inert, and rich (copper-loaded) electrolyte continually replaces lean (copper-depleted) electrolyte as copper is plated at the cathode.
- **Fire-refined copper.** The product of a fire-refining furnace. It is an intermediate, more concentrated (with respect to the desired metal) material than blister, from which it is made. Fire-refined copper contains about 99 percent copper, the exact percentage depending on the process parameters.
- **Primary copper.** Copper extracted from ores and recovered as copper metal or copper-bearing chemicals.
- **Secondary refined material**. Secondary refined material represents scrap that has been fire-refined, or that has been converted to anode at the smelter level and then electrolytically refined.
- **Solvent extraction**. A method of separating one or more metals from a leach solution by treating with a solvent that will extract the required metal, leaving the others. The metal is recovered from the solvent by further treatment.
- **Stocks.** ICSG reports refined copper stocks as those held by the exchanges, consumers, producers and governments. Merchant stocks are included where it is certain that these are nonduplicative to those already reported. Only refined products at plant sites are included. Items such as wire rod, tube and other semifabricated forms are not included.
- **Usage.** Copper usage represents refined copper used by semifabricators. Usage data is either directly reported, or ICSG estimates an **apparent usage** using the following formula: Refined copper production + refined imports - refined exports + refined beginning stocks - ending stocks.

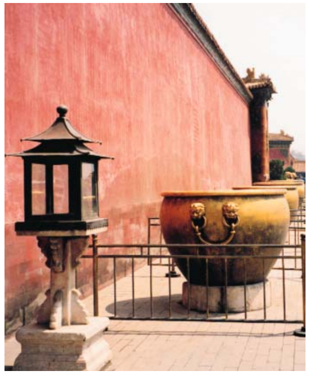
Sources: ICSG and USGS.

# Copper in History

Archaeological evidence demonstrates that copper was one of the first metals used by humans and was used at least 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.

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.

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. Although copper has been in use for at least 10,000 years, innovative applications for copper are still being developed as evidenced by the development of the copper chip by the semi-conductors industry.



Images courtesy of the British Museum, the Copper Development Association and ICSG.

# Copper Today

The global demand for copper continues to grow: world refined usage has more than tripled in the last 50 years thanks to expanding sectors such as electrical and electronic products, building construction, industrial machinery and equipment, transportation equipment, and consumer and general products. Some of the highlights of 2019 copper production and usage are listed below. In the chapters that follow, more in-depth information is presented on copper production, trade, usage, and recycling. For the most up-to-date information on the global copper market, please visit our website at www.icsg.org.

## Copper Production Highlights

Preliminary figures indicate that global **copper mine production** in 2019 reached 20.5 million tonnes. The largest producer of mined copper was **Chile** (5.8 million tonnes).

**Smelter production** in 2019 reached around 20.0 million tonnes. **China** was the largest producer of blister & anode in 2019

**Refinery Production** in 2019 increased to 24.0 million tonnes, including 4.1 million tonnes of secondary refined production. China was the largest producer.

## Copper Usage Highlights

**Refined copper usage** (usage by semis plants or the first users of copper) in 2019 reached 24.4 million tonnes. **China** was also the largest consumer of refined copper in 2019 with apparent usage of around 12.7 million tonnes.

According to the International Copper Association (ICA), equipment was the largest copper end-use sector in 2019, followed by building construction and infrastructure.

**New copper applications** being developed include antimicrobial copper touch surfaces, lead-free brass plumbing, high tech copper wire, heat exchangers, and new consumer products as well.

Images courtesy of CDA and Luis Hernán Herreros from www.visnu.cl, © Copyright Anglo American (Faena Los Bronces y Mantos Blancos – Chile)

# Chapter 2: Copper Resources and Long-Term Availability of Copper

## Copper Reserves and Resources

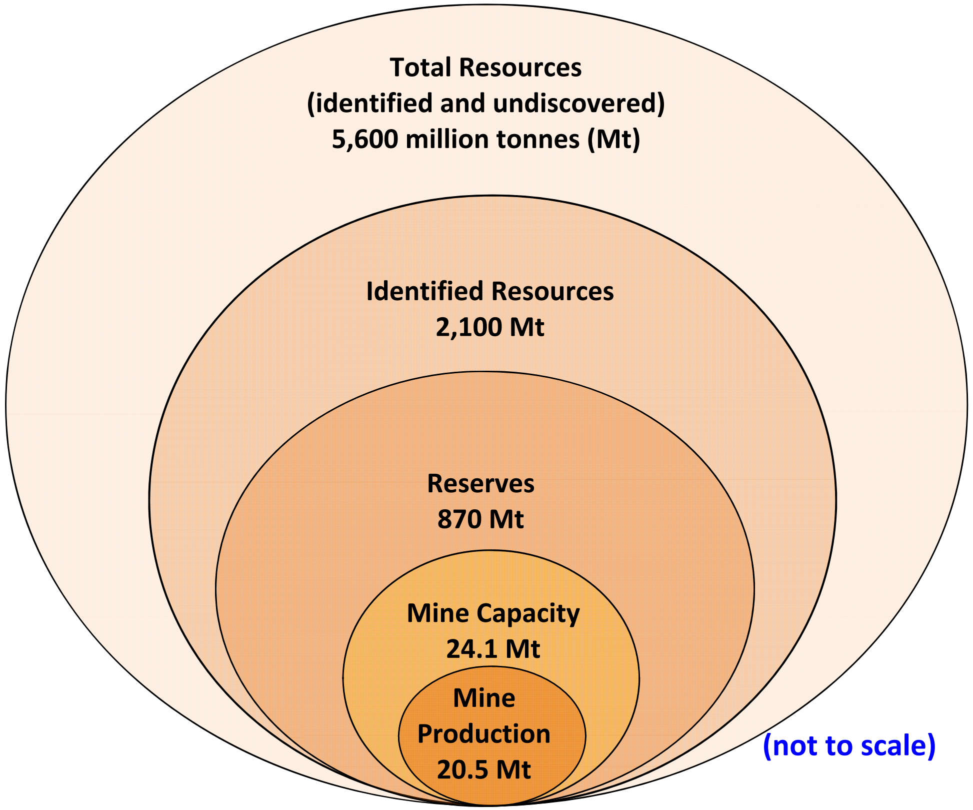
Typically, the future availability of minerals is based on the concept of reserves and resources. Reserves are deposits that have been discovered, evaluated and assessed to be economically profitable to mine. Resources are far bigger and include reserves, discovered deposits that are potentially profitable, and undiscovered deposits that are predicted based on preliminary geological surveys (see definitions below).

According to the United States Geological Survey (USGS), copper reserves currently amount to around 870 million tonnes (Mt). Identified and undiscovered copper resources are estimated at around 2,100 Mt and 3,500 Mt, respectively (USGS basis 2013, see next page). The latter does not take into account the vast amounts of copper found in deep sea nodules and land-based and submarine massive sulphides. Current and future exploration opportunities will lead to increases in both reserves and known resources.

**Definitions (http://minerals.usgs.gov/minerals/pubs/mcs/2014/mcsapp2014.pdf)**
**Resource:** A concentration of naturally occurring solid, liquid, or gaseous material in or on the Earth's crust in such form and amount that economic extraction of a commodity from the concentration is currently or potentially feasible.
**Identified Resources:** Resources whose location, grade, quality, and quantity are known or estimated from specific geologic evidence. Identified resources include economic, marginally economic, and sub-economic components.
**Undiscovered Resources:** Resources, the existence of which are only postulated, comprising deposits that are separate from identified resources. Undiscovered resources may be postulated in deposits of such grade and physical location as to render them economic, marginally economic, or sub-economic.
**Reserves:** That part of the reserve base (part of an identified resource that meets specified minimum physical and chemical criteria related to current mining and production practices, including those for grade, quality, thickness, and depth) which could be economically extracted or produced at the time of determination. The term reserves need not signify that extraction facilities are in place and operative.

### 2019 World Copper Reserves & Mine Production 1/

(undiscovered resources not including deep sea nodules and land-based and submarine massive sulfides - contained copper)

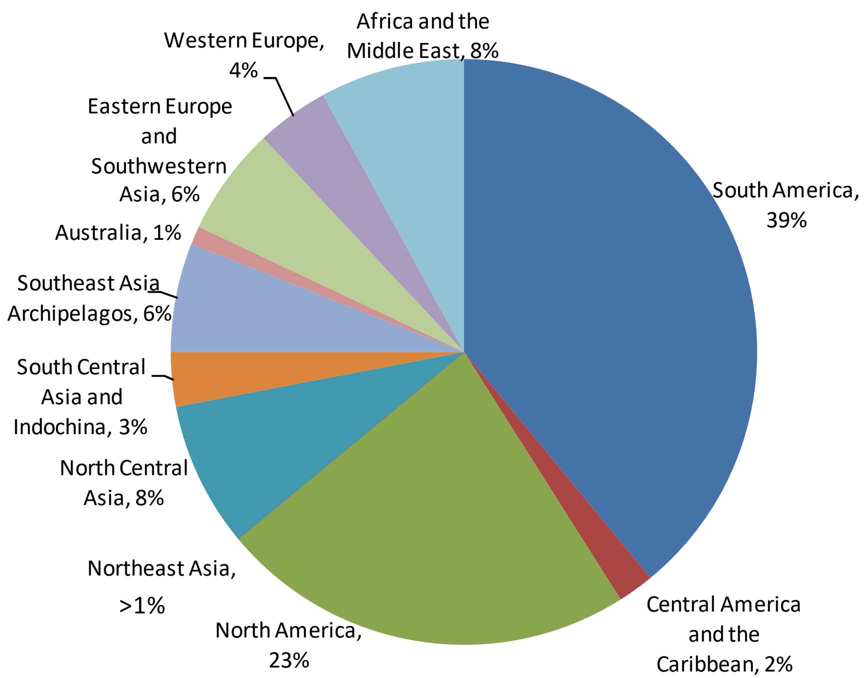



1/ Source: USGS (resources/reserves data) and ICSG (capacity/production data)

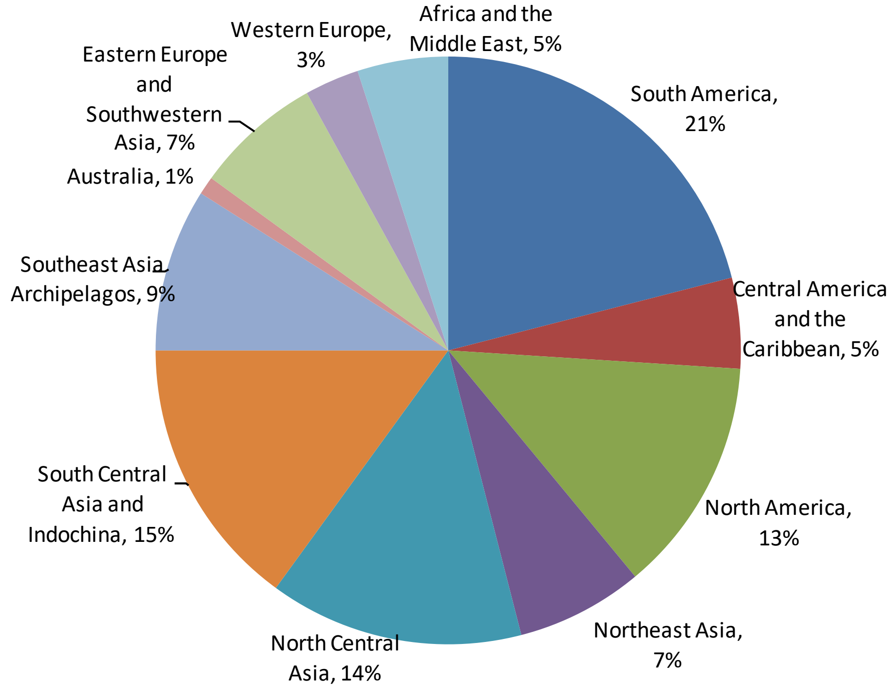
## Global Distribution of Identified and Undiscovered Copper Resources in Porphyry and Sediment-hosted Stratabound Copper Deposits [1/]

In 2013 the U.S. Geological Survey (USGS) completed a geology-based, cooperative international assessment of copper resources of the world [2/]. The USGS assessed undiscovered copper in two deposit types that account for about 80% of the world's copper supply. Porphyry copper deposits account for about 60% of the world's copper. In porphyry copper deposits, copper ore minerals are disseminated in igneous intrusions. Sediment-hosted stratabound copper deposits, in which copper is concentrated in layers in sedimentary rocks, account for about 20% of the world's identified copper. The mean undiscovered totals for porphyry and sediment-hosted deposits are 3,100 and 400 Mt respectively, resulting in a global total of 3,500 Mt of copper. With identified copper resources currently estimated at 2,100 Mt, total copper resources (undiscovered + identified) are estimated at 5,600 Mt.

**A. Identified Copper Resources**




**B. Undiscovered Copper Resources**

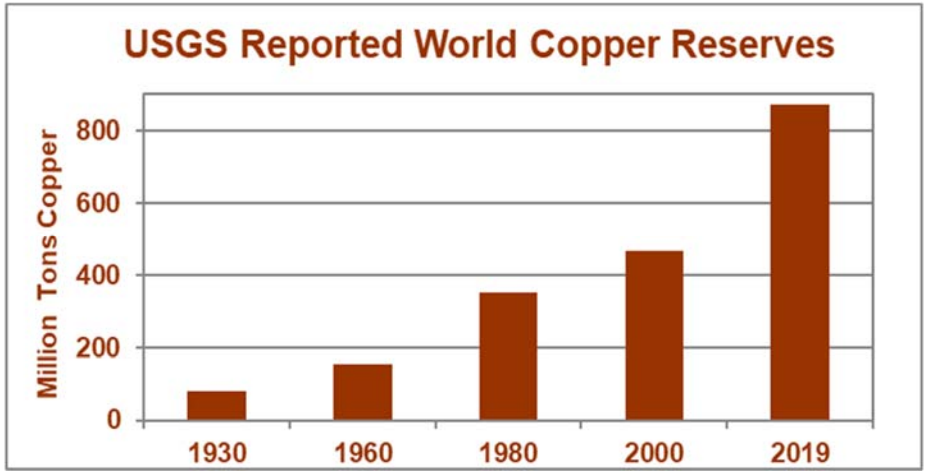



1/ Undiscovered Copper Resources - A Global Assessment, April 2014, Presentation at ICSG meeting, Lisbon, by Mrs *Jane M. Hammarstrom (USGS Global Mineral Resource Assessment Team)*
2/ Supporting studies, including documentation of the assessment methodology and descriptions of individual tracts, are available on the USGS Mineral Resources Program Web site, at https://www.usgs.gov/energy-and-minerals/mineral-resources-program/science/global-mineral-resource-assessments?qt-science_center_objects=0#qt-science_center_objects

## Are We Going to Run Out of Copper[1]?

**It is highly improbable**. Since 1960, there has always been, on average, 38 years of reserves, and significantly greater amounts of known resources (USGS data). In addition, recycling, innovation and mining exploration continue to contribute to the long-term availability of copper.

Despite increased demand for copper produced from ore in recent years, increases in reserves have grown, and there is more identified copper available to the world than at any other time in history.




In the period 2009-2019, 202 million tonnes of copper have been mined. In that same period however, reserves have grown by 330 million tonnes. This reflects additional exploration, technological advances and the evolving economics of mining.

Technology has a key role to play in addressing many of the challenges faced by new copper production. Known and as yet unknown innovations will ensure new mine production continues to provide vital copper supplies.

In addition copper recycling plays an important role in copper availability since today's primary copper is tomorrow's recycled material. Unlike other commodities such as energy or food, copper is not "consumed". Copper is one of the few raw materials which can be recycled repeatedly without any loss of performance, and key stakeholders such as policy-makers, scrap collectors, copper producers and recyclers must all focus on ensuring that yesterday's metal is recycled and re-used.

While this will ensure a progressive move towards a more sustainable economy, the loop cannot be completely closed for two reasons. Firstly, demand will continue to increase due to population growth, product innovation and economic development. Secondly in most applications, copper stays in use for decades.

Consequently, meeting future metals demand will continue to require a combination of primary raw materials, coming from mines, as well as recycled materials, while innovative policies and technology should continue to contribute to improvements in recycling performance and resource efficiency.

Based on the latest knowledge on geological availability and continuous industry innovation there are good reasons to believe that copper will continue to be a vital and positive contributor to society well into the future.

1/ Based on the International Copper Association briefing note on copper's long-term availability. See http://copperalliance.org/about-copper/long-term-availability/

# Chapter 3: Copper Production

## How is Copper Produced?

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.

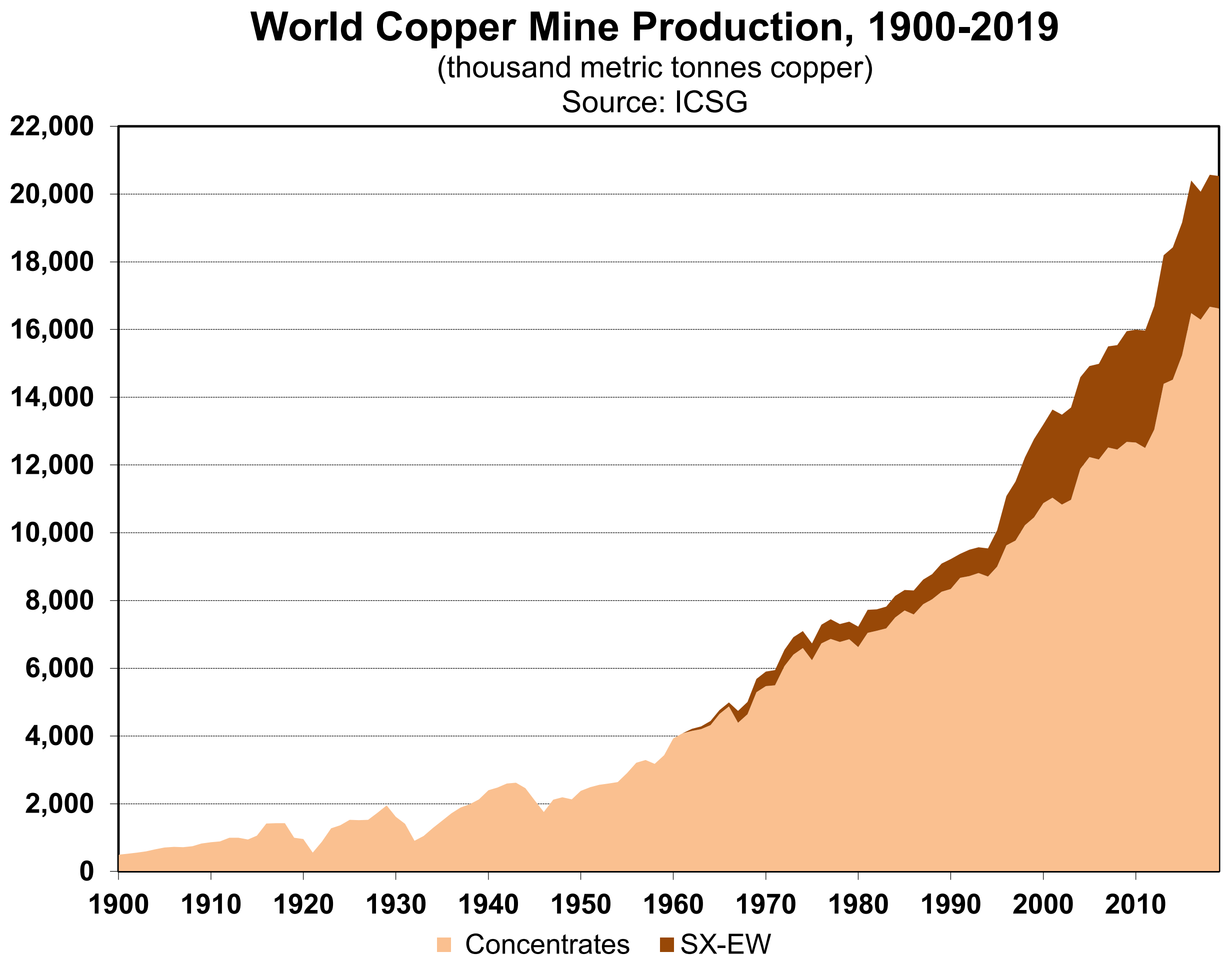
After the ore has been mined, it is crushed and ground followed by a concentration by flotation. The obtained copper concentrates typically contain around 30% of copper, but grades can range from 20 to 40 per cent. In the following smelting process, sometimes preceded by a roasting step, copper is transformed 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 2019, refined copper production from SX-EW represented around 16% 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 employed for primary production. ICSG estimates that in 2019, at the refinery level, secondary copper refined production reached 17% of total copper refined production.

