



International Copper
Association
Copper Alliance

2017 Annual Report



Global Mega Trends
and Key Markets
for Copper



CONTENTS

Copper Alliance Directory

4

ICA Value Proposition

5

Message to Membership from
ICA's Chairman and President

6

The Regulatory Landscape:
Challenges and Opportunities
for Copper

9

Copper and the 21st
Century Energy Transition

10

Copper and Pollution
Reduction in China

13

Copper in the \$140B Heating,
Ventilation and Cooling Market

14

Copper and the Circular Economy

15

Ultra-Conductive Copper

16

Copper is the Material of Choice

17

Copper in the China Five-Year
Plan and Made in China 2025

18

The Value of Membership

ICA's members represent a majority of global copper production and include some of the largest copper and copper-alloy fabricators. ICA's status as a not-for-profit trade association provides its members with a credible, independent advocate to address challenges faced by the collective industry.

The investments by its members ensure ICA is able to maintain an effective leadership position on behalf of the world's copper industry. By pooling resources through ICA, the



industry is able to accomplish much more than any single copper industry company could on its own. The commitment and ongoing investment by its membership base benefits the whole of the copper industry and is critical to sustainable development.

ICA is committed to partnering with its members to increase the percentage of industry that is funding ICA's efforts to maintain the long-term viability of copper markets.

... a credible, independent advocate to address challenges faced by the collective industry.

Members

As of 31 December 2017

Anglo American • Antofagasta Minerals S.A. • Aurubis • BHP Billiton Plc • Boliden AB • Buenavista de Cobre, S.A. de C.V. • Chinalco Luoyang • Compañía Minera Doña Inez Collahuasi • Compañía Minera Zaldívar • CODELCO-Chile • Daechang Co., Ltd. • Freeport McMoRan Inc. • Glencore • Golden Dragon Precise Copper Tube • Kennecott Utah Copper Corp. • KGHM Polska Miedź S.A. • KM Europa Metal AG • LS-Nikko Copper Inc. • Metalurgica de Cobre S.A. de C.V. • Minera Antamina S.A. • Minera Centinela • Minera Escondida Limitada • Minera Esperanza • Minera Los Pelambres • Mitsubishi Materials Corporation • Mueller Industries • Nexans • Operadoras de Minas de Nacozari, S.A. de C.V. • Outotec Oyj • Pan Pacific Copper • Revere Copper Products, Inc. • Rio Tinto Plc • Sociedad Contractual Minera el Abra • Sociedad Minera Cerro Verde S.A.A. • Southern Perú Copper Corporation • Sumitomo Metal Mining Co., Ltd. • Teck • Tenke Fungurume • Wieland-Werke AG • Yunnan Copper Industry (Group) Ltd.

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**We are a credible,
independent advocate
on issues critical to
future copper demand.**

ICA Value Proposition

WHAT IS THE INTERNATIONAL COPPER ASSOCIATION (ICA)?

- Not-for-profit trade association representing the majority of the world's copper production
- A credible, independent advocate on issues critical to future copper demand

WHY THE INDUSTRY NEEDS ICA?

- Industry is more effective, credible and efficient when it works together. ICA makes this possible.
- As an association, ICA can participate in forums, where individual commercial organizations could not.
- Without ICA, members would incur major expenditures individually, losing leverage opportunity.

HOW ICA MEETS THE NEEDS OF THE COPPER INDUSTRY

- Active in more than 60 countries
- Working in partnership with more than 500 organizations:
 - Local copper fabricators and equipment manufacturers

- Governments, regulators, United Nations and NGOs.
- Trade and other end users
- Four key contributions:
 - Market Access
 - Maintain copper industry license to operate in complex regulatory environments
 - Ensure market access for copper products
 - Market Defense/Growth
 - Prevent or slow substitution by alternative materials
 - Increase intensity of copper use in equipment (kg per unit) and in buildings (kg per m²)
 - Image/Reputation building
 - Communicate messages showing copper has a positive contribution to society
 - Position copper industry as a trusted partner of governments and non-governmental organizations
 - Align copper and the copper industry with global sustainable development goals

- Copper information
 - Ensure market commentators use accurate ICA data and informed analyses on copper end use
- Achieved through a mix of health and environmental science, codes and standard setting, direct promotion, technical innovation, market intelligence, and strong communications.

OUR VALUE TO MEMBERS IS MEASURABLE:

- Annual tonnage impact of over 250,000 tonnes.
- Insurance against long-term destruction of multi-million tonne markets such as power cable.
- Savings to industry by way of avoided costs of over \$100 million each year.
- Creation of a positive reputation for copper and the copper industry.
- Maintenance of industry's regulatory and social license to operate.



Message to Membership

The theme of the 2017 International Copper Association (ICA) Annual Report is “Global Mega Trends and Key Markets for Copper.” This Annual Report includes numerous case studies demonstrating that copper is truly a metal for the 21st century, playing a central and critical role in the clean-energy transition. The case studies also showcase ICA’s close involvement in leveraging these mega trends to ensure copper demand remains strong for a long time to come.