# Copper Mine Production

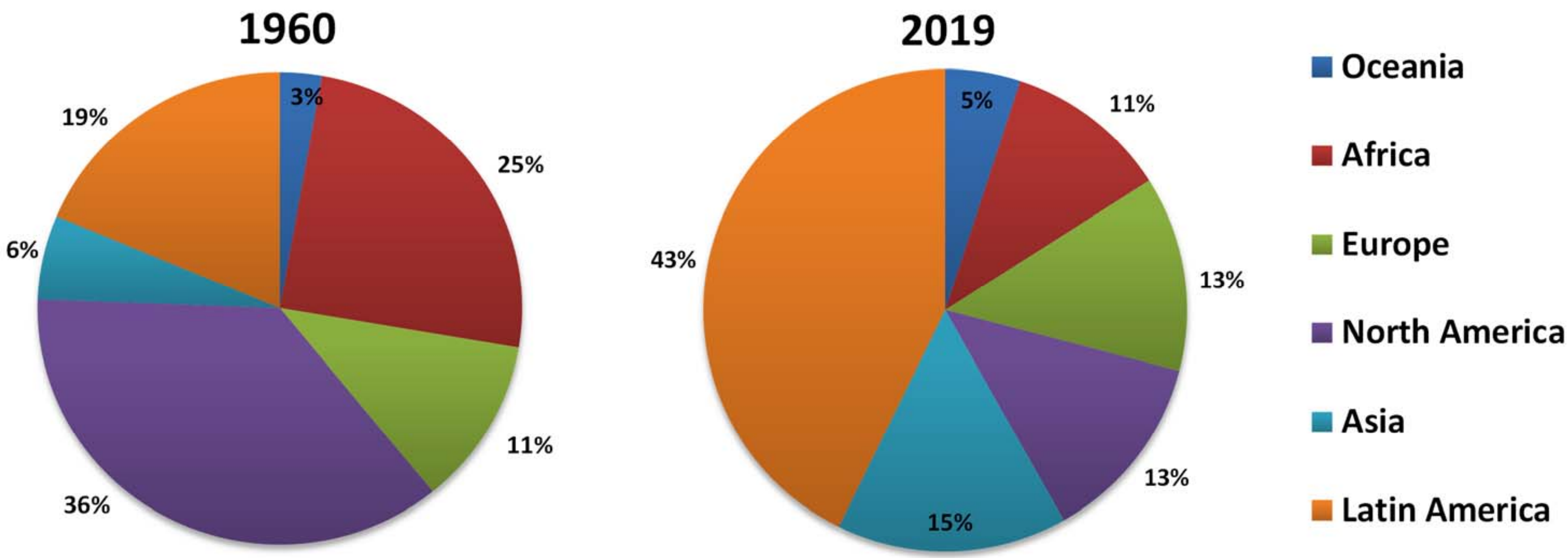



**Since 1900, when world production was less than 500 thousand tonnes copper, world copper mine production has grown by 3.2% per annum to 20.5 million tonnes in 2019. SX-EW production, virtually non-existent before the 1960s, stood at 3.9 million tonnes in 2019.**

## Copper Mine Production by Region, 1960 versus 2019

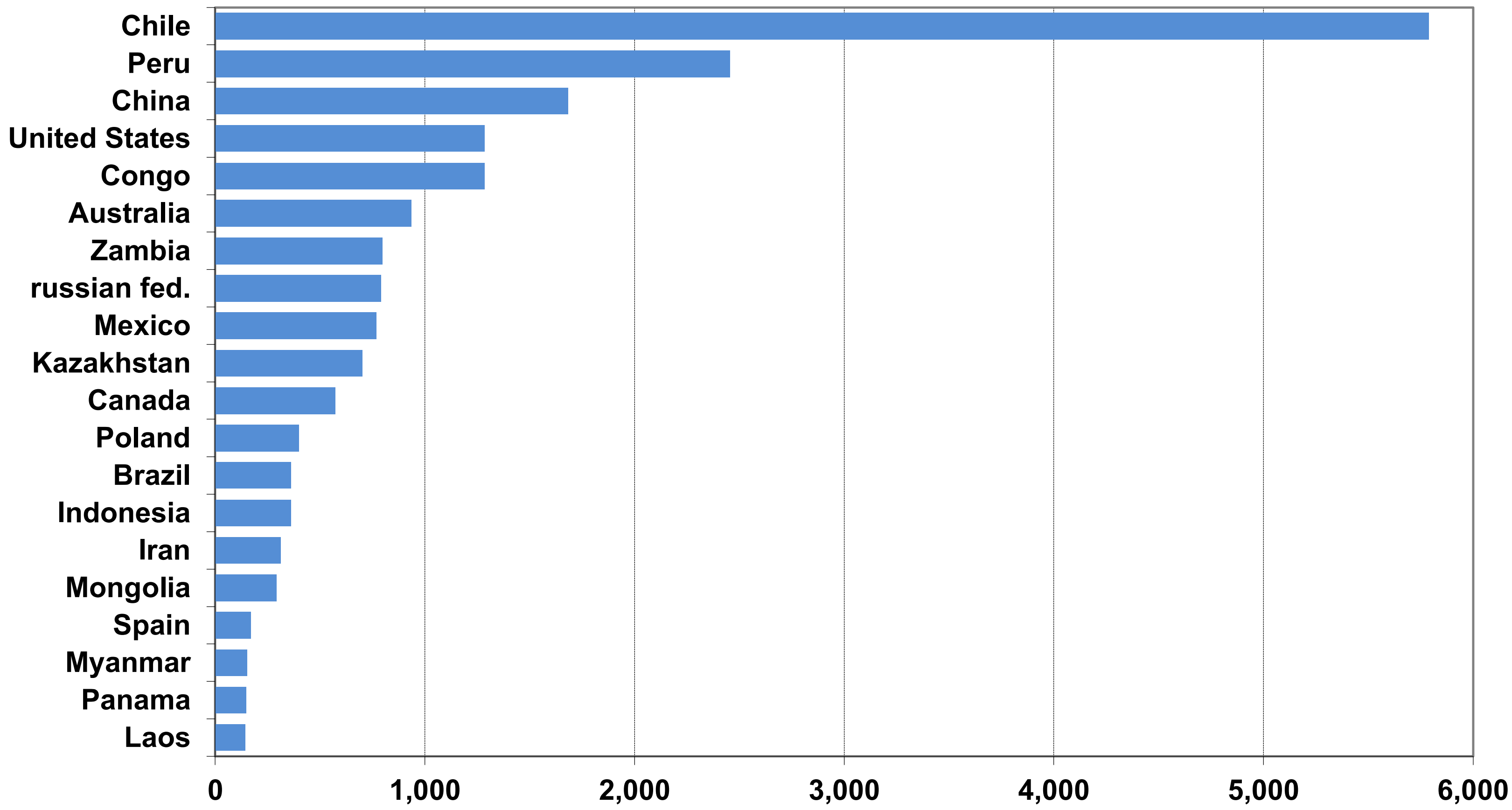
Thousand metric tonnes copper

Source: ICSG




**From less than 750,000 tonnes copper in 1960, copper mine production in Latin America has increased to 8.8 million tonnes in 2019, representing 43% of the global total. Asia has also exhibited significant growth. The region's share of global production has increased from just 6% to 15% over the respective period. Conversely, North America's share declined from 36% to 13%.**

## Copper Mine Production by Country: Top 20 Countries in 2019
**(Thousand metric tonnes copper)**
**Source: ICSG**

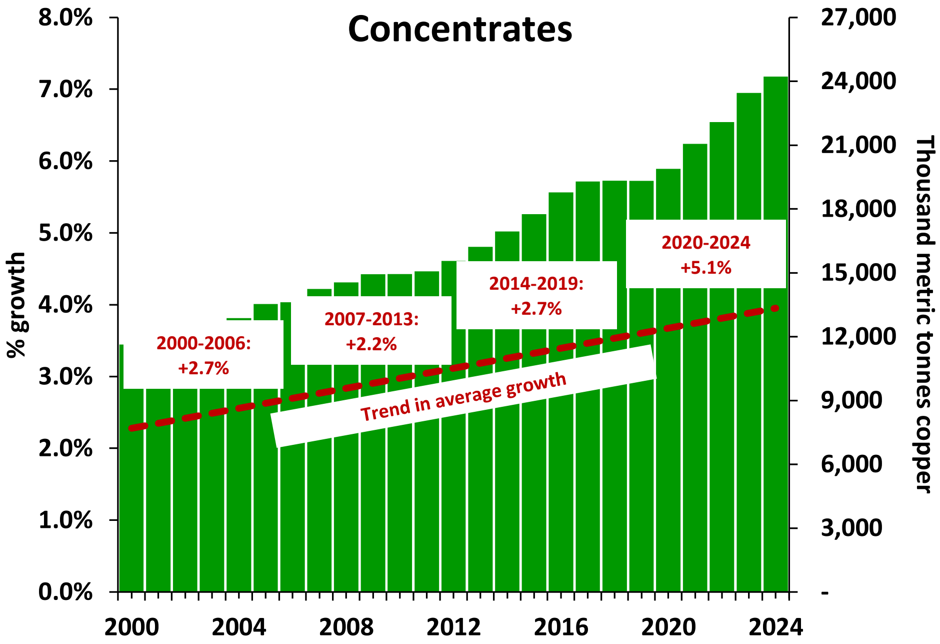


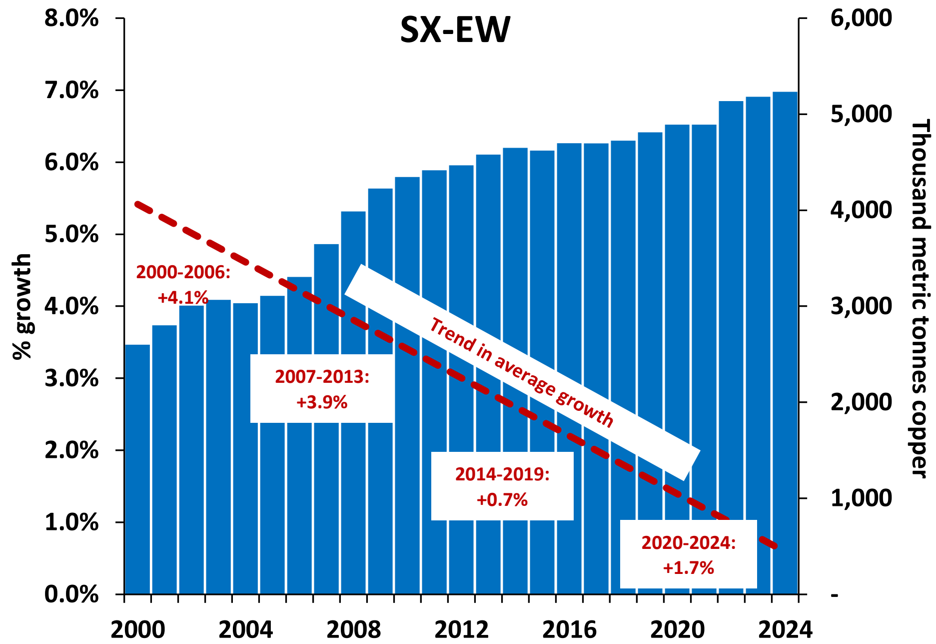

**Chile accounted for almost a third of world copper mine production in 2019 with mine output of 5.8 million tonnes copper. Peru, which has seen a sharp increase in output since 2015, accounted for 12% of world mine production.**

# Trends in Copper Mining Capacity, 2000-2024

Thousand metric tonnes copper (Bars) and Annual percentage change (Line)

Source: ICSG Directory of Copper Mines and Plants – September 2020 Edition




**Copper mining capacity is estimated to reach 29.5 million tonnes copper in 2024, with 18% being SX-EW production. This will be 22% higher than global capacity of 24.1 million tonnes copper recorded in 2019. Growth in copper mine capacity is expected to average 5.1% per year going forward as new capacity is added at existing and some new operations. The ratio between production and capacity is called the capacity utilization rate. The world mine capacity utilization rate was around 85% in 2019.**

***Note: Capacity data reflects production capabilities not necessarily production forecasts***

# Top 20 Copper Mines by Capacity (basis 2020)

Thousand metric tonnes copper

Source: ICSG Directory of Copper Mines and Plants – September 2020 Edition

| Rank | Mine | Country | Owner(s) | Source | Capacity |
|---|---|---|---|---|---|
| 1 | Escondida | Chile | BHP Billiton (57.5%), Rio Tinto Corp. (30%), Japan Escondida (12.5%) | Concs & SX-EW | 1,400 |
| 2 | Collahuasi | Chile | Anglo American (44%), Glencore plc (44%), Mitsui (8.4%), JX Holdings (3.6%) | Concs & SX-EW | 610 |
| 3 | Buenavista del Cobre (former Cananea) | Mexico | Grupo Mexico | Concs & SX-EW | 525 |
| 4 | Morenci | United States | Freeport-McMoRan Inc 72%, 28% affiliates of Sumitomo Corporation | Concs & SX-EW | 520 |
| 5 | Cerro Verde II (Sulphide) | Peru | Freeport-McMoRan Copper & Gold Inc. 54%, Compañia de Minas Buenaventura 19.58%, Sumitomo 21% | Concentrates | 500 |
| 6 | Antamina | Peru | BHP Billiton (33.75%), Teck (22.5%), Glencore plc (33.75%), Mitsubishi Corp. (10%) | Concentrates | 450 |
| 6 | Polar Division (Norilsk/ Talnakh Mills) | Russia | Norilsk Nickel | Concentrates | 450 |
| 8 | Las Bambas | Peru | MMG (62.5%), Guoxin International Investment Corporation Limited (22.5%), CITIC Metal Co., Ltd. (15%) | Concentrates | 430 |
| 9 | Grasberg | Indonesia | PT Freeport Indonesia (PT Inalum and the provincial/regional government 51.2% and Freeport-McMoRan Inc 48.8%) | Concentrates | 400 |
| 10 | El Teniente | Chile | Codelco | Concs & SX-EW | 399 |
| 11 | Chuquicamata | Chile | Codelco | Concs & SX-EW | 370 |
| 11 | Los Bronces | Chile | Anglo Amercian 50.1%, Mitsubishi Corp. 20.4%, Codelco 20%, Mitsui 9.5% | Concs & SX-EW | 370 |
| 11 | Los Pelambres | Chile | Antofagasta Plc (60%), Nippon Mining (25%), Mitsubishi Materials (15%) | Concentrates | 370 |
| 14 | Kansanshi | Zambia | First Quantum Minerals Ltd (80%), ZCCM (20%) | Concs & SX-EW | 340 |
| 15 | Radomiro Tomic | Chile | Codelco | Concs & SX-EW | 330 |
| 16 | Cobre Panama | Panama | First Quantum Minerals Ltd 90%, Korea Panama Mining Corp. (LS-Nikko Copper Inc. and Korean Resources Corporation) 10% | Concentrates | 300 |
| 16 | Kamoto | Congo | Katanga Mining Ltd (86.33% Glencore plc) 75%, Gecamines 25% | SX-EW | 300 |
| 18 | Bingham Canyon | United States | Kennecott | Concentrates | 280 |
| 19 | Toquepala | Peru | Southern Copper Corp (Grupo Mexico 88.9%, international investment community 11.1%) | Concentrates | 265 |
| 20 | Sentinel | Zambia | First Quantum Minerals Ltd | Concentrates | 260 |

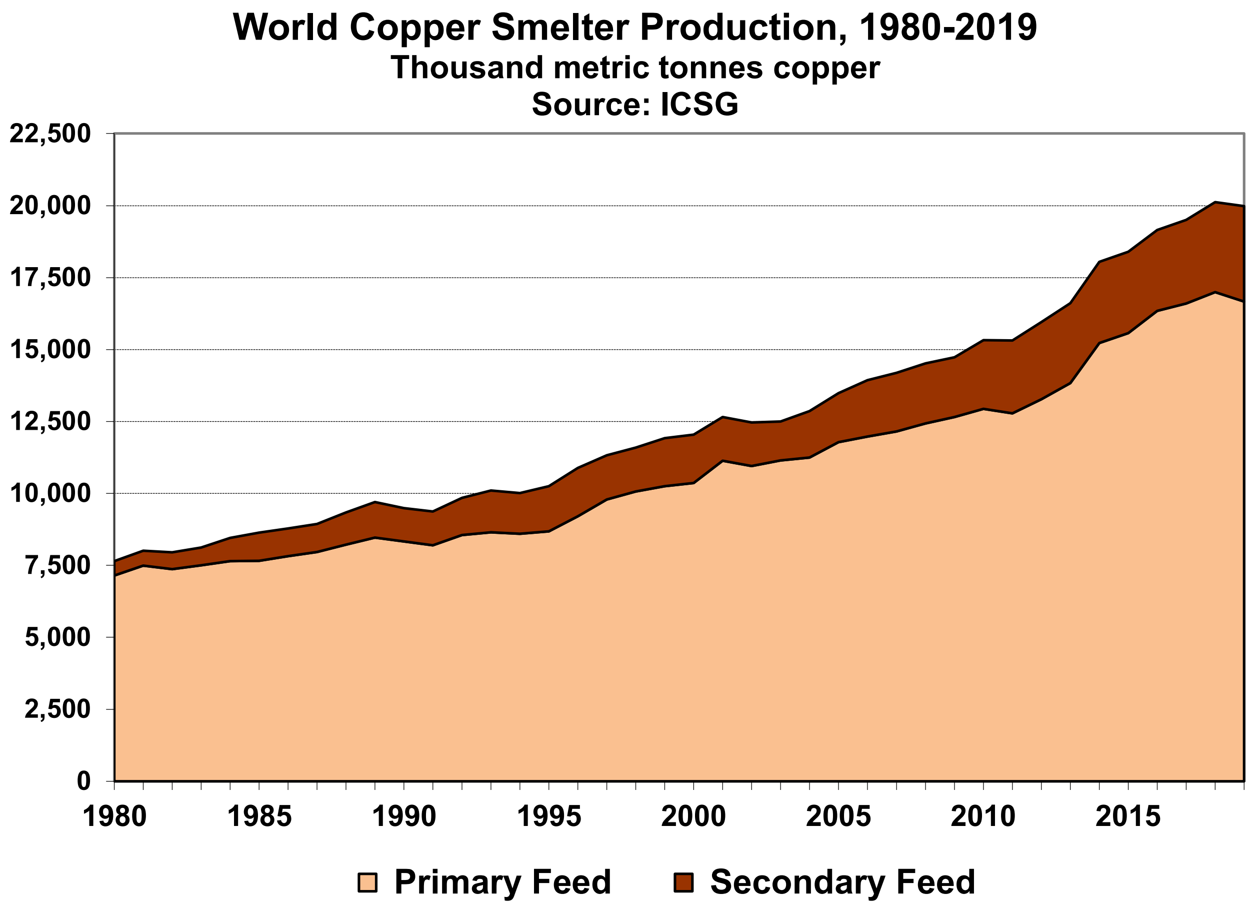
***Note: Capacity data reflects production capabilities not necessarily production forecasts***

# Constraints on Copper Supply

With copper concentrate in strong demand, there has been growing interest in understanding the obstacles that can prevent copper mine supply from coming on-stream. Below are some of the **operational and financial constraints** identified from a study undertaken by the ICSG. For more information about ICSG research related to constraints on copper supply, please contact the ICSG Secretariat at mail@icsg.org

- Declining ore grades: a serious issue in developed copper areas such as the USA and Chile
- Project finance: prolonged economic and price volatility may have significant impact on cost of capital
- Tax & investment regimes: recent research indicates these are less important than geological endowments
- Other cost issues: lower capital expenditure may have adverse long term effect on copper supply; operating cost escalation
- 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
- Other environmental issues: governments are becoming more aware of the impact of mining to the surrounding environment in recent years. In countries like Peru and the Philippines, the relationship with indigenous community is also a key factor.
- Resource nationalism: It has become a priority for certain governments to develop their mineral resources that have not been exploited until now. While willing to develop their natural resources, countries might be seeking to extract strong revenue flows from them. It will be important to balance royalty/taxation levels with the need to encourage capital investment to develop their rising industries.
- 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 otherwise
- 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
- Political risks: Security and transport accessibility is crucial to mine operation