The material in this report is derived largely from ICA’s newly launched program to develop and disseminate accurate end-use data, market intelligence and informed analyses to commodity sector analysts and media. ICA is positioning itself as a leading authority on copper end-use markets and demonstrating the fundamentals of long-term copper demand. We invite the reader to review these examples of the strength of copper markets and the role ICA plays in developing and defending them.

Through its market development work, ICA is positioning copper as necessary to the global movement toward clean energy. All the elements of the clean-energy transition—renewables, e-mobility, energy efficiency—are favorable to copper due to the metal’s superior electrical and thermal conductivity.

A flagship program for ICA, and its main partner UN Environment, is United for Efficiency (U4E, united4efficiency.org), which is transforming markets worldwide to energy-efficient appliances, industrial equipment and lighting. U4E has more than 20 ongoing country-level projects, with financial support from the Global Environment Facility and more than two dozen project partners. U4E is leading the charge on the regional harmonization of minimum energy performance standards (MEPS) in Southeast Asia, Southern Africa, Meso-America, the Pacific Island States, and the Caribbean.

ICA’s close partnership with U4E allows us to extend the benefits of our energy-efficiency programs into new geographies through leveraged funding and partnerships, without compromising our existing portfolio of good work.

2017 also marked the first full year of operation for our new Public Affairs function. The initiative aims to ensure the copper industry maintains its license to operate and fair market access for its products, through proactive advocacy

to governments and regulators. A new and complete Public Affairs team is now in place, with individuals on-board in the key geographies leading the global regulatory agenda related to copper: Beijing, Brussels, Santiago, and Washington, D.C. We invite you to learn more about ICA’s Public Affairs strategy and supporting communications work at copperalliance.org. In addition, sustainablecopper.org provides a wealth of information on copper’s critical contributions to sustainable development; there is perhaps no metal or material as closely linked to sustainable development challenges worldwide as is copper.

As an extension of our increased efforts in Public Affairs and advocacy, ICA has strengthened its partnership and collaboration with other organizations linked to copper and the broader mining industry. In particular, we highlight our partnership with the International Council on Mining & Metals (ICMM) and the International Wrought Copper Council (IWCC). Collaboration with organizations like these allows for synergies that amplify the collective voice of the industry, and the sharing of resources allows for all parties to operate more cost effectively and efficiently.

China continues to grow in importance to copper—not only from a demand perspective, but also from a production one as well. Through ICA Asia, collaboration between the Chinese copper industry and ICA is greater than ever. In addition to supporting existing market-development programs such as power cable defense and aquaculture, new programs focusing on green manufacturing and the circular economy have been initiated. These new projects represent a new, collaborative platform where the Chinese copper industry and ICA work collectively on issues important to them. This combined strength allows ICA to expand its already impressive reach within China.

From an operational perspective, ICA is in the process of reorganizing its headquarters and associated back-office



Hennie Faul
Chairman



Tony Lea
President

functions. This includes a transition of the New York head office to Washington, D.C., which positions the organization closer to the U.S. regulatory nexus and better aligns with ICA's overall advocacy strategy. The transition will be completed by the time of the publication of this report.

The success of ICA would not be possible without the ongoing support of its members. We offer thanks, as always, for these commitments. We also offer thanks to the employees of ICA and its Copper Alliance® affiliates worldwide. The strength of any organization is the individuals within it, and ICA is fortunate to have built an amazing team of hardworking and dedicated employees around the world. Partnership with ICA's members ensures the needs of industry are met, and collaboration between members and staff remains strong.

As ever, we encourage the leaders of those copper industry organizations that are not yet members of ICA to consider joining. ICA serves the copper industry as a whole and not just its membership base, and greater participation from industry will only serve to strengthen ICA's effectiveness.

Iván Arriagada, Group CEO of Antofagasta Minerals, was elected as Vice Chairman of ICA in October 2017. Iván will serve in this capacity for one year, and he will assume the role of Chairman of the Board of Directors of ICA at the conclusion of ICA's annual meetings in October 2018. We thank Iván for this commitment to the leadership of ICA in support of the world's copper industry.





As part of our commitment to sustainability, and to help our members improve their own processes, ICA has gathered information and data to enable the users of copper to evaluate its impact and benefits across the life cycle. The result of this work is our **Copper Environmental Profile**, which features the most representative and comprehensive global life cycle assessment (LCA) data set on copper cathode and concentrate to be made publicly available to date. The profile results highlight hot spots for our members across multiple environmental impact categories (e.g., energy demand, global warming), while providing the necessary building blocks for LCAs involving copper conducted globally. Overall, this data will help ICA and our members to enhance the industry's contribution to sustainable development and take part in global dialogues on the circular and low-carbon economy transition. The LCA dataset, along with our recently completed update of global copper stocks and flows data, provide the necessary foundation for a circular economy analysis of copper.