# Copper Smelter Production

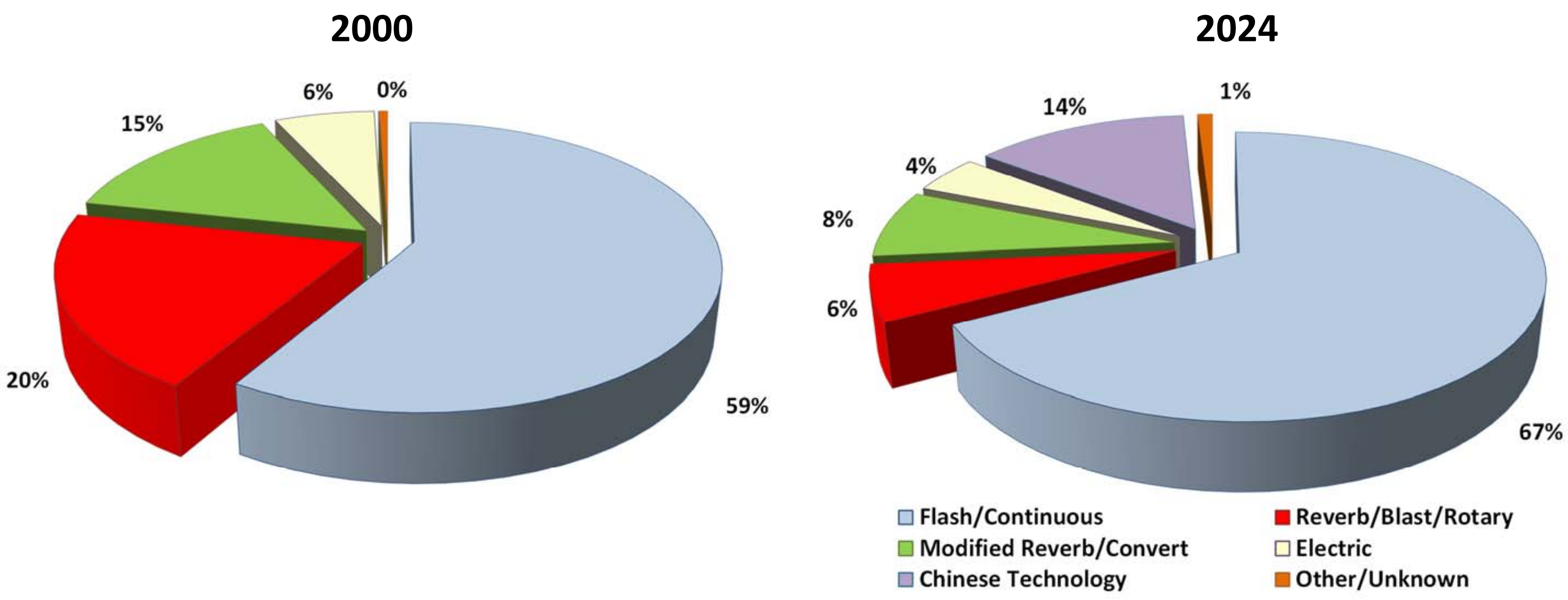



**Smelting is the pyrometallurgical process used to produce copper metal. In 2019, world copper smelter production reached 20.0 million tonnes copper. Recently, the trend to recover copper directly from ores through leaching processes has been on the increase. Primary smelters use mine concentrates as their main source of feed (although some use copper scrap as well). Secondary copper smelters use copper scrap as their feed.**

# Trends in Copper Smelting Capacity, 2000 and 2024

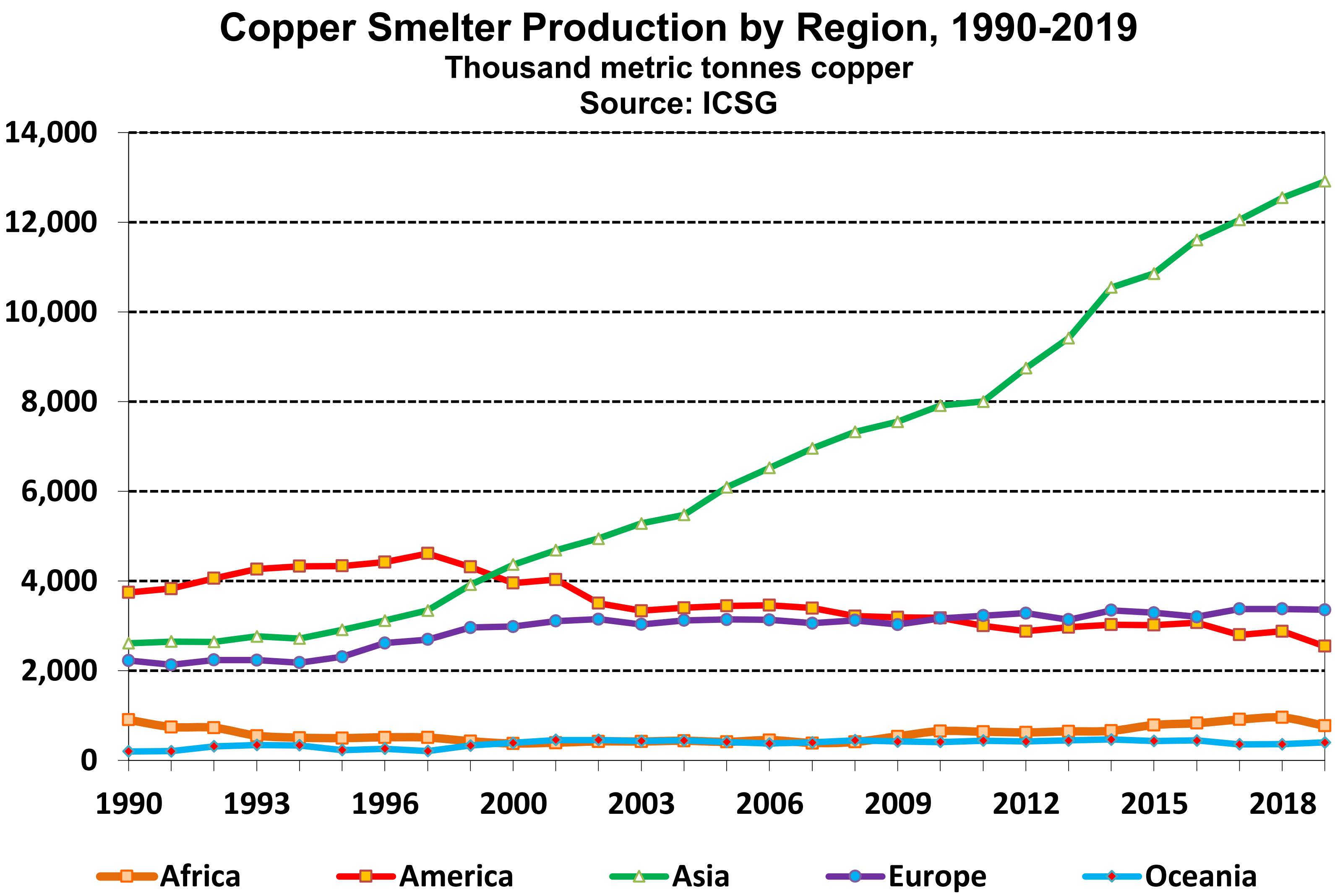
**Percentage share of total capacity, by technology type**

**Source: ICSG Directory of Copper Mines and Plants – September 2020 Edition**




**The use of Flash/Continuous technology accounted for 59% in total copper smelting capacity in 2000. This share rose to 67% in 2019. It is expected to remain around this level until 2024. There has also been a rapid expansion of Chinese technology, which first emerged in 2004. It now accounts for around 14% of total copper smelting capacity.**

***Note: Capacity data reflects production capabilities not necessarily production forecasts***

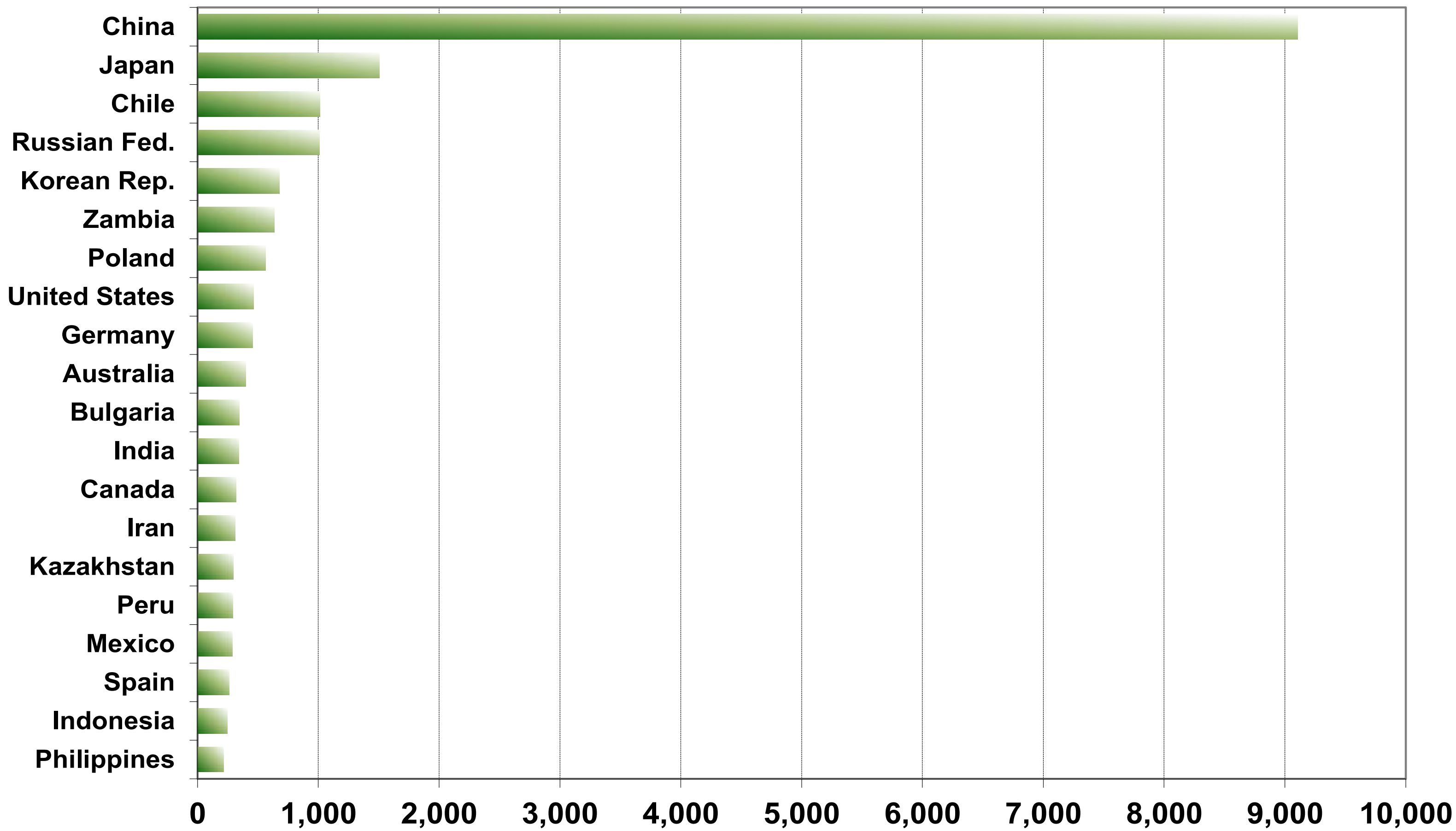



**Asia's share of world copper smelter output jumped from 27% in 1990 to 65% in 2019 as smelter production in China expanded rapidly.**

## Copper Smelter Production by Country: Top 20 Countries in 2019

**Thousand metric tonnes copper**

**Source: ICSG**




**In 2019, China accounted for almost 50% of world copper smelter production, followed by Japan (8%), Chile (5%) and Russian Federation (5%).**

***Note: Capacity data reflects production capabilities not necessarily production forecasts***

# Top 20 Copper Smelters by Capacity (basis 2020)

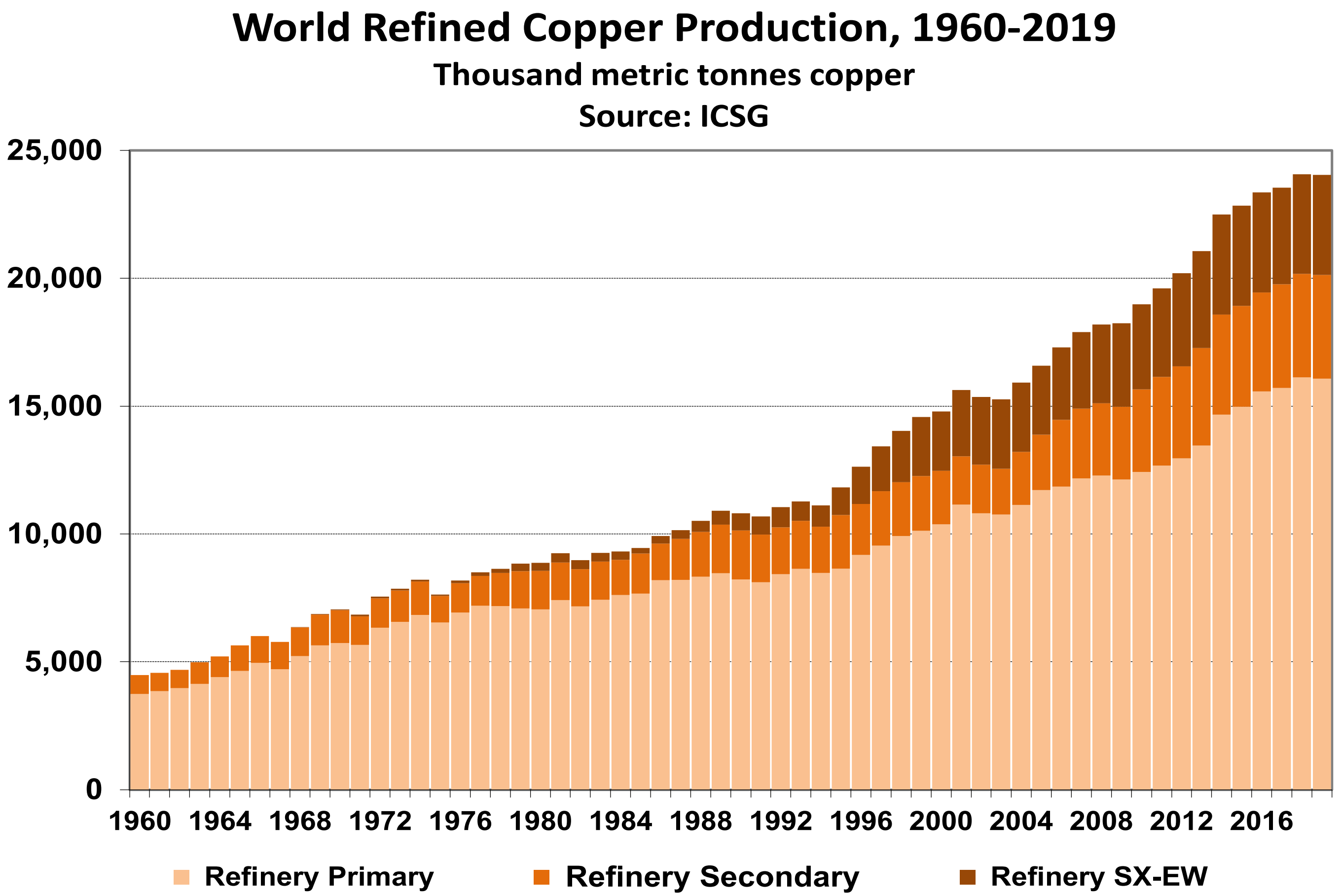
Thousand metric tonnes copper

Source: ICSG Directory of Copper Mines and Plants – September 2020 Edition

| Rank | Smelter | Country | Operator/Owner(s) | Process | Capacity |
|---|---|---|---|---|---|
| 1 | Guixi (smelter) | China | Jiangxi Copper Corp. | Outokumpu Flash | 600 |
| 2 | Birla Copper (Dahej) | India | Birla Group (Hidalco) | Outokumpu Flash, Ausmelt, Mitsubishi Continuous | 500 |
| 3 | Chuquicamata (smelter) | Chile | Codelco | Outokumpu/ Teniente Converter | 450 |
| 3 | Jinchuan (Fangchenggang smelter) | China | Jinchuan Non-Ferrous Metal Co. | Flash smelter | 450 |
| 3 | Hamburg | Germany | Aurubis | Outokumpu, Contimelt, Electric | 450 |
| 3 | Besshi/ Ehime (Toyo) | Japan | Sumitomo Metal Mining Co. Ltd. | Outokumpu Flash | 450 |
| 3 | Saganoseki/ Ooita (smelter) | Japan | JX Nippon Mining & Metals Co., Ltd. | Outokumpu Flash | 450 |
| 8 | El Teniente (Caletones) | Chile | Codelco Chile | Reverberatory/ Teniente Conv. | 400 |
| 8 | Chifeng | China | Chifeng Jinfeng (Yunnan Copper 45%, Taisheng 45%, Jinfeng Copper 10%) | Side-Blown | 400 |
| 8 | Chinalco Southeast Copper (smelter) | China | Chinalco | Flash Smelter | 400 |
| 8 | Jinguan (smelter) | China | Tongling Non-Ferrous Metals Group | Flash Smelter | 400 |
| 8 | Xiangguang copper (smelter) | China | Yanggu Xiangguang Copper Co | Outokumpu Flash | 400 |
| 8 | Sterlite Smelter (Tuticorin) | India | Vedanta | Isasmelt Process | 400 |
| 8 | Norilsk (Nikelevy, Medny) | Russia | Norilsk Nickel | Reverb, Electric, Vanyukov | 400 |
| 15 | Pirdop (smelter) | Bulgaria | Aurubis (99.77%) | Outokumpu Flash | 360 |
| 15 | Ilo Smelter | Peru | Southern Copper Corp (Grupo Mexico 88.9%, international investment community 11.1%) | Isasmelt Process | 360 |
| 17 | Onahama/ Fukushima | Japan | Mitsubishi Materials Corp. (55.714%), Dowa Metals & Mining Co. Ltd.(31.621%), Furukawa Metals & Resources Co. Ltd. (12.665%) | Mitsubishi/ Reverb. | 354 |
| 18 | Heding Copper | China | Jiangxi Copper, Fuchunjiang (joint venture) | Side-Blown | 350 |
| 18 | Jinlong (Tongdu) | China | Tongling Nonferrous Metals Corp. (57.4%), Sumitomo (35%), Pingguo Aluminium Co. | Flash Smelter | 350 |
| 18 | Sarchesmeh Copper Complex (smelter) | iran | National Iranian Copper Industry Co. | Flash Smelter | 350 |