The Regulatory Landscape: Challenges and Opportunities for Copper

ICA safeguards copper industry license to operate and fair market access for copper products

The copper industry is operating and selling in markets where metals are increasingly scrutinized in regards to human health, the environment and sustainable development (HESD). Yet copper is critical to a sustainable future, enabling e-mobility and renewable sources of energy, accelerating green buildings, electrifying state-of-the-art power grids, and reducing risks in hospitals via antimicrobial surfaces. ICA recognizes that copper is a critical material for a sustainable future and that this presents both risks and opportunities for its members. Overall, the HESD program aims to maintain the copper industry's license to operate, maintain market access for its products, and improve the industry's reputation with regard to sustainable development. It does so by developing and implementing plans to address critical issues identified by membership.

The safety of bulk marine transport is governed by the International Maritime Solid Bulk Cargoes (IMSBC) code, an element of international legislation by the International Maritime Organization (IMO). Effective 01 January 2015, IMO added several new hazard criteria to the IMSBC, including corrosivity of metals. These criteria were created to indicate that a cargo may cause corrosion on the inside of the ship hull and require the use of a test method originally designed for liquids. Designation of copper concentrates as corrosive to metals could have far-reaching consequences for the industry, including increased freight rates due to handling precautions, and reduced access to port facilities. This would result in over 150M USD annually in increased costs, as well as reputational damage. Copper concentrates have been shipped for decades in bulk, and to the best of ICA's knowledge, no major incident of hull corrosion has ever been reported.

Rather than launching an initiative to find or develop an alternative test and attempting to change the regulation—a potentially lengthy and costly venture—the ICA IMO task force first undertook a sampling and testing program to determine the viability of the required test for copper concentrates. The program was carried out at a leading laboratory in Australia and overseen by both the task force and an external expert on corrosivity of metals. The program began with reproducibility testing, moved to a design of experiments, and finished with confirmatory tests. Overall, the program was successful in determining that the test can be used for copper concentrates for the purpose of the code. In parallel, the task force worked closely with colleagues at the International Council for Mining and Metals (ICMM) to establish a global mining and minerals industry alliance. This included collaboration via data sharing, collaborative test plans, and developing and executing advocacy strategies. In 2018 the alliance will conclude findings and implement an advocacy plan to syndicate to key stakeholders.

Responsible sourcing is a critical emerging issue for the global copper industry. End users such as automakers and electronics producers are demanding increasing assurance that materials in their supply chains are not associated with poor practices across a broad range of issues. These include environmental issues such as climate change and water, governance issues in the communities where our members operate, and health and safety standards. In 2017 ICA established a task force of members to determine the best path forward. Action requires careful consideration of multiple options and their potential short- and long-term implications for the market. Currently, the task force is conducting a strategic scoping exercise to determine the viability of options going forward. These will be vetted in the second quarter of 2018, and work will begin in earnest to implement the preferred approach.

HESD will be working hand in hand with advocacy colleagues to achieve the overall goals of the ICA Public Affairs program in 2018. Focus areas include a range of activities, from working with decision makers globally to ensure life cycle-based data is utilized to represent copper in circular economy and low-carbon initiatives, to working to establish copper's utility in green and healthy building schemes.

Copper and the 21st Century Energy Transition

ICA ensures copper is a key component in Clean Energy and Energy-Saving Technologies

According to a report presented by Wood Mackenzie, a research and consultancy business for the global energy, chemicals, metals and mining industries, copper usage in three energy-related sectors is expected to increase as clean energy and energy-saving technologies replace more traditional, energy-intensive technologies. As the best nonprecious conductor of heat and electricity, copper is vital to a clean-energy future. Renewables, electromobility and energy-efficient equipment are recognized as the key pillars of the clean-energy transition and all these sectors represent major growth opportunities for copper. As such, a significant portion of ICA's efforts worldwide focus on ensuring copper's place in these markets.

WIND AND SOLAR

Wind and solar power currently constitute 12 percent of the global energy mix. Europe dominates with nearly 25 percent of its power generated by wind and solar. It is estimated that global solar and wind power will each account for over one terawatt of capacity by 2035. The rapid growth of wind-power installations, in particular,

will be a short-term copper demand driver with new installations expected to consume, on average, 550kt per year of copper over the next three years.

ICA is considered to be one of the most active industrial trade associations in the clean energy space. As an example, Leonardo Energy (leonardo-energy.org), a Copper Alliance initiative managed by the European Copper Institute in close collaboration with its partners, provides sustainable energy professionals with the knowledge to manage the energy transition. Leonardo Energy was created as a platform to connect energy technologies, policies and markets. It aims to accelerate the transition to a sustainable energy economy by advocating progressive energy policies and providing free education and training tools.

ELECTROMOBILITY

Electric Vehicles (EVs) contain more copper than conventional vehicles due to additional wiring, the electric motor and the battery. The charging infrastructure for EVs also accounts for increased copper usage.



As the best nonprecious conductor of heat and electricity, copper is vital to a clean-energy future.



Electric vehicles are expected to account for 34 percent of global sales by 2035, with over 50 percent of the EVs being hybrid electric vehicles (HEVs).