***Note: Capacity data reflects production capabilities not necessarily production forecasts***

# Refined Copper Production

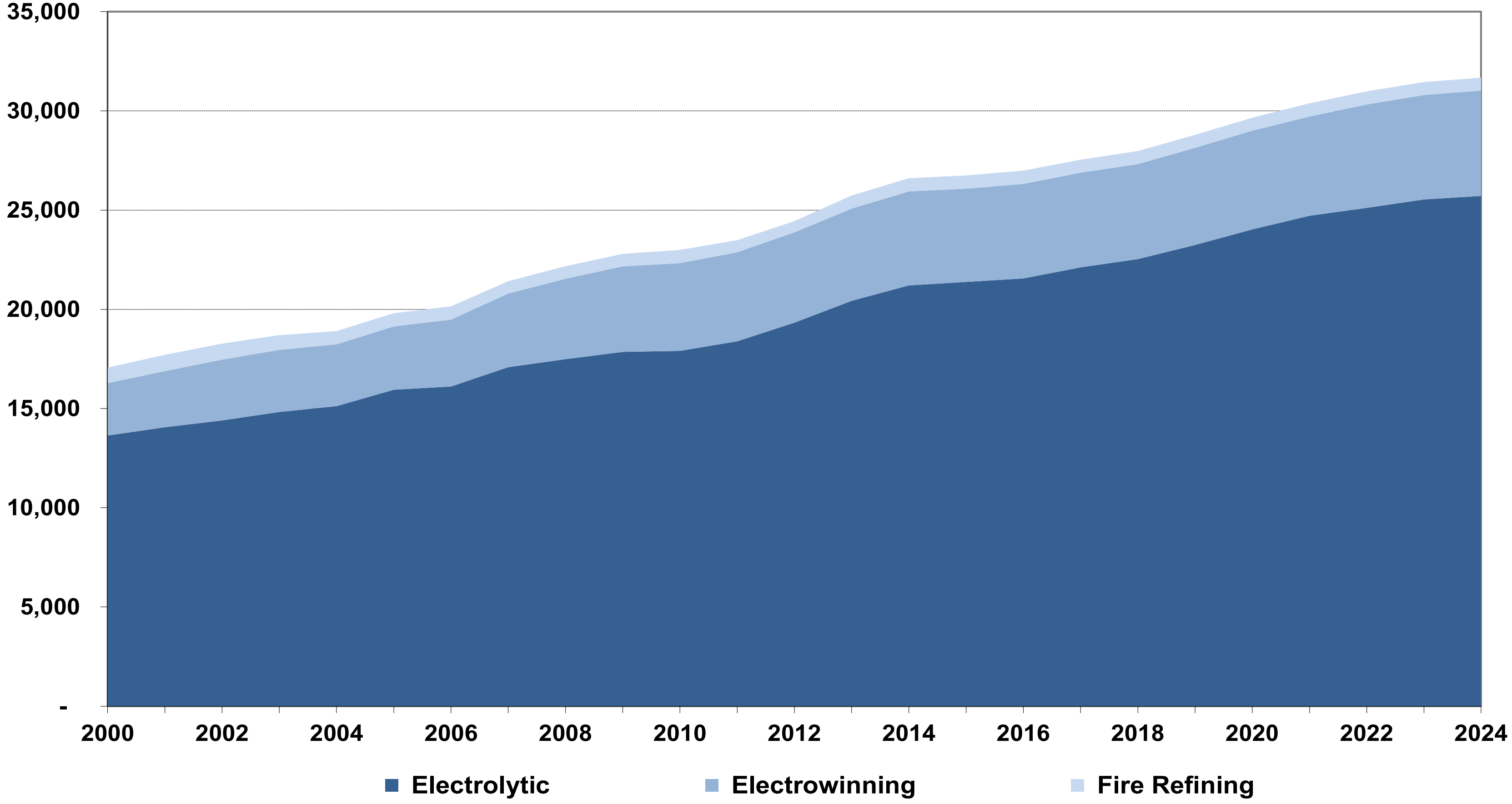



**With the emergence of solvent extraction-electrowinning (SX-EW) technology, refined copper produced from leaching ores has increased from less than 1% of world refined copper production in the late 1960's to 16% of world output in 2019. World copper refined production amounted to 24.0 million tonnes in 2019.**

## Trends in Refined Capacity, 2000-2024

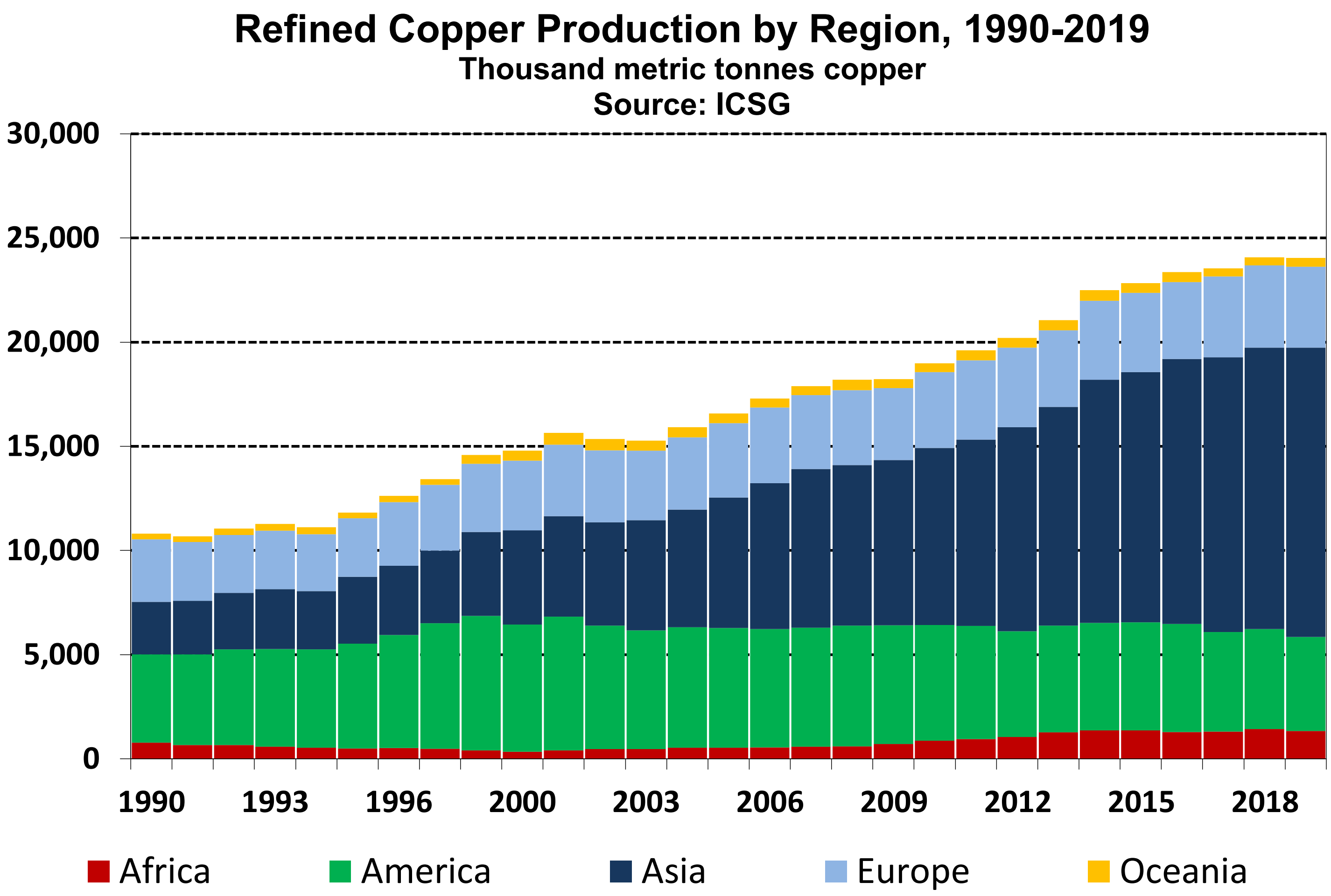
**Thousand metric tonnes copper**

**Source: ICSG Directory of Copper Mines and Plants - September 2020 Edition**




**This chart shows world copper refinery capacity by refining process. The ratio between production and capacity is called the capacity utilization rate. The world refinery capacity utilization rate was around 84% in 2019.**

***Note: Capacity data reflects production capabilities not necessarily production forecasts***



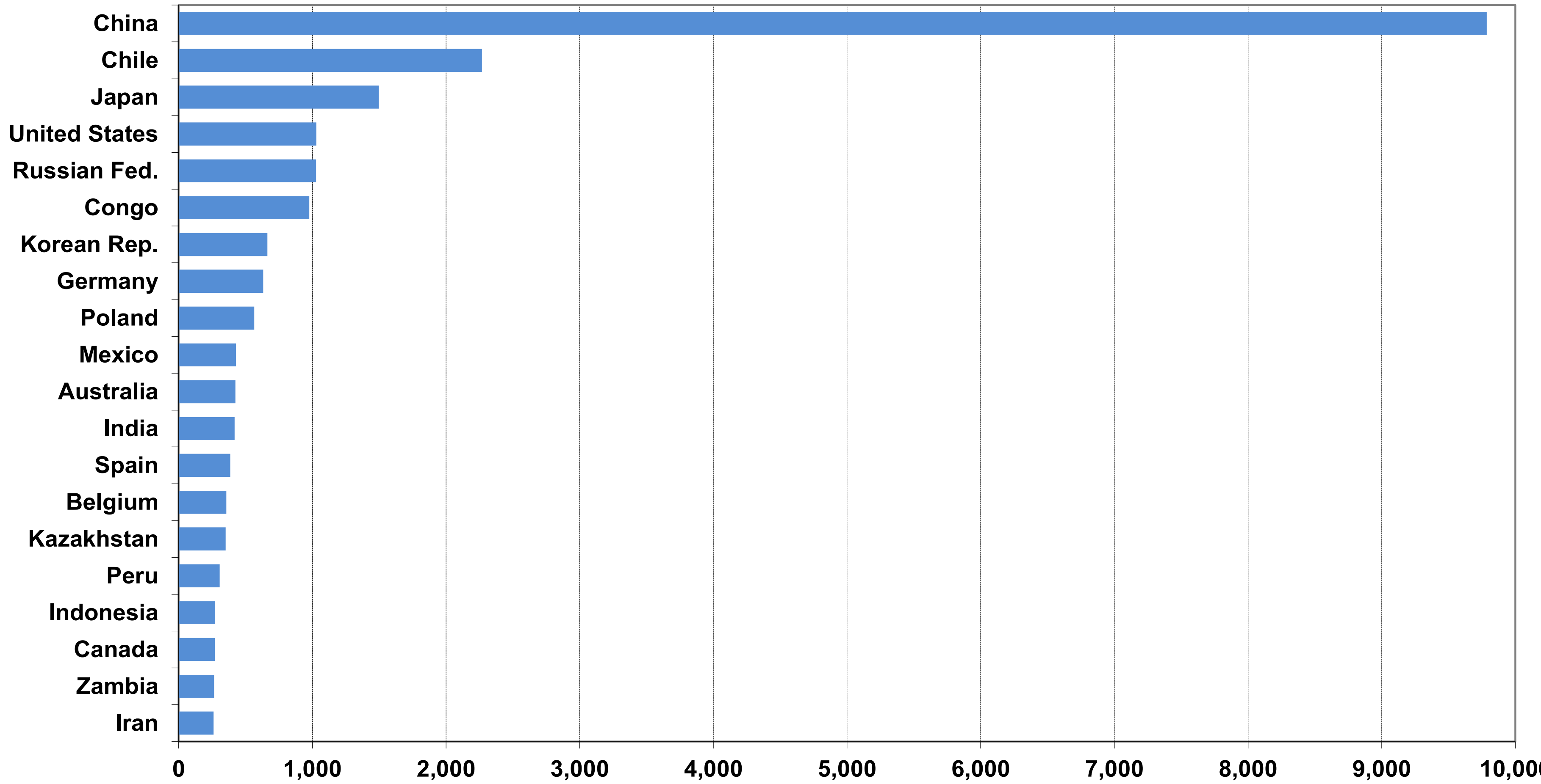

**Regions with the highest output of refined copper in 1990: the Americas (4,250 kt), followed by Europe (3,004 kt)**

**Leading region in the world in 2019: Asia (13,898 kt) as compared to 2,505kt in 1990.**

## Refined Copper Production by Country: Top 20 Countries in 2019

**Thousand metric tonnes copper**

**Source: ICSG**




**In 2019, China accounted for 41% of world copper refined production, followed by Chile (9%), Japan (6%) and the United States (4%).**

# Top 20 Copper Refineries by Capacity (basis 2020)

Thousand metric tonnes copper

Source: ICSG Directory of Copper Mines and Plants – September 2020 Edition

| Rank | Refinery | Country | Owner(s) | Process | Capacity |
|---|---|---|---|---|---|
| 1 | Guixi | China | Jiangxi Copper Corporation | Electrolytic | 1100 |
| 2 | Shandong Fangyuan | China | Dongying, Shandong | Electrolytic | 700 |
| 3 | Daye/ Hubei (refinery) | China | Daye Non-Ferrous Metals Co. | Electrolytic | 600 |
| 3 | Jinchuan | China | Jinchuan Non Ferrous Co. | Electrolytic | 600 |
| 5 | Yunnan Copper | China | Yunnan Copper Industry Group (64.8%) | Electrolytic | 500 |
| 5 | Birla | India | Birla Group (Hidalco) | Electrolytic | 500 |
| 7 | Sterlite Refinery | India | Vedanta | Electrolytic | 460 |
| 7 | Pyshma Refinery | Russia | UMMC (Urals Mining & Metallurgical Co.) | Electrolytic | 460 |
| 8 | Jinchuan (Fangchenggang | China | Jinchuan Non-Ferrous Metal Co. | Electrolytic | 450 |
| 8 | Toyo/Niihama (Besshi) | Japan | Sumitomo Metal Mining Co. Ltd. | Electrolytic | 450 |
| 8 | Amarillo | United States | Grupo Mexico | Electrolytic | 450 |
| 8 | Chuquicamata Refinery | Chile | Codelco | Electrolytic | 450 |
| 13 | Onsan Refinery I | Korean Republic | LS-Nikko Co. (LS, Nippon Mining) | Electrolytic | 440 |
| 14 | Hamburg (refinery) | Germany | Aurubis | Electrolytic | 416 |
| 15 | El Paso (refinery) | United States | Freeport-McMoRan Copper & Gold Inc. | Electrolytic | 415 |
| 15 | Las Ventanas | Chile | Codelco | Electrolytic | 410 |
| 17 | Jinguan (refinery) | China | Tongling Non-Ferrous Metals Group | Electrolytic | 400 |
| 17 | Jinlong (Tongdu) (refinery) | China | Tongling NonFerrous Metal Corp. 52 %, Sharpline | Electrolytic | 400 |
| 17 | Xiangguang Copper | China | Yanggu Xiangguang Copper Co | Electrolytic | 400 |
| 17 | Chifeng (refinery) | China | Chifeng Jinfeng (Yunnan Copper) | Electrolytic | 400 |

***Note: Capacity data reflects production capabilities not necessarily production forecasts***

# Chapter 4: Corporate Social Responsibility (CSR) in Mining

## What is Corporate Social Responsibility?

Corporate Social Responsibility refers to the continuing commitment by "the corporation" to behave ethically and contribute to economic development while improving the quality of life of the workforce and their families as well as of the local community and society at large.


The basis of CSR is rooted in Archie Carroll's "Pyramid of Corporate Social Responsibility."[1] In this Pyramid a corporation has **four** types of responsibilities. The first and most obvious is the **economic** responsibility to be profitable. The second is the ***legal*** responsibility to obey the laws set forth by society. The third, which is closely linked to the second, is the ***ethical*** responsibility. That is to do what is right even when business is not compelled to do so by law. The fourth is the ***philanthropic*** responsibility. It is best described by the resources contributed by corporations toward social, educational, recreational and/or cultural purposes.

## Why is CSR Important?

Corporate Social Responsibility has been around since the 1950s, but its importance and practice took hold much later. With mining activity increasing, CSR is more relevant than ever before.

CSR programs usually invest in infrastructure (potable water, electricity, schools, roads, hospitals, hospital equipment, drainage repairs, etc.), building social capital (providing high-school and university education, workshops on gender issues, information on family planning, improving hygiene, etc.), and building human capital (training local people to be employed by the mining business or to provide outsourced services, promote and provide skills on microbusiness, aquaculture, etc.).[2]

Mining companies engage in CSR programs because:

- From a community perspective, they provide a mechanism of compensation for the social and environmental costs associated with mining. CSR is also a means through which a mining company can be seen to actively give back to the community.

- Mining companies also benefit from CSR programs by building better relations with the local communities in which they operate. The economic risks of not having good community relations include project delays, and even mine closures.

Source: 1/ based on Archie Carroll's research on The Pyramid of Corporate Social Responsibility: Toward the Moral Management of Organizational Stakeholders (1991)
2/ https://www.miningfacts.org/communities/what-is-corporate-social-responsibility/

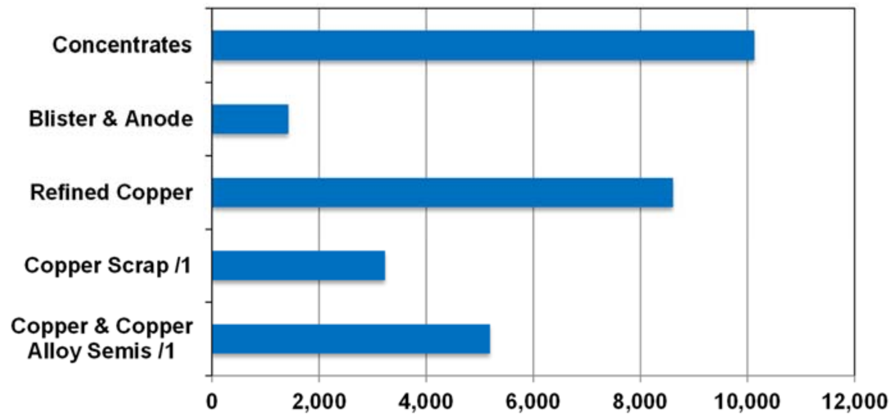
# Chapter 5: Copper Trade

Copper products across the value chain are traded internationally. Often, countries where upstream copper production capacity exceeds downstream production capacity will import the raw materials needed to meet their production needs, and vice versa. **Major product categories** of copper traded internationally include:

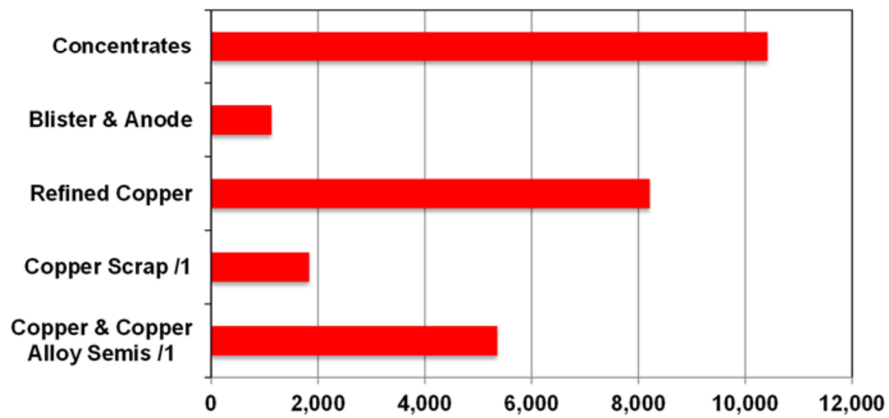
- Copper concentrates
- Copper blister and anode
- Copper cathode and ingots
- Copper scrap and
- Copper semis

Copper powders and compounds are also traded globally, but typically in much smaller quantities. In additional, copper is contained in end-use products that are traded globally including automobiles, appliances, electronic equipment and other products. Changes in **trade regulations**, such as import duties or export quotas, can have significant impacts on the international trade of copper. For more information about the international trade of copper and changes in regulations that can affect the trade of copper, please contact the ICSG Secretariat at mail@icsg.org

World Copper Imports by Product Category, 2019 /2
Thousand metric tonnes copper (unless otherwise noted)
Source: ICSG




World Copper Exports by Product Category, 2019 /2
Thousand metric tonnes copper (unless otherwise noted)
Source: ICSG




[1] Gross weight.
[2] Exports and Imports might not match due to transit time, under-reporting or product misclassification

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

Major **Exporters** of Copper Ores and Concentrates, 2019

1. Chile
2. Peru
3. Australia
4. Mexico
5. Canada
6. Mongolia
7. United States
8. Brazil
9. Spain
10. Kazakhstan

Major **Importers** of Copper Ores and Concentrates, 2019

1. China
2. Japan
3. Korean Rep.
4. Spain
5. Germany
6. India
7. Bulgaria
8. Russian Fed.
9. Mexico
10. Finland

Image courtesy of the Copper Development Association.

[1]Figure is intended to illustrate trade flows but not actual trade routes. Detailed trade matrices are available in ICSG Statistical Yearbook.