Growth will continue to come from Europe, the U.S. and developed Asian markets. China is leading the way in this booming market as a consequence of strong government direction and subsidies outlined in the China Five Year Plan and the “Made in China 2025” plan (referenced later in this report).

According to research by IDTechEx, a market research firm specializing in emerging technologies, while typical internal combustion engine cars require around 23kg of copper, a hybrid electric vehicle uses 40kg of copper, a plug-in hybrid electric vehicle uses 60kg, a battery electric vehicle 83kg, and a hybrid electric bus 89kg. A battery-powered electric bus can use between 220kg and 560kg of copper, depending on the size of battery used.

In total, copper demand from passenger car EVs is forecast to be nearly 1.9 million tonnes of copper per annum by 2035, overtaking demand from internal combustion engine cars.

ICA is currently undertaking investigative work to define the copper marketing with EV charging infrastructures, but it is already known that charging types have significantly varying copper intensities, with Direct Current public chargers requiring nearly 20kg of copper per unit.

ICA and its Copper Alliance® partners take actions that ensure copper’s critical and increasing role in e-mobility. As an example, in Europe, an industrial consortium of 13 partners—including the European Copper Institute (ECI), Aurubis Breuckmann, and major vehicle manufacturers Jaguar and Land Rover—started work in October 2017 on the ReFreeDrive project. This project has been awarded a \$6 million EUR grant by the European Commission to improve two motor technologies (copper-rotor induction and synchronous reluctance) as part of the Horizon 2020 call to create the next generation of drivetrains for fully electric vehicles.

In the U.S., spearheaded by the Alliance to Save Energy, Copper Development Association U.S. (CDA) is serving on the Alliance Commission on the Transportation Sector Efficiency (Commission), which is working to reduce energy use in the U.S. transportation sector by 50 percent by 2050 while meeting future mobility needs.

In China, ICA formed a project team in 2017 to implement our EV strategy, to provide the industry a full-copper solution, including: developing and commercializing heat pump air conditioning in EVs to grow copper tube usage; promoting small-diameter copper tube technology in electric bus air conditioning systems to defend against market penetration of aluminum microchannel heat exchangers; developing and commercializing thermal management of battery systems in EVs to use more fan motors; and facilitating Copper Rotor Motor (CRM, see next page) drivetrains in EVs.



ENERGY EFFICIENCY

The third sector studied by Wood Mackenzie for ICA and the Copper Alliance® was energy-efficient equipment, including distribution transformers, electric motors and air conditioners. These applications are among the largest electricity consumers and are also major consumers of copper. They accounted for an estimated 4.7 million tonnes of copper in 2017 or approximately 17 percent of all copper usage. A combined growth rate of 4.1 percent per annum to 9.7 million tonnes by 2035 is forecast for these applications.

All three markets are targets for energy-efficiency regulation and other initiatives, and as a result the intensity of copper use is predicted to increase, as each incremental unit of efficiency becomes more difficult to attain and thus more materials intensive. All else being equal, increased efficiency will require increased copper usage.

ICA is a recognized leader in the field of energy efficiency, including the technology and use of energy-efficient motors. Motors—and the systems driven by them—consume more than 40 percent of electricity worldwide, with that number as high as 70 percent in some highly industrialized nations.

In China motor systems account for more than 500kt of copper each year, making this a priority for ICA market development. Strategies include market transformations toward IE3 (premium efficiency) and IE4 (super-premium efficiency) motors. On the product development side, the Copper Rotor Motor (CRM), an ICA-developed technology, continues to gain market share in China and other parts of the world. While still a relatively new technology, sales of CRM in 2017 reached 150,000 units, a 25 percent increase year on year, representing a 5.8 percent share of the high-efficiency motor market, starting from a zero base in 2012.

ICA Latin America worked with the Energy Ministry in Argentina on legislation to increase the efficiency of motors. At COP23 in Bonn, in November, Argentina announced new legislation to adopt minimum energy performance standards (MEPS) for motors at the Premium efficiency level of IE3. Also in Latin America, the Ministry of Mines and Energy of Brazil published a mandatory regulation to upgrade MEPS for distribution transformers, air conditioning and refrigerators.

More broadly, ICA led the development of a new policy guidebook on energy-efficient motors as part of its leadership of United For Efficiency (U4E, united4efficiency.org). Argentina recognized this U4E resource as critical to the decision to move forward with this higher-efficiency standard for its motors.

... ICA led the development of a new policy guidebook on energy-efficient motors as part of its leadership of United For Efficiency.

Copper and Pollution Reduction in China

ICA is focused on the development and adoption of clean copper technologies in China.

Coal burning is causing an enormous pollution problem in major cities in China, including the chronic smog problems in Beijing.

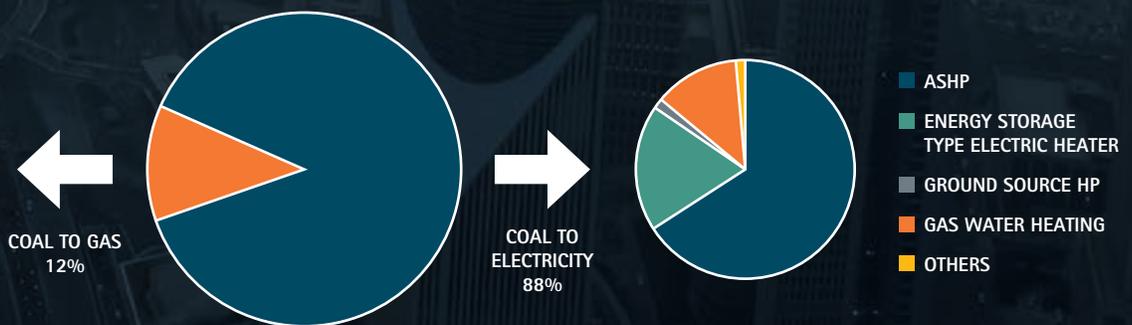
The use of air source heat pumps (ASHP) rather than coal-fired boilers is part of the solution to the pollution problem. In partnership with the China Energy Conservation Association, ICA worked to overcome initial doubt and resistance toward ASHPs. ICA developed a series of working plans for residential uptake, proposed that Beijing and North China province governments include ASHP water-heating equipment as a renewable energy product in China's 13th five-year building energy conservation plan, worked on industrial standards and specifications for after-sale service, and boosted the Product Council's building and technician installation capacity through targeted training.

The result is that 12 key cities in Northern China will invest 20 billion RMB (\$3.2 billion USD) in clean heating in the next three years. In the case of Beijing, government subsidies are currently 24,000 RMB per ASHP unit, with the remaining 2,000 RMB paid by homeowners.

For copper this means an additional 130kt of copper use between 2017 and 2020, due to the additional equipment and required infrastructure.

2016 CONTRIBUTIONS (000 tons)	
Coal reduction	50.3
SO ₂ reduction	3722
Nox reduction	805
CO ₂ reduction	70466
VOCs reduction	2012
PM10 reduction	6790
PM2.5 Reduction	5432

In 2016, Beijing completed coal to clean energy tasks for 227 thousand households in 663 villages, including coal to electricity for nearly 200 thousand households and coal to gas in 28,000 households.



Data source: Beijing Rural Work Committee

Copper in the \$140B Heating, Ventilation and Cooling Market

ICA is committed to the sustainable development of copper in the \$140B HVAC growth market

Copper's high conductivity, durability and workability give it a dominant role in the fast-growing and rapidly changing Heating, Ventilation, Air Conditioning and Refrigeration (HVAC(R)) market. Design change is a key feature of this industry, as the use of more environmentally friendly refrigerants and more efficient products are required, at a reasonable cost. ICA considers not only increasing the energy efficiency of air conditioners, but also improvement of the long-term performance of these high-energy-using products. Energy efficiency and the movement toward low-global-warming-potential refrigerants will contribute to reductions in CO₂ emissions and increased copper usage.

The HVAC(R) market comprises a variety of product types used in both residential and commercial applications, from room air conditioners and large commercial systems to commercial and industrial refrigeration. Altogether, these systems make up a \$140 billion market that has grown by 55.5 percent over the last 12 years. Room air conditioners make up the majority of the units sold, and they also form the largest sector for copper. The current market for room air conditioners requires annually just over one million tonnes of copper, compared with 430,000 tonnes for refrigeration products and 220,000 tonnes in chillers.

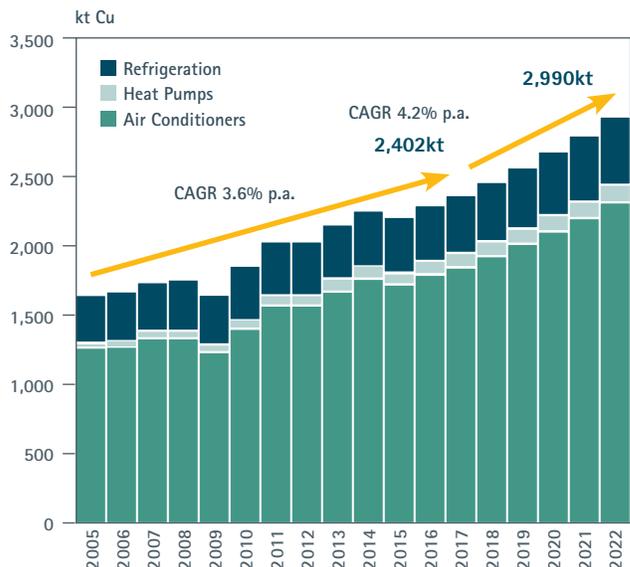
The market is set to continue its growth as countries like India, Indonesia and the Philippines have high populations as well as a high number of cooling degree days, which measure potential demand for air conditioning. Meanwhile these countries have the lowest density of room air conditioners in place. These market factors represent a significant demand opportunity for additional units.