## Major International Trade Flows of Copper Blister and Anode[1]

Major **Exporters** of Copper Blister and Anode, 2019

1. Zambia
2. Chile
3. Bulgaria
4. South Africa
5. Spain
6. Belgium
7. Netherlands
8. Peru
9. Germany
10. Italy

Major **Importers** of Copper Blister and Anode, 2019

1. China
2. Belgium
3. India
4. Canada
5. Korean Rep.
6. Austria
7. Germany
8. Japan
9. Brazil
10. Netherlands

Image courtesy of the Copper Development Association.

[1]Figure is intended to illustrate trade flows but not actual trade routes. Detailed trade matrices are available in ICSG Statistical Yearbook.

## Major International Trade Flows of Refined Copper[1]

Major **Exporters** of Refined Copper, 2019

1. Chile
2. Russian Fed.
3. Japan
4. Kazakhstan
5. Australia
6. China
7. Poland
8. Belgium
9. Peru
10. Korean Rep.

Major **Importers** of Refined Copper, 2019

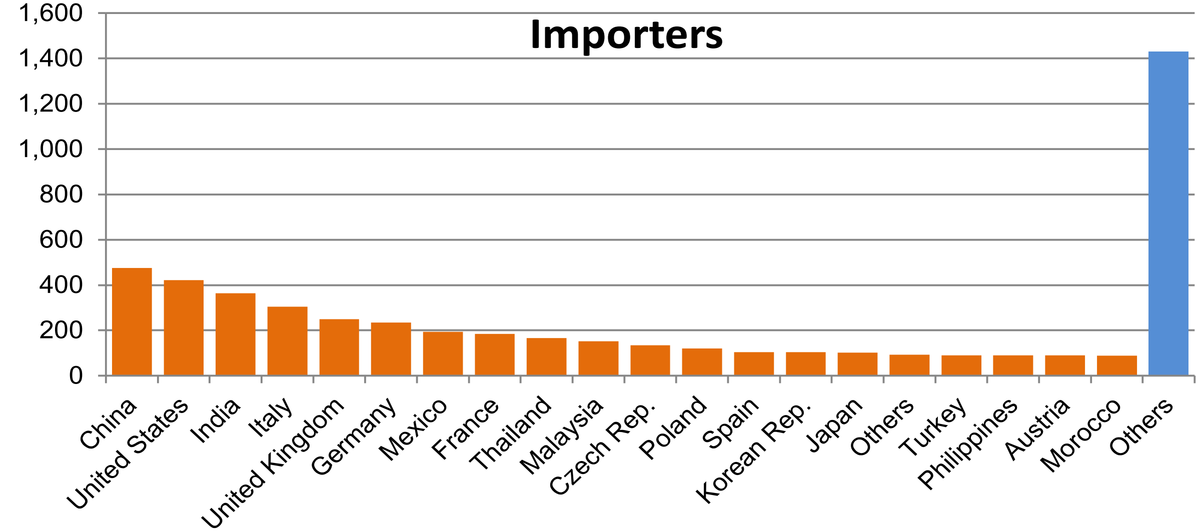
1. China
2. United States
3. Italy
4. Germany
5. Taiwan (China)
6. Thailand
7. Turkey
8. Malaysia
9. Korean Rep.
10. France

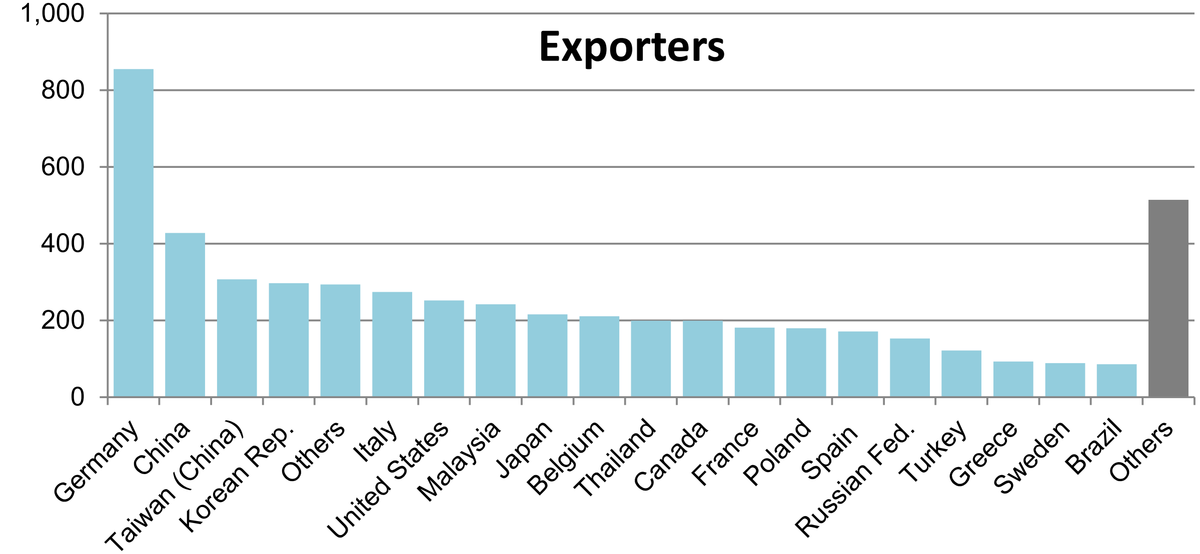
Image courtesy of the Copper Development Association.

[1]Figure is intended to illustrate trade flows but not actual trade routes. Detailed trade matrices are available in ICSG Statistical Yearbook.

## Leading Exporters and Importers of Semi-Fabricated Copper Products, 2019

Thousand metric tonnes gross weight, Source: ICSG



# Chapter 6: Commodity Copper: Exchanges, Prices and Stocks

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.

**Exchanges**

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 Futures Exchange (SHFE). 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 SHFE, 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.

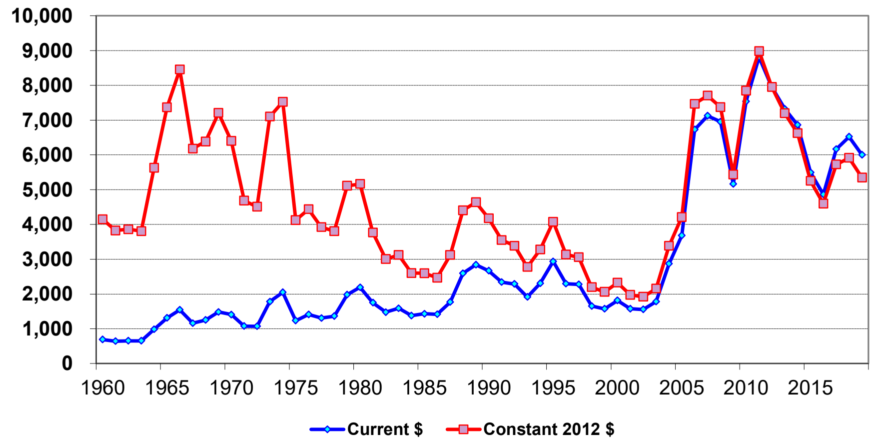
Exchanges also provide for the trading of futures and options contracts. These allow producers and consumers to fix a price in the future, thus providing a hedge against price variations. In this process the participation of speculators, who are ready to buy the risk of price variation in exchange for 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), 1960-2019**

US$ per tonne

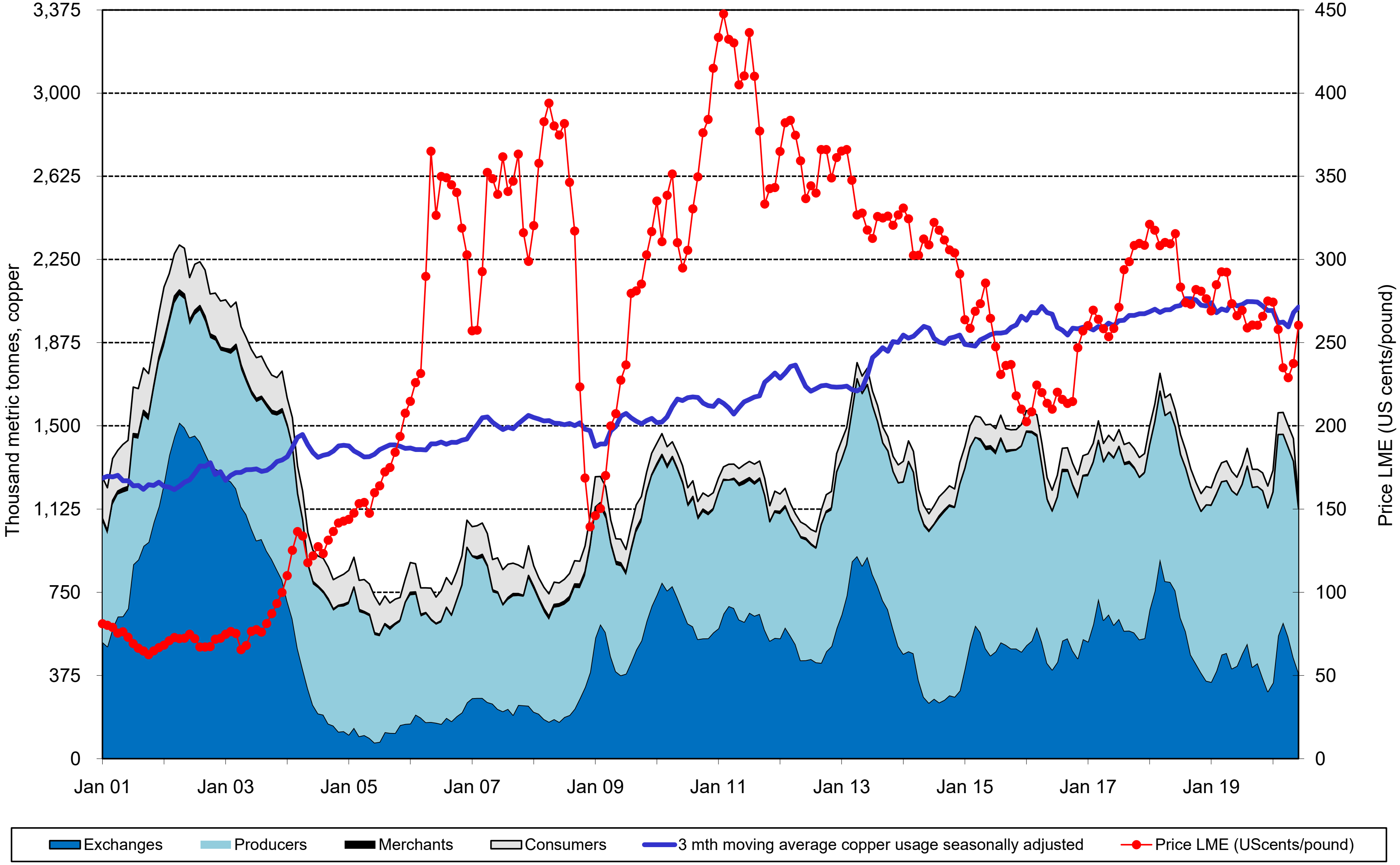
Source: ICSG



# Copper Stocks, Prices and Usage (Jan 2001-Jun 2020)

Thousand metric tonnes copper and US cents/pound

Source: ICSG



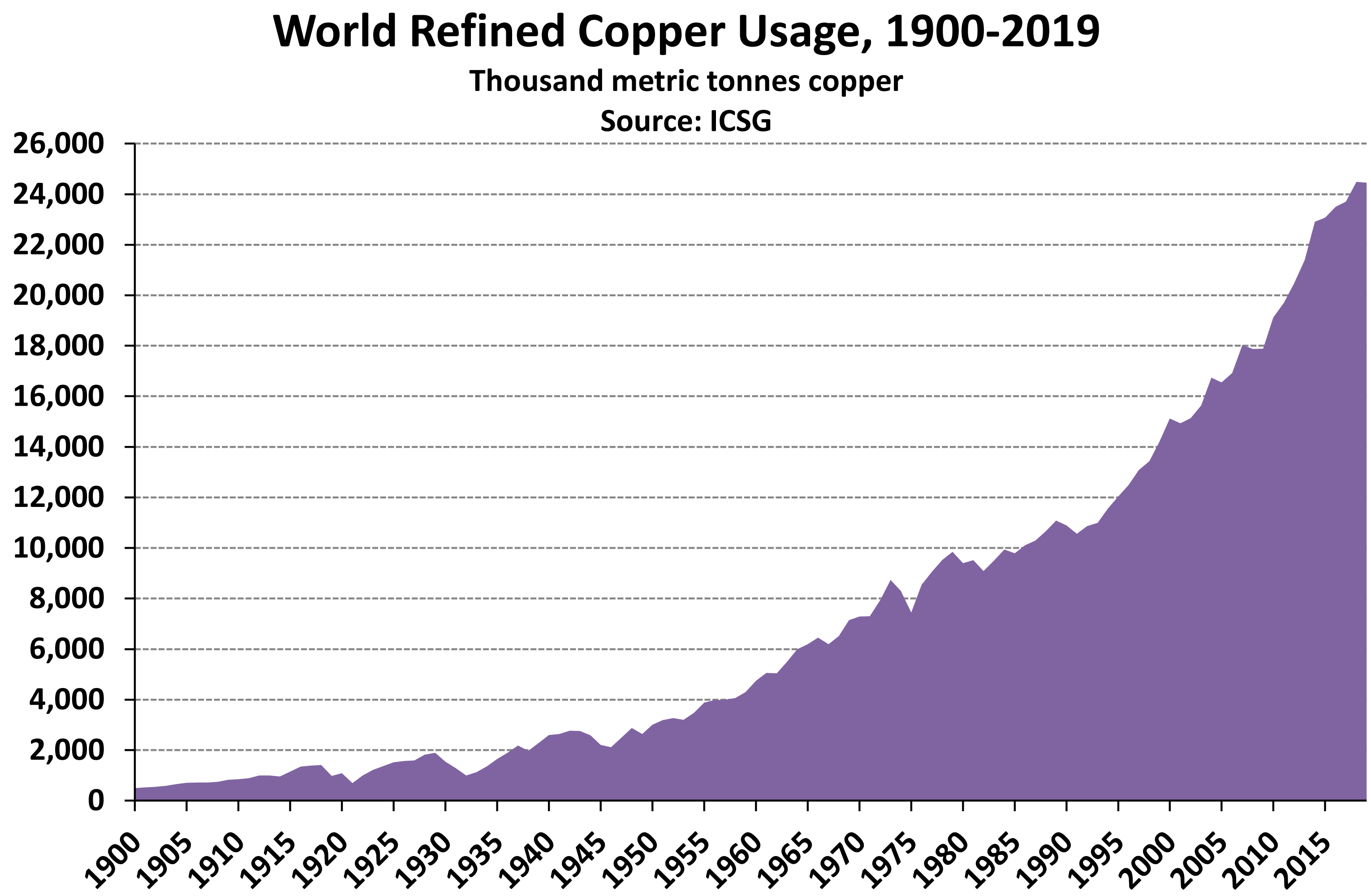
# Chapter 7: Copper Usage

## How Is Copper Used?

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. The fabricators of these shapes are called the first users of copper. The total use of copper includes copper scrap that is directly melted by the first users of copper to produce copper semis.

Copper and copper alloy semis can be further transformed by downstream industries for use in end use products such as automobiles, appliances, electronics, and a whole range of other copper-dependent products in order to meet society's needs. This section provides a range of information about refined copper usage, total use, major uses of copper and end-use.

For the most up-to-date information on refined copper usage, please visit the ICSG website at [www.icsg.org](http://www.icsg.org)

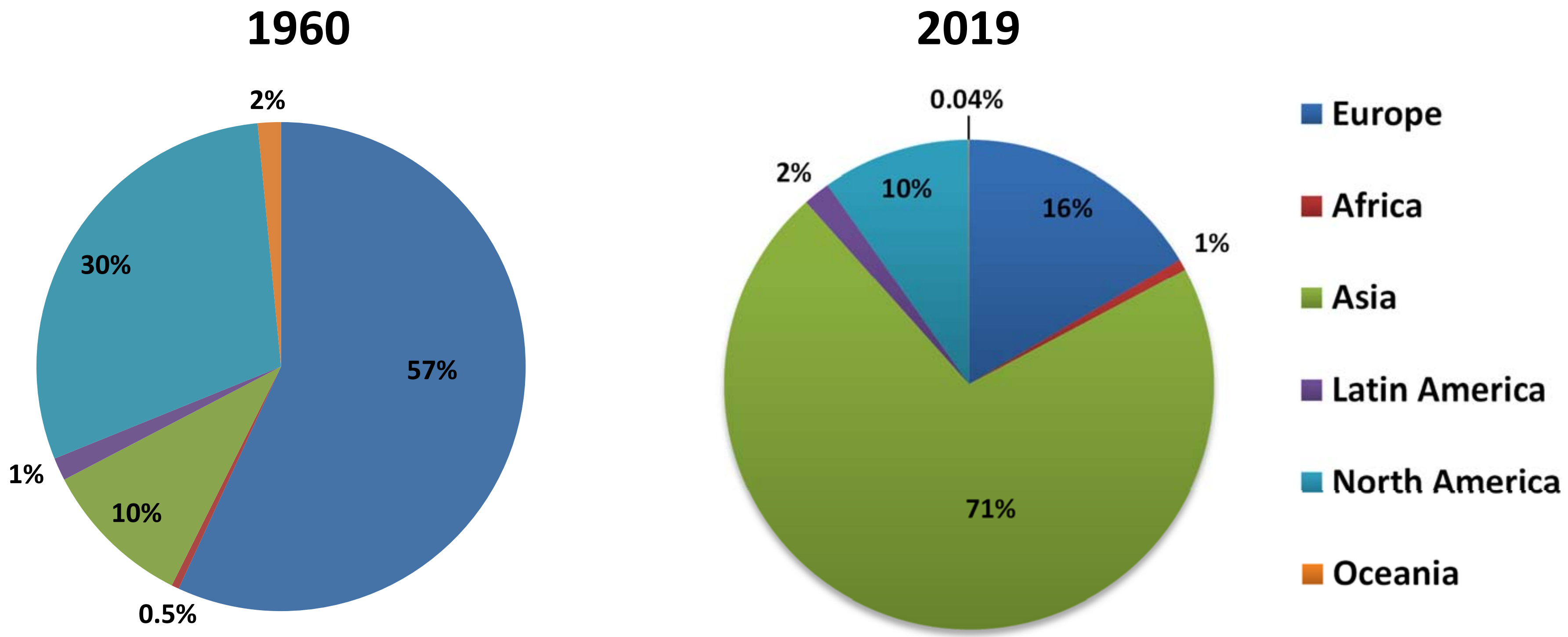



**Since 1900, apparent usage for refined copper has increased from less than 500 thousand tonnes to 24.5 million metric tonnes in 2019 as usage over the period grew by a compound annual growth rate of 3.4% per year.**

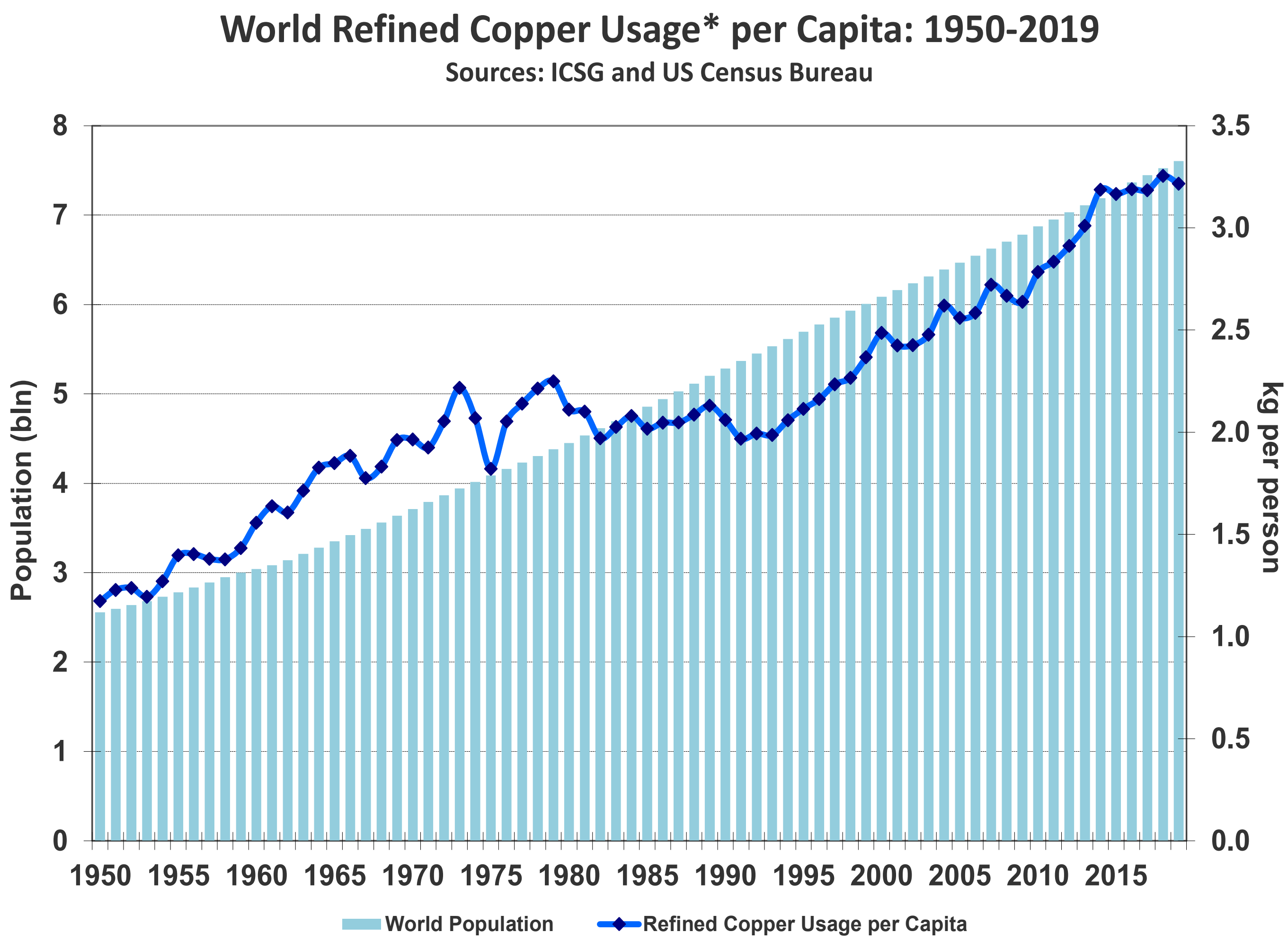
## Refined Copper Usage by Region, 1960 versus 2019

Thousand metric tonnes copper

Source: ICSG




**The key driver of global refined copper usage has been Asia, where demand has expanded almost eight-fold over the past four decades mainly due to China.**

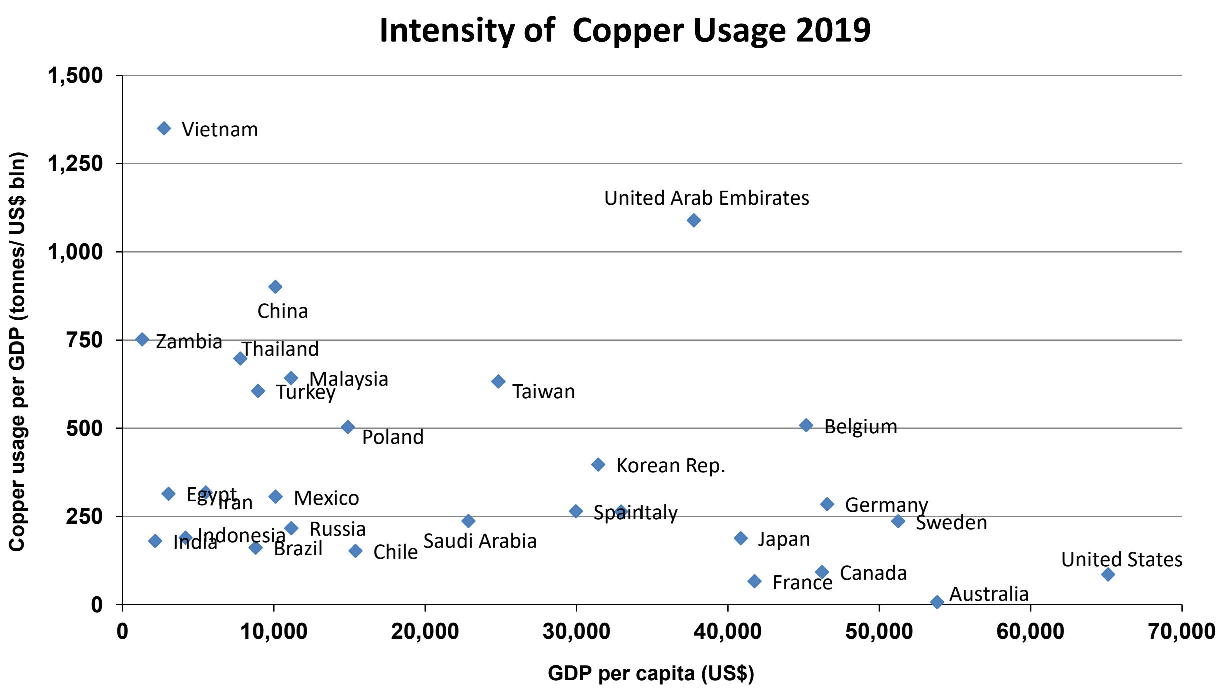



*Refined copper is typically used by semis fabricators or the "first users" of refined copper, including ingot makers, master alloy plants, wire rod plants, brass mills, alloy wire mills, foundries and foil mills. As a result, per capita usage of refined copper refers to the amount of copper used by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

# Intensity of Refined Copper Usage*

Sources: ICSG and International Monetary Fund

| 2019 data | GDP per capita (US$) | Intensity (tonnes/US$bln) |
|---|---|---|
| Australia | 53825 | 7.264 |
| Belgium | 45174 | 508.233 |
| Brazil | 8797 | 161.545 |
| Canada | 46213 | 92.729 |
| Chile | 15399 | 152.598 |
| China | 10099 | 900.794 |
| Egypt | 3047 | 314.386 |
| France | 41760 | 66.513 |
| Germany | 46564 | 284.978 |
| India | 2172 | 180.195 |
| Indonesia | 4164 | 189.307 |
| Iran | 5506 | 318.212 |
| Italy | 32946 | 264.032 |
| Japan | 40847 | 188.374 |
| Korean Rep. | 31431 | 397.169 |
| Malaysia | 11137 | 641.933 |
| Mexico | 10118 | 306.085 |
| Poland | 14901 | 503.467 |
| Russian Fed. | 11163 | 216.972 |
| Saudi Arabia | 22865 | 237.401 |
| Spain | 29961 | 264.695 |
| Sweden | 51243 | 236.323 |
| Taiwan | 24828 | 632.523 |
| Thailand | 7792 | 697.459 |
| Turkey | 8958 | 606.036 |
| United Arab Emirates | 37750 | 1,089.038 |
| United States | 65112 | 85.748 |
| Vietnam | 2740 | 1,349.297 |
| Zambia | 1307 | 751.566 |

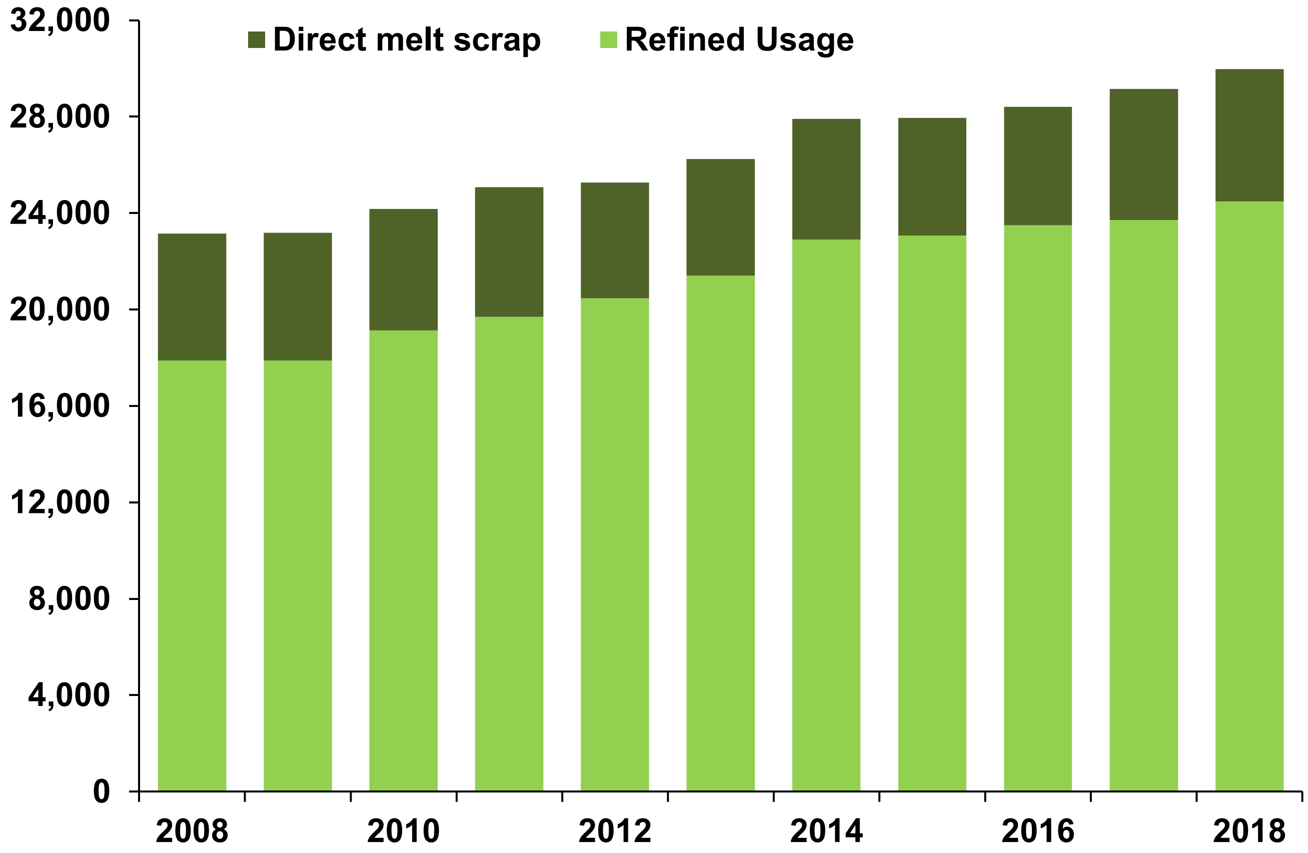



***Refined copper is typically used by semis fabricators or the "first users" of refined copper, including ingot makers, master alloy plants, wire rod plants, brass mills, alloy wire mills, foundries and foil mills. As a result, intensity of refined copper usage per GDP refers to the amount of copper used by industry divided by GDP and does not represent copper used in finished products per person.**

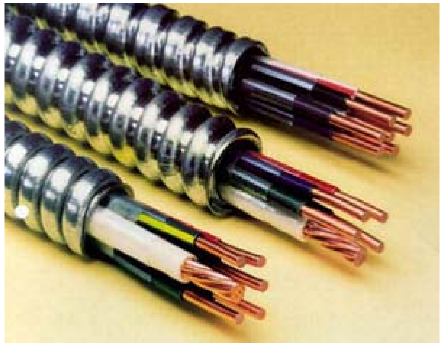
## Total Copper Usage, Including Direct Melted Copper Scrap, 2008-2018

Thousand metric tonnes copper

Source: ICSG Recyclables Survey April 2020



## 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.

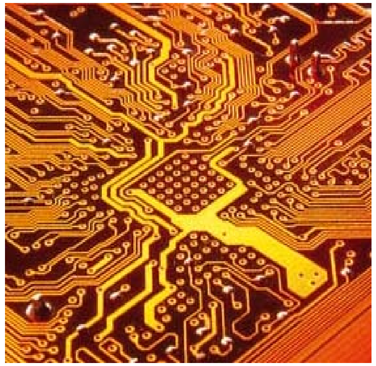
**ICSG, in partnership with the Common Fund for Commodities, the International Copper Association and the International Copper Promotion Council (India), undertook the Transfer of Technology for High Pressure Copper Die Casting in India project. The project facilitated the transfer of technology related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

Images courtesy of the Copper Development Association.

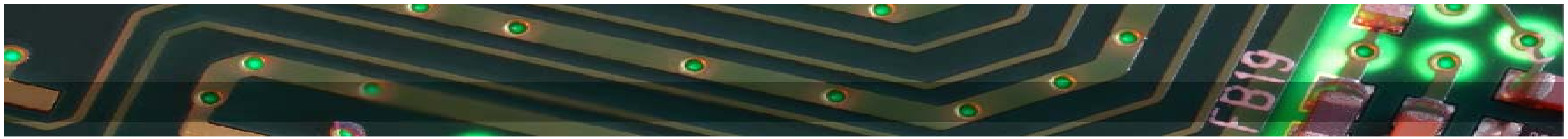
## Major Uses of Copper: Electronics and Communications

**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.




Images 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.

Images courtesy of the Copper Development Association and the International Copper Association.

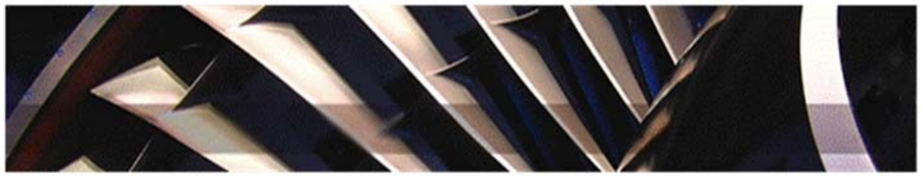
## Major Uses of Copper: Industrial Machinery and Equipment

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



Images 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**, **cookware, 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.

Images courtesy of the International Copper Association and the Copper Development Association.

[1] Source: U.S. Department of the Treasury.

## Major Uses of Copper: Transportation

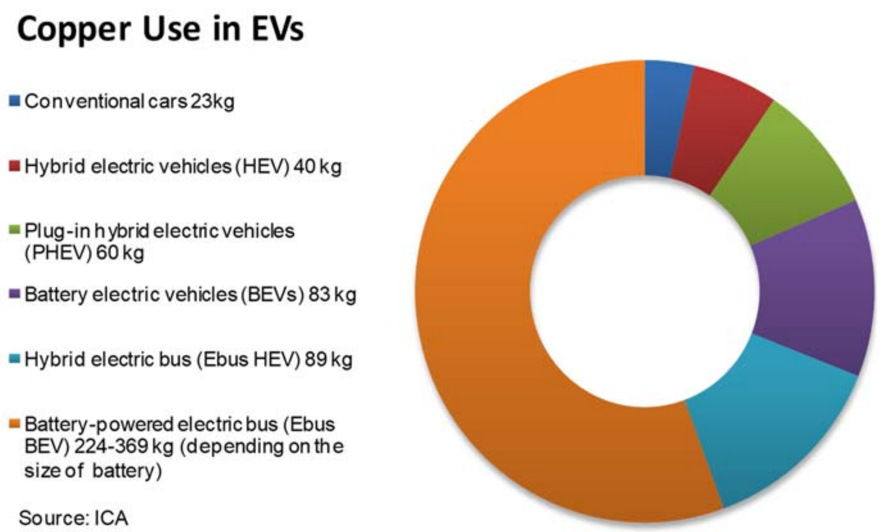
All major forms of transportation depend on copper to perform critical functions.

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

Automobiles and trucks rely on copper motors, wiring, radiators, connectors, brakes and bearings. Today, the average internal combustion engine 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.

### ELECTRIC VEHICLES

**Electric vehicles (EVs)** contain approximately four times more copper than conventional cars. It is used in batteries, windings and copper rotors used in electric motors, wiring, busbars and charging infrastructure.




It is estimated that globally over 7 million electric vehicles were on the road in 2019. In an effort to reduce carbon emissions it is expected that the use of EVs will continue to rise. The demand for EVs is also expected to increase as a result of technology improvements, increased affordability and the deployment of

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

more electric chargers (each EV charger will add 0.7 kg of copper. Fast chargers can add up to 8 kg of copper each). This increase will result in greater demand for copper.

Copper's superior thermal conductivity, strength, corrosion resistance and recyclability also 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 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.

## Growth Markets for Copper Usage

In the longer term, copper could benefit from use in the following markets: [1]

**1. Antimicrobial** – copper is gaining popularity as an alternative to plastic in medical applications, such as sterile table tops and medical cart handles

**2. Aquaculture –** marine aquaculture nets and pens made with copper-alloy mesh are emerging as an effective solution to important problems facing the near-shore fish farming industry

**3. Electrical Propulsion –** powering EVs require changes to the electrical infrastructure that will benefit from copper

**4. Renewable Energy** – copper plays important roles in clean energy systems from wind to solar thermal plants

**5. Seismic Energy Dissipation –** earthquake damage can be controlled through the use of copper-based devices that absorb energy to limit building motions

**6. Ultra-conductive Copper Components –** progress is being made in the methods of incorporating nanocarbon materials into copper in a way that promises to deliver large efficiency improvements in electrical energy transmission and distribution networks

**7. Electrical Vehicles (EVs) –** to reduce carbon emissions. Rising number of EVs is expected to result in increased copper usage

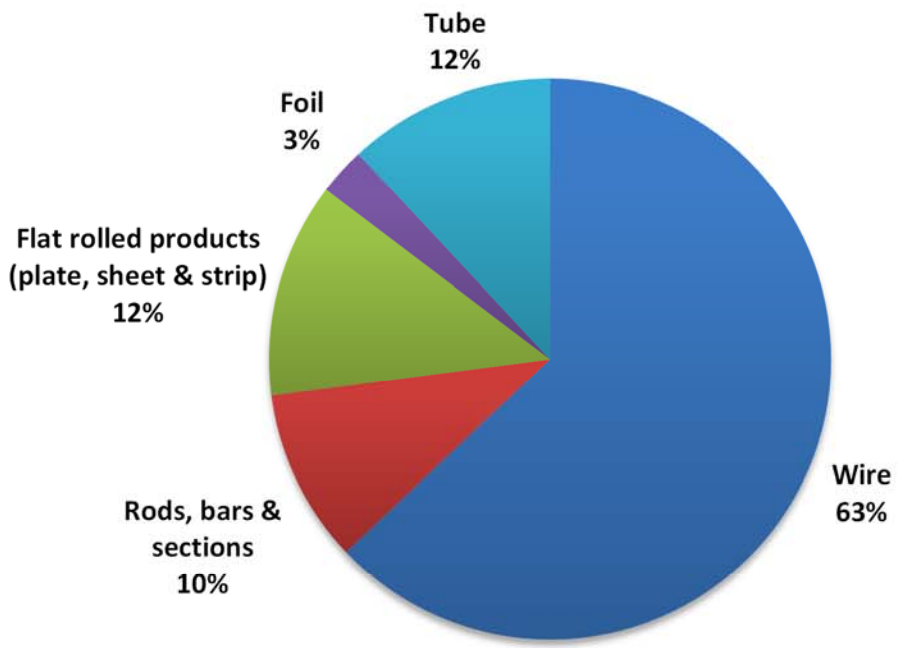
Images courtesy of the Copper Development Association and the European Copper Institute.