ICA's work has been central to many recent improvements in HVAC(R) design. For example, smaller-diameter, thinner copper tubes and the inner grooving of copper tubes have been used to optimize product designs and increase efficiency in heat exchangers. These modern MicroGroove® heat exchangers have dropped to 5mm in diameter, down from 9.52 mm over the past 20 years. The MicroGroove heat exchangers are more efficient, use less refrigerant and can work with high-pressure refrigerants. Similarly, motor-driven systems have been improved to deliver better and more efficient design. High-efficiency motors are more

likely to use copper stator windings. In this way, copper's efficiency and its ability to be worked into smaller and more complex designs help to deliver reliable, more eco-friendly products for the same cost.

In China the establishment of the Refrigeration and Air-conditioning Heat Exchanger Technology Alliance (HETA) by ICA has led to further improvements in small-diameter tube design, as well as dissolution performance of lubricants in heat exchangers, and refrigerant distribution technology. Meanwhile, 5mm copper tube heat exchanger technology will be transferred to more products, such as commercial refrigeration and database station refrigeration. It should be noted that room air-con (RAC) production in China has now reached 136 million units in 2017, with about 37 million of these using 5mm copper tube heat exchangers. Meanwhile, aluminium micro-channel heat exchangers only account for 0.36 percent market share.

In summary, the HVAC(R) market will continue to adapt to climate-change mitigation and efficiency demands. At the same time, growing populations in emerging markets will increase demand for air conditioning units. Copper demand will be driven by both these factors – overall growth and growth in intensity of copper use.



Copper and the Circular Economy

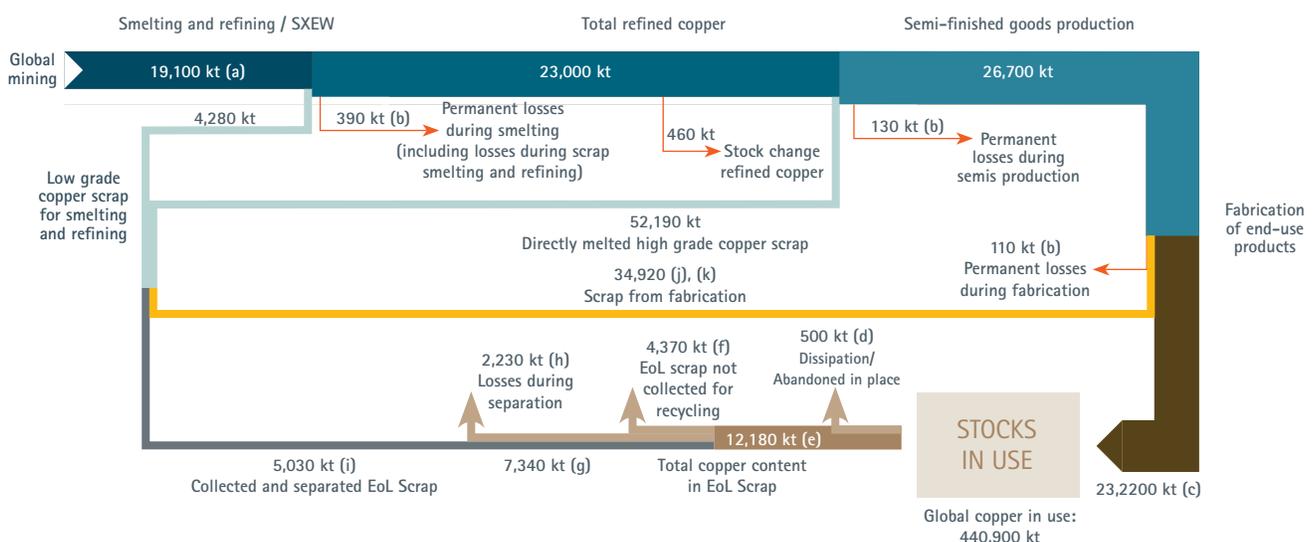
Copper's inherent recyclability provides it with advantages over competitive materials. Copper is infinitely recyclable without loss of its properties, making it important to a global movement toward a circular economy.

ICA is dedicated to understanding the contribution copper makes to the circular economy.

Commissioned by ICA, Dynamic Modelling by the Fraunhofer Institute (a research organization focused on different fields of applied science) tracks copper through time, based on the best available data, both public and proprietary. It quantifies recycling and pinpoints areas for improvement. The study examines the life cycle of copper in unprecedented detail, from copper primary production, through the production of semi-finished goods, to the fabrication of end-use products. At the end of the life cycle of end-use products, the copper becomes part of the "urban mine," and it is either recycled or becomes waste.

According to the study, approximately 440 million tonnes (Mt) of copper were in use (in buildings, machinery, computers, etc.) worldwide in 2015. Well over 26 Mt went into service that year, while approximately 12 Mt of copper contained in discarded products became available for recycling. Collection and recycling of discarded products together with recycling of manufacturing scrap yielded well over 8 Mt of recycled copper.

The study by the Fraunhofer Institute concludes that copper recycling alone cannot satisfy demand for copper. Still, the contribution of recycling to global supply can be raised through improved collection and investment in the development and use of better separation technologies for discarded products.