Source: 1/ ICA Annual Reports

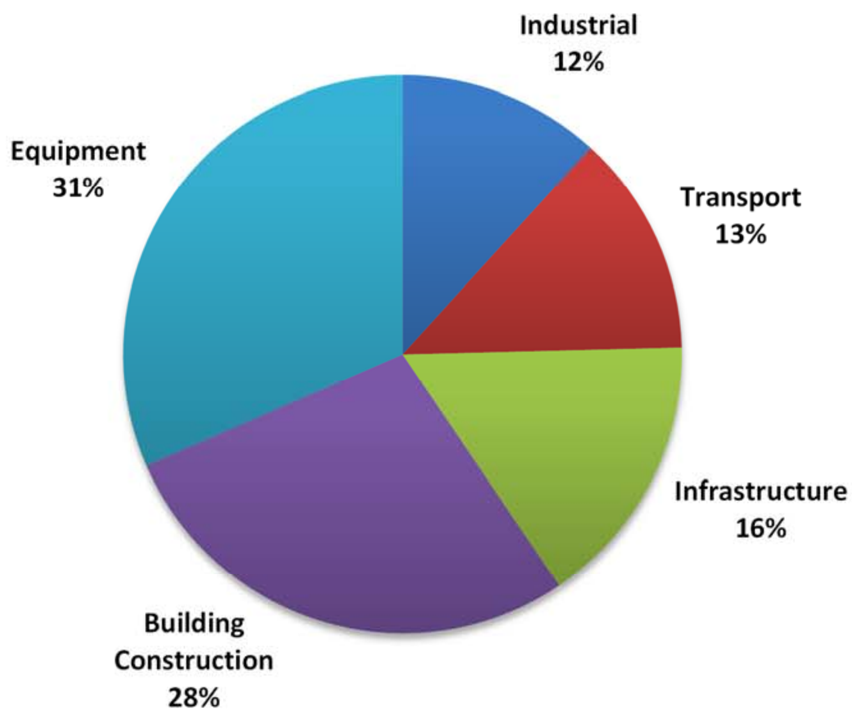
# Major Uses of Copper, 2019

Source: International Wrought Copper Council (IWCC) and International Copper Association (ICA)

## First-Use (Semis Production*)




## End-Use



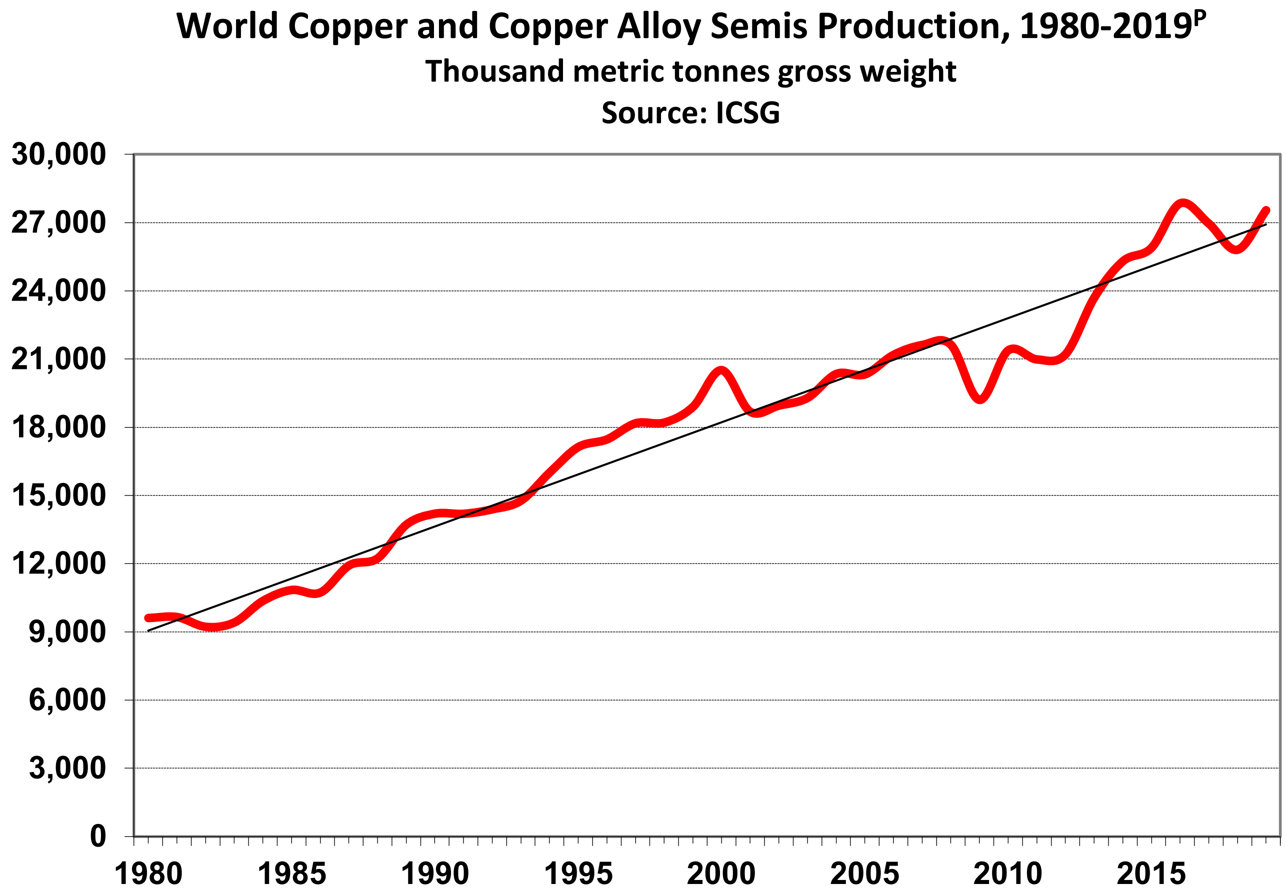

*copper and copper alloy production

**Notes:**

Copper foil production includes foil produced by the rolling process and by electro-deposition

The copper content of alloy semis is assumed to be 70%

# World Copper and Copper Alloy Semis Production



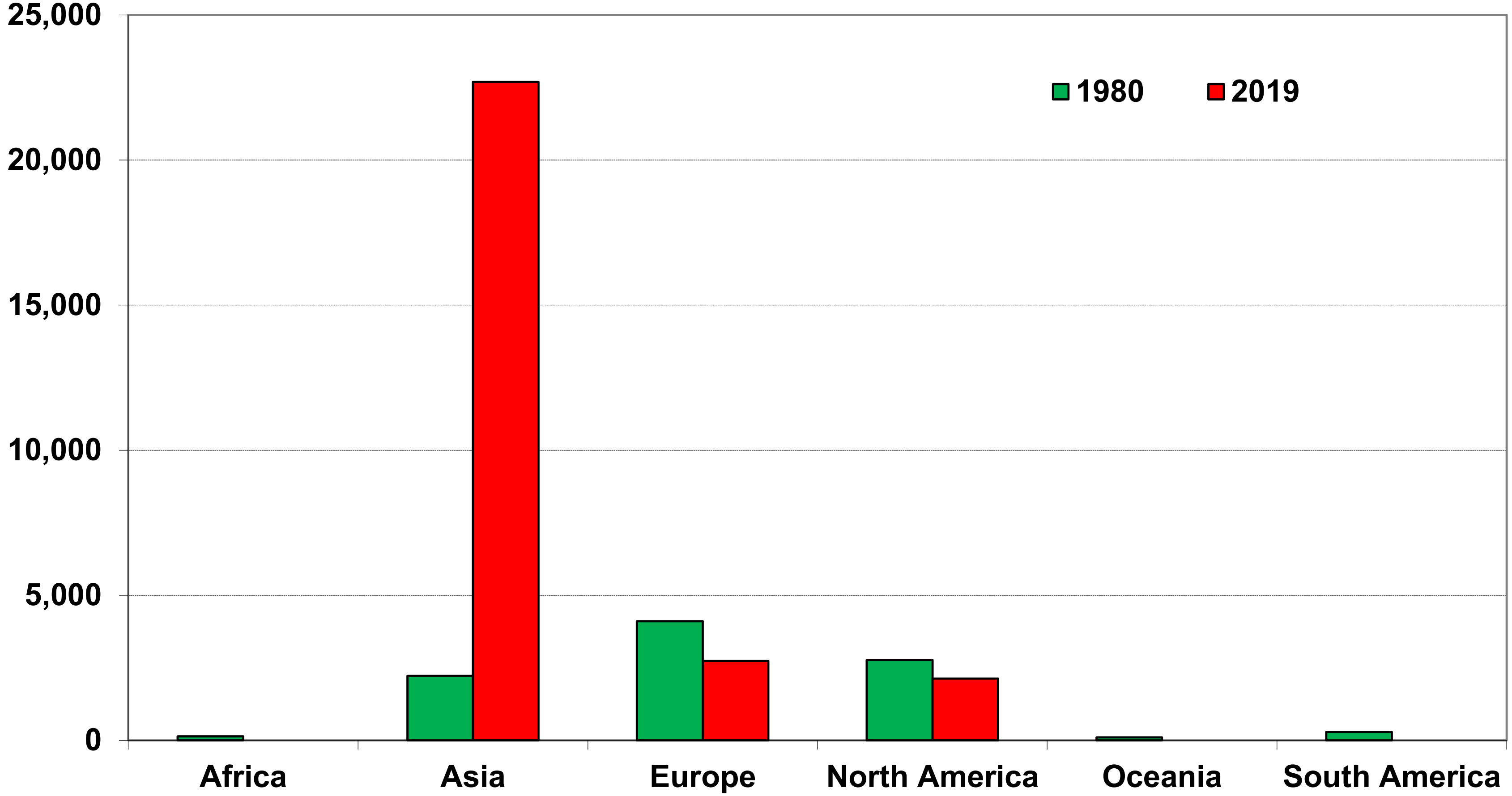

**Semis fabricators** process refinery shapes such as cathodes, wire bar, ingot, billet slab and cake into semi-finished copper and copper alloy products using both unwrought copper materials and direct melt scrap as raw material feed. Semis fabricators are considered to be the "first users" of refined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

P / Preliminary. Data for some countries still incomplete

## Copper and Copper Alloy Semis Production by Region, 1980 & 2019P

**Thousand metric tonnes gross weight**

**Source: ICSG**



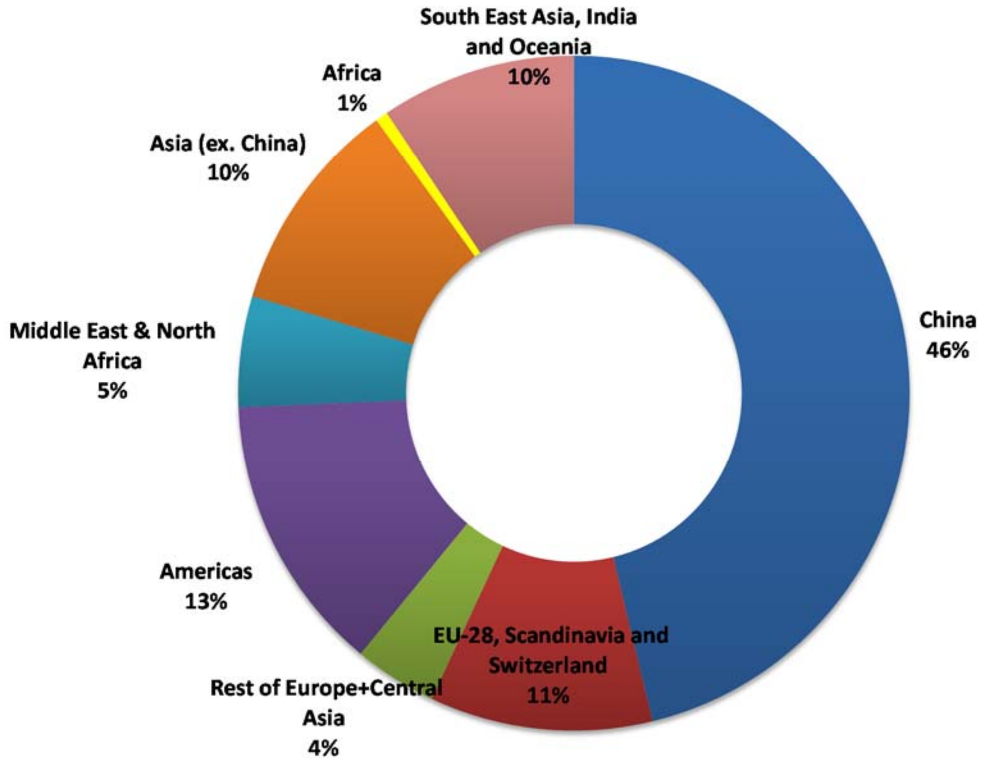

**Asia accounted for over 80% (or almost 22.7 million metric tonnes) of semis output in 2019, compared to 23% in 1980.**

P / Preliminary. Data for some countries still incomplete

## Copper & Copper Alloy Semis Production Capacity by Region & Product

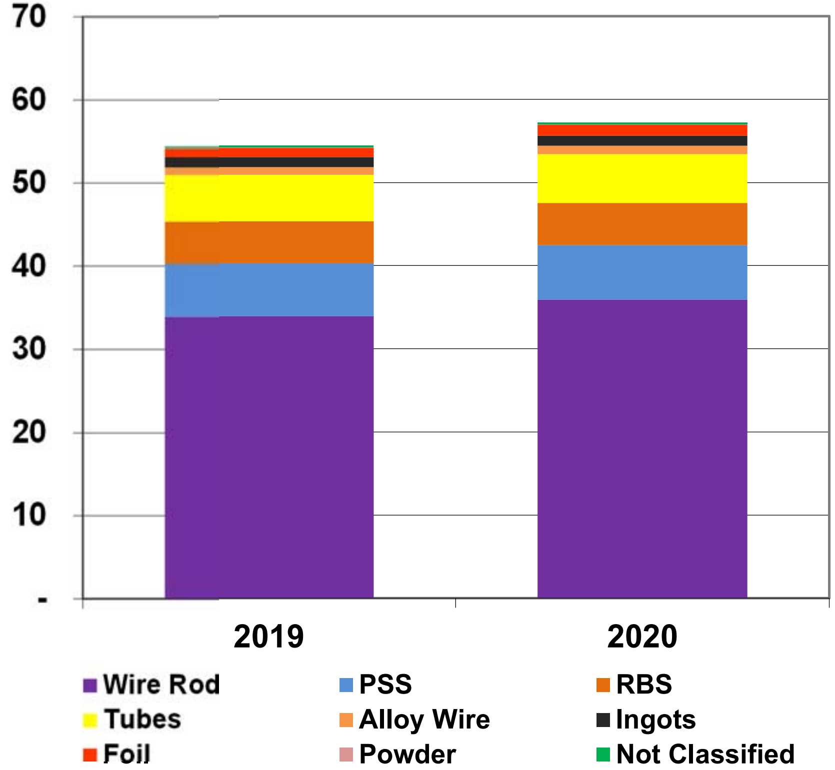
**Source: ICSG Directory of Copper and Copper Alloy Fabricators 2020**

**Semis Production Capacity by Region, 2020 (%)**
**Source: ICSG**




In 2020, **China** will account for the largest share of world semis production capacity (46%).

**Semis Production Capacity by Product, 2019 vs 2020 (million tonnes gross weight)**
**Source: ICSG**



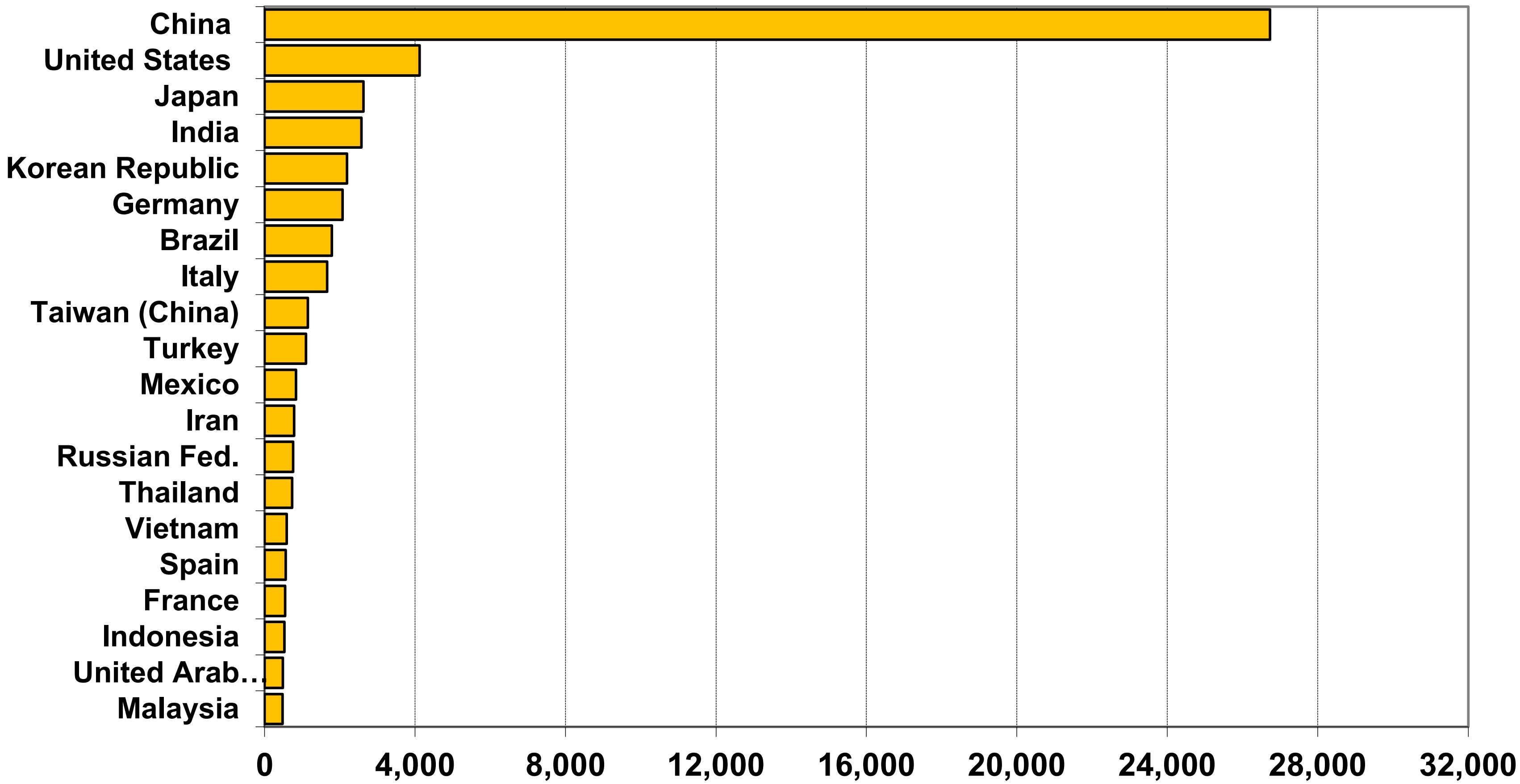

**Wire rod plants** are estimated to account for 63% of world first use capacity in 2020.

***Note: Capacity data reflects production capabilities not necessarily production forecasts***

## Copper and Copper Alloy Semis Production Capacity by Country: Top 20 Countries, 2020

**Thousand metric tonnes gross weight**

**Source: ICSG Directory of Copper and Copper Alloy Fabricators 2020**




***Note: Capacity data reflects production capabilities not necessarily production forecasts***

# Chapter 8: 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 2018, ICSG estimates that 32% of global copper use 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.

Images courtesy of the European Copper Institute.

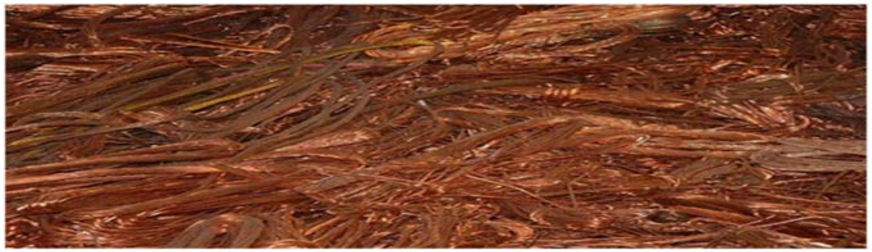
## Copper Recycling Rate Definitions

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** 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 Rate** 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.

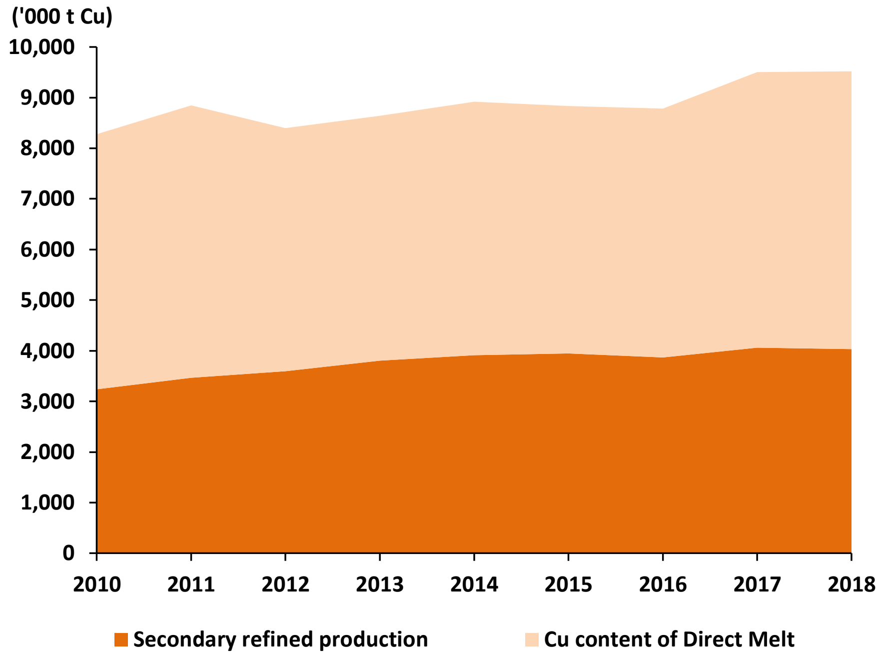


# ICSG Global Copper Use (incl. Recycling), 2010-2018

Source: ICSG Recyclables Survey April 2020

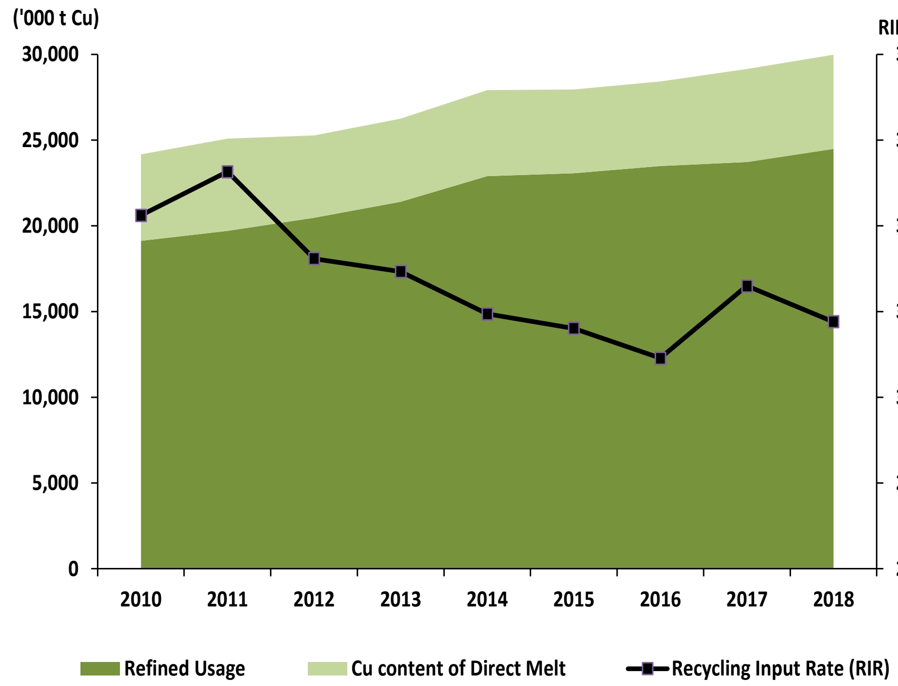
## Global Scrap Use

(incl. secondary refined production and scrap direct melt)




## Global Copper Use and Recycling Input Rate

(incl. refined usage and scrap direct melt)



# ICSG Global Copper Scrap Research Project and recent scrap reports

Based on interest expressed by 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. The final report of the project was published in August 2010. In addition, ICSG has completed a number of new detailed reports on NAFTA, European, Middle Eastern and Chinese scrap recovery and scrap supply in recent years. For more information about ICSG work related to copper scrap, please contact the ICSG Secretariat at mail@icsg.org

## Key Drivers of the Global Copper Scrap Market

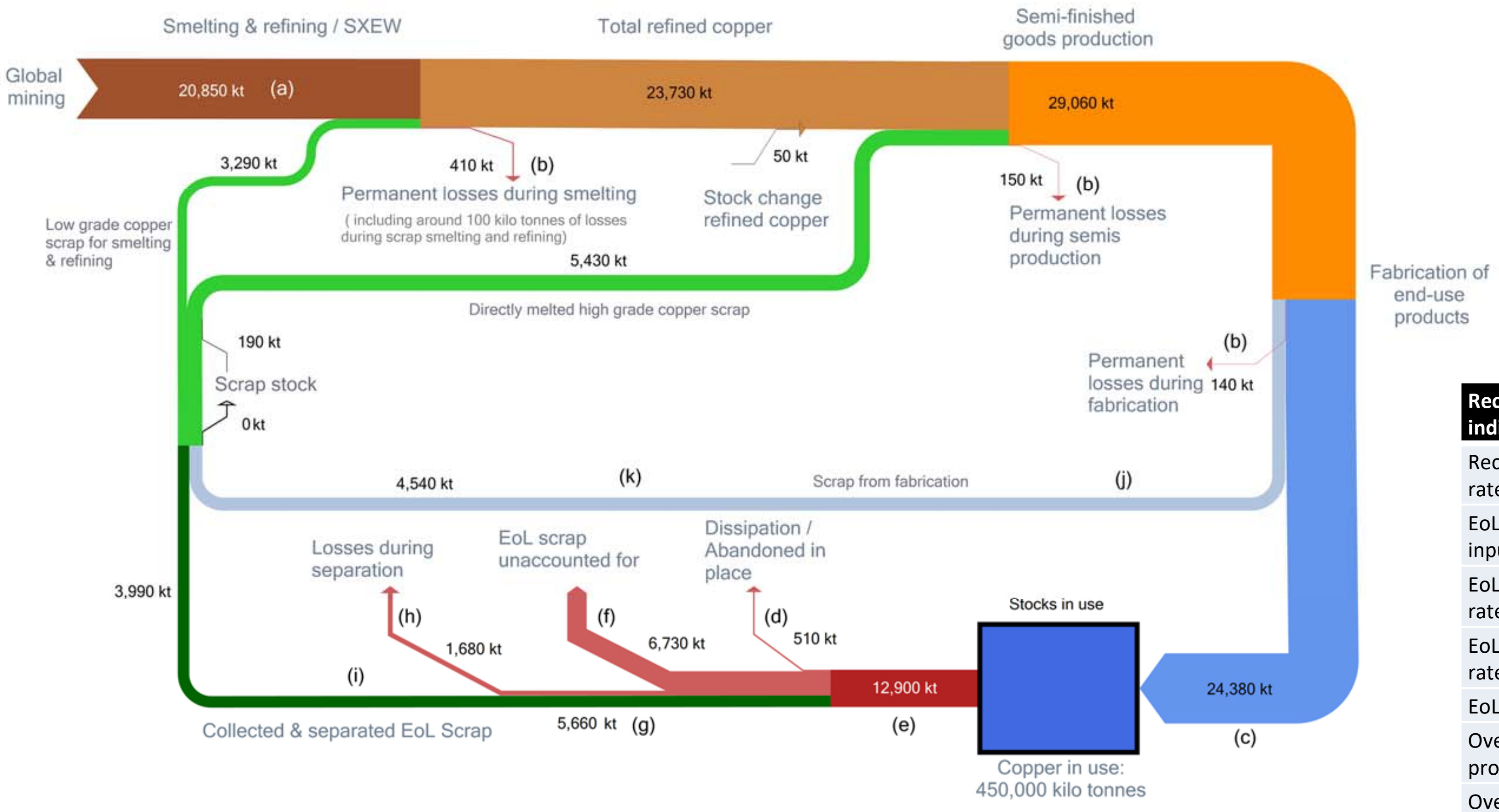
- Expanding Copper Mine Production and Refined Copper Substitution
- Industrialization and Economic Growth
- Prices
    - Copper Scrap Prices and Spreads
    - Refined Copper Prices and the Demand for Scrap
- Chinese scrap market developments
- The Shift in Regional Scrap Processing Capacity
- Regulations on Recycling and Trade
- Technology

## ICSG Global Copper Scrap Project Reports

- European Semi Manufactured Copper Products Capacity (2019)
- Copper Use in Fabrication in Japan, Korea, Taiwan (China) and Vietnam (2018)
- Industrial Use of Refined Copper and Scrap in Fabrication in China (2017)
- Manufacture and Use of Semi-fabricated copper in Latin America/Canada (2017)
- Fabrication and Copper Use in Indian Subcontinent, ASEAN and Oceania (2015)
- Survey of Brass Mills, Copper Products and Foundries in China (2014)
- Middle East and North Africa Copper Use Study (2014)
- Copper and Copper Alloy Scrap Supply Survey in EU-27 (2013)

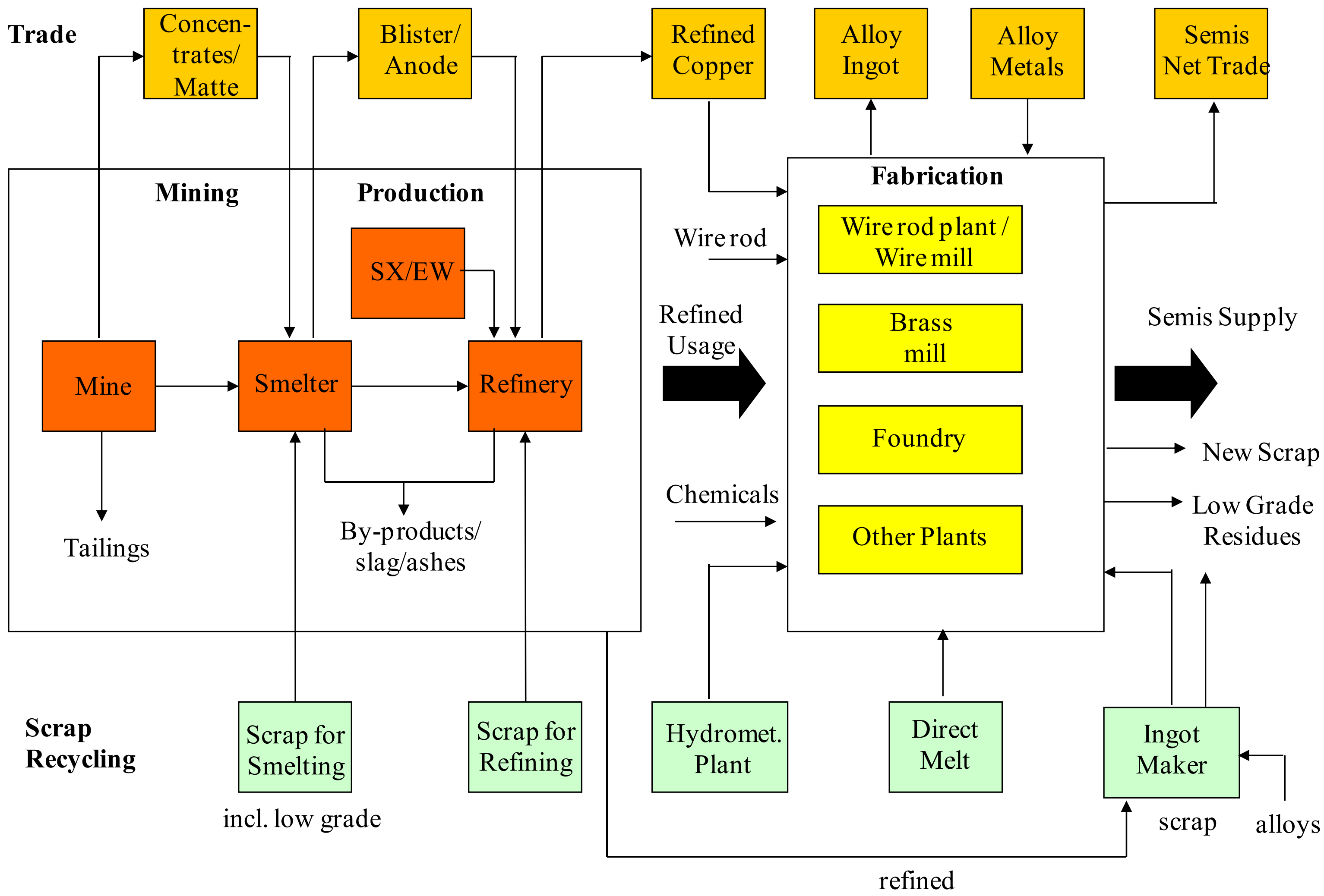
# Industry Global Flows of Copper (2018) and Derived Recycling Rates

Figures produced for the International Copper Association by Fraunhofer ISI based on Environ. Sci. Technol. **47** (12), pp. 6564–6572 (freely available under http://dx.doi.org/10.1021/es400069b).

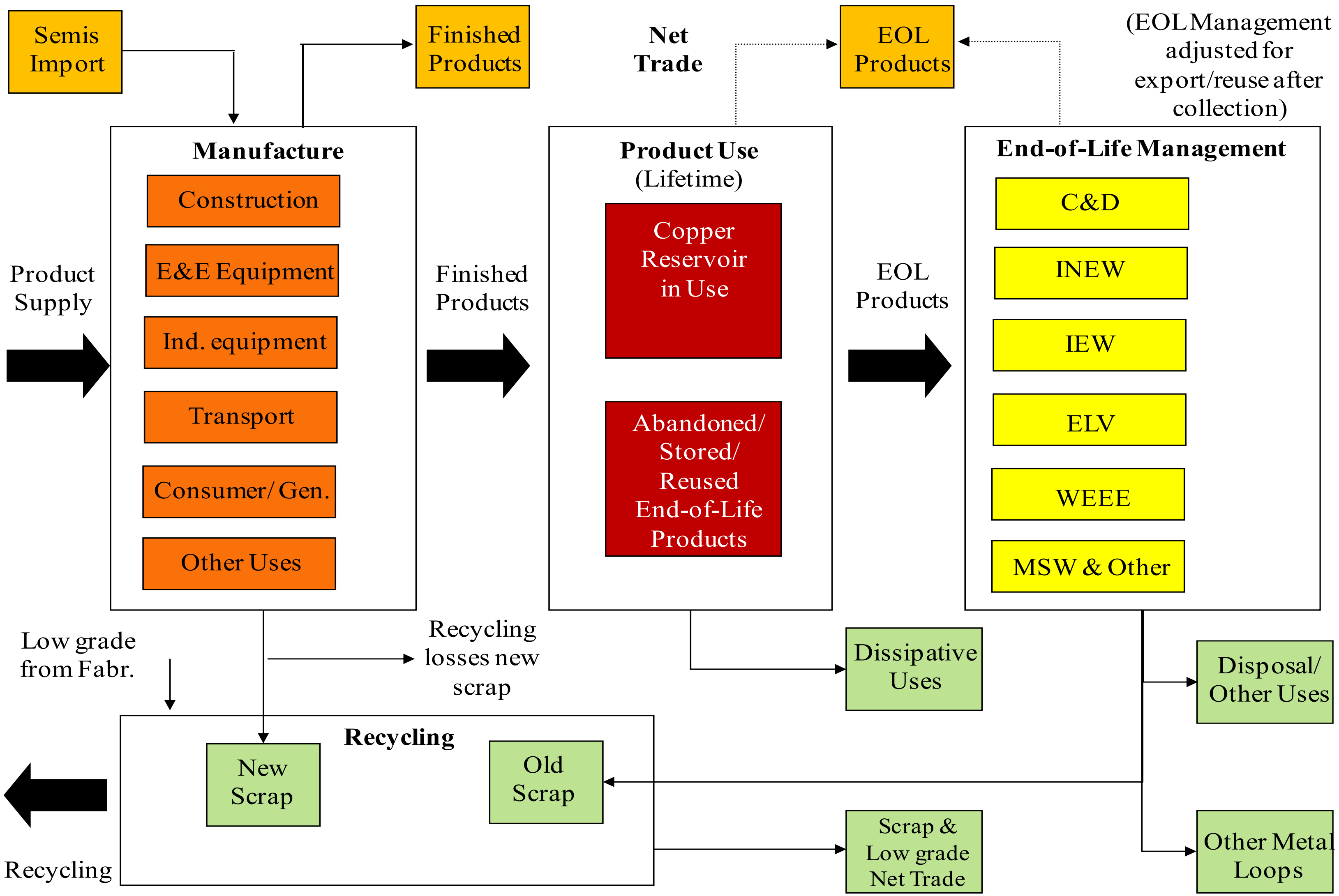



| Recycling indicator | 10-yr avg |
|---|---|
| Recycling input rate | 32% |
| EoL recycling input rate | 16% |
| EoL collection rate | 56% |
| EoL processing rate | 71% |
| EoL recycling rate | 40% |
| Overall processing rate | 81% |
| Overall recycling efficiency rate | 56% |
| Old Scrap Ratio | 51% |

## The Flow of Copper



## The Flow of Copper (cont.)



# ANNEX

## World Copper Production and Refined Usage, 1960-2019

Thousand Metric Tonnes Copper

Source: ICSG

| | Mine Production | Refined Production | Refined Usage | | Mine Production | Refined Production | Refined Usage | | Mine Production | Refined Production | Refined Usage |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **1960** | 3,924 | 4,998 | 4,738 | **1980** | 7,227 | 9,261 | 9,396 | **2000** | 13,199 | 14,793 | 15,122 |
| **1961** | 4,081 | 5,127 | 5,050 | **1981** | 7,721 | 9,573 | 9,522 | **2001** | 13,636 | 15,638 | 14,938 |
| **1962** | 4,216 | 5,296 | 5,048 | **1982** | 7,745 | 9,319 | 9,090 | **2002** | 13,487 | 15,354 | 15,133 |
| **1963** | 4,286 | 5,400 | 5,500 | **1983** | 7,824 | 9,541 | 9,510 | **2003** | 13,699 | 15,272 | 15,641 |
| **1964** | 4,443 | 5,739 | 5,995 | **1984** | 8,135 | 9,440 | 9,930 | **2004** | 14,594 | 15,918 | 16,743 |
| **1965** | 4,769 | 6,059 | 6,193 | **1985** | 8,288 | 9,616 | 9,798 | **2005** | 14,927 | 16,572 | 16,552 |
| **1966** | 4,987 | 6,324 | 6,445 | **1986** | 8,295 | 9,920 | 10,112 | **2006** | 14,983 | 17,288 | 16,917 |
| **1967** | 4,743 | 6,004 | 6,195 | **1987** | 8,620 | 10,148 | 10,293 | **2007** | 15,508 | 17,895 | 18,026 |
| **1968** | 5,010 | 6,653 | 6,523 | **1988** | 8,773 | 10,512 | 10,668 | **2008** | 15,532 | 18,191 | 17,877 |
| **1969** | 5,682 | 7,212 | 7,137 | **1989** | 9,086 | 10,908 | 11,081 | **2009** | 15,941 | 18,234 | 17,889 |
| **1970** | 5,900 | 7,592 | 7,291 | **1990** | 9,227 | 10,805 | 10,886 | **2010** | 15,987 | 18,981 | 19,130 |
| **1971** | 5,941 | 7,404 | 7,296 | **1991** | 9,373 | 10,686 | 10,563 | **2011** | 15,960 | 19,601 | 19,704 |
| **1972** | 6,541 | 8,100 | 7,942 | **1992** | 9,497 | 11,042 | 10,866 | **2012** | 16,687 | 20,194 | 20,468 |
| **1973** | 6,915 | 8,544 | 8,740 | **1993** | 9,571 | 11,274 | 10,992 | **2013** | 18,185 | 21,058 | 21,401 |
| **1974** | 7,097 | 8,759 | 8,310 | **1994** | 9,539 | 11,118 | 11,560 | **2014** | 18,422 | 22,490 | 22,908 |
| **1975** | 6,735 | 8,187 | 7,445 | **1995** | 10,070 | 11,817 | 12,043 | **2015** | 19,153 | 22,838 | 23,057 |
| **1976** | 7,289 | 8,632 | 8,539 | **1996** | 11,084 | 12,628 | 12,489 | **2016** | 20,393 | 23,357 | 23,487 |
| **1977** | 7,444 | 8,884 | 9,057 | **1997** | 11,514 | 13,425 | 13,082 | **2017** | 20,058 | 23,548 | 23,705 |
| **1978** | 7,306 | 9,030 | 9,527 | **1998** | 12,228 | 14,032 | 13,440 | **2018** | 20,565 | 24,058 | 24,484 |
| **1979** | 7,371 | 9,200 | 9,848 | **1999** | 12,767 | 14,576 | 14,223 | **2019/p** | 20,528 | 24,045 | 24,427 |

p/ preliminary

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Cardholders Address___________________________________

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