Ultra-Conductive Copper

ICA is committed to technological innovation in copper, building toward a more sustainable future.

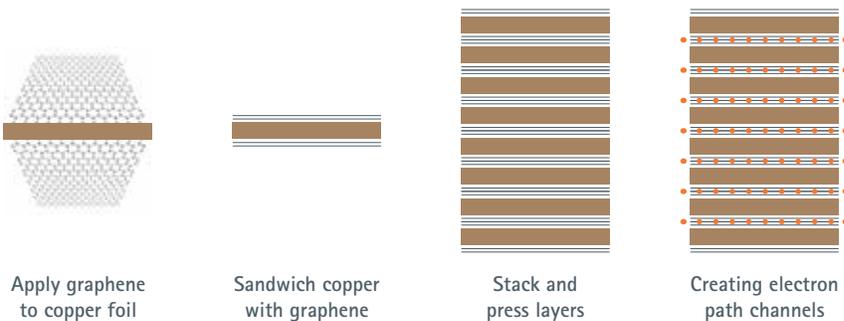
According to ICA-funded and directed research at Shanghai Jiao Tong University (SJTU), the use of alternating layers of graphene and copper has achieved a verified breakthrough, providing conductivity 16 percent higher than that of copper at room temperature.

In 1913, the International Annealed Copper Standard (IACS) was established as a method of defining the conductivity of copper wires. Copper at 20°C was set at 100 percent IACS. Today, copper at 99.99999 purity only reaches 103 percent IACS. The newly recorded 116 percent IACS conductivity at room temperature represents the most conductive bulk material ever produced. Identifying copper-based materials with a higher percent IACS at room temperature has the potential to be a game-changing technology since 60 percent of total copper usage is in wire and cable electrical conductivity applications. Improved conductors would have lower resistance, high ampacity, lighter weight, smaller size and insensitivity to temperature.

Ultra-Conductive Copper (UCC) technology could see use in all electrical applications, including data cable, magnet wires in motor stators, copper foil in batteries, circuit boards, bonding wire for lead frame to chip, chip-level connections, power transmission cable, and power cable.

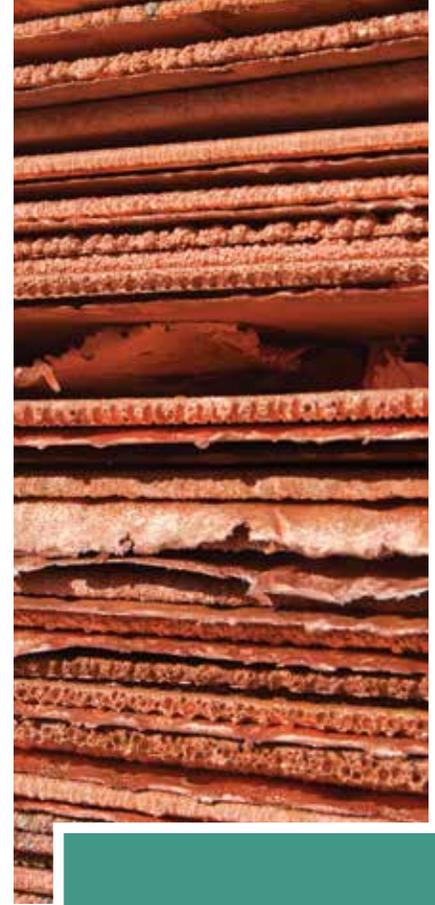
HOW IT WORKS

Graphene is applied to a copper foil and then another layer of copper sandwiches the graphene. A stack of copper and graphene layers are pressed together, creating electron-path channels, and experimental results show a dramatic increase in bulk electrical conductivity with six layers. The conductivity of the channels has been measured at 100 times the conductivity of copper.

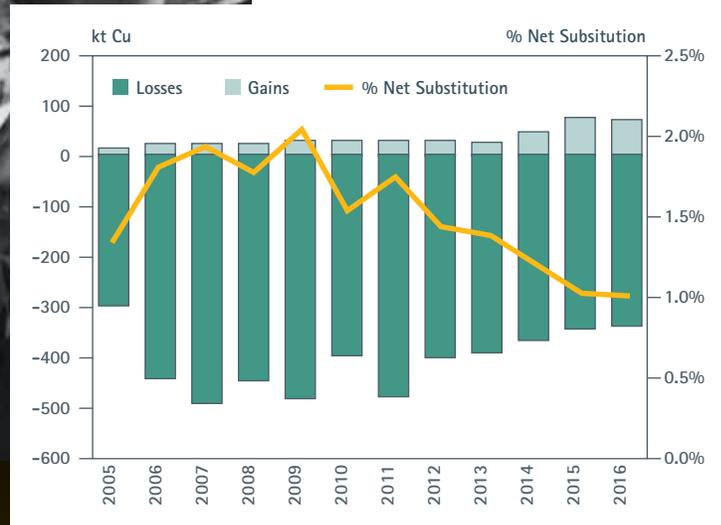


THE QUEST FOR HIGH CONDUCTIVITY

Scientific discoveries starting in the 1820s set the stage for new applications of electricity and copper. Today, the world is electrifying further, as evidenced by the expansion of renewable energy, power grids, electromobility, communications, computing and energy storage. The first applications for UCC are expected to be in motor windings and offshore power transmission. UCC enables lighter weight, more compact, more efficient aerospace and vehicle motors. UCC cables could deliver megawatts of power with smaller diameters and lower losses.



... the world is electrifying further...



Copper is the Material of Choice

ICA and its supply chain partners are dedicated to defending copper as the natural material of choice.

Net material substitution losses for copper fell to 240kt or 0.9 percent of the market in 2016, following five consecutive years of similar decline, according to work by MetalsPlus Research and Consulting.

Additional findings from the study by MetalsPlus Research and Consulting show that of the total 240kt substituted globally in 2016, China accounted for 40 percent, followed by other Asia and Oceania countries at 23 percent, Europe and Africa with 19 percent, and the Americas at 17 percent. The higher amounts in Asia are reflective of the considerably larger size of those markets. Further, the research revealed decreases in material substitution across all product applications examined in the report. Those categories, and the percentage they represent of the total net substitution include copper tube (12 percent), power cable (19 percent) and other mill and non-mill products (29 percent).

Copper also made some substitution gains in 2016 totalling 84kt, including copper tube and copper/copper alloy plate, sheet, strip and foil (31 percent), and wire and cable (43 percent). The net substitution figure for copper incorporates gains as well as losses.

A key element of ICA's Mission Statement is to "to develop and defend markets for copper." With a broad market-development program encompassing about two-thirds of its budget and executed by its Copper Alliance®

partners, ICA is the only organization worldwide focused on ensuring copper is the material of choice.

Defensive programs minimize the substitution of copper by other materials in end-use markets, for example, the promotion of small-diameter copper tube in air conditioners to defend against substitution by aluminium (microgroove.net), mentioned earlier in this report.

There are also great examples of markets where copper is now finding a new foothold. Flint, Mich., was in the global spotlight due to hazardous human health conditions from lead water service lines. Copper Development Association U.S. (CDA) successfully advocated for the replacement of lead with copper service lines. By the end of 2017, 40 miles (64 km) of copper tube were delivered to Flint, destined to make the drinking water in Flint's homes safe again. This effort would not have been possible without collaboration between CDA, five global copper producers, three copper tube fabricators, as well as dedicated advocates on the ground in Flint, like Mayor Karen Weaver.

In parallel with defensive programs, growth programs create new markets for copper, including Antimicrobial Copper® (antimicrobialcopper.org) and copper in aquaculture (cuaquaculture.org), both of which made inroads into new markets in 2017.

Copper in the China Five-Year Plan and Made in China 2025

ICA recognizes the importance of China to copper demand and dedicates its largest team to the further development of the market.

China's "13th Five Year Plan" (FYP) covers economic development in multiple industries and markets, from 2016 to 2020. The plan includes five key copper-intensive end-use markets: building construction, power infrastructure, transportation, home appliances, and electronic information. This FYP is focused more on growth on industrial scale, for example, the number of vehicles likely to be produced, or monetary investment in the power grid (distribution network).

In contrast, "Made in China 2025" is a long-term strategic plan, aiming to upgrade China's manufacturing system and the quality of domestic products, over a ten-year horizon. This includes promotion of high-efficiency and green products. The plan emphasizes "pattern growth," for instance, the efficiency of electrical applications (transformers or motors).

Both plans are national-led initiatives published by the central government of China and can be seen as the most important guidelines for growth of the overall economy, as well as the copper industry for China over the next five to ten years.

Analysis of the 13th Five Year Plan by All China Marketing Research, which studies and analyzes data and information on the macro economy, industrial sectors, enterprises and business markets in China, shows an estimated 16 percent increase in copper demand compared to the previous FYP. In the sectors analyzed demand for copper is expected to grow from approximately 28 million tonnes to 32 million tonnes.

A detailed look at the data shows the power infrastructure sector is expected to see a growth in copper demand from 4 to 5 million tonnes. Within this sector, China is expected to add 470 gigawatts of power to its infrastructure. Thirty-one percent of that new power generation will come from wind and solar PV.

The building construction market is forecast to increase 14 percent, from 12.6 to 14.4 million tonnes. Non-electrical applications such as heating, ventilation, and air conditioning, hardware, and water and gas will account for 75 percent of the anticipated copper demand.

Within transportation, the electrical vehicle market is expected to see significant growth under the 13th FYP. The number of electric vehicles on the road is expected to increase over 830 percent, from 480,000 to 4.5 million units. In parallel, the number of charging stations will grow from 2,000 to 12,000, and charging piles will increase from 240,000 to 4.6 million.

The Chinese government's Made in China 2025 initiative will also have a significant impact on copper demand in China, according to research by Brilliance Consulting, a Shanghai think tank.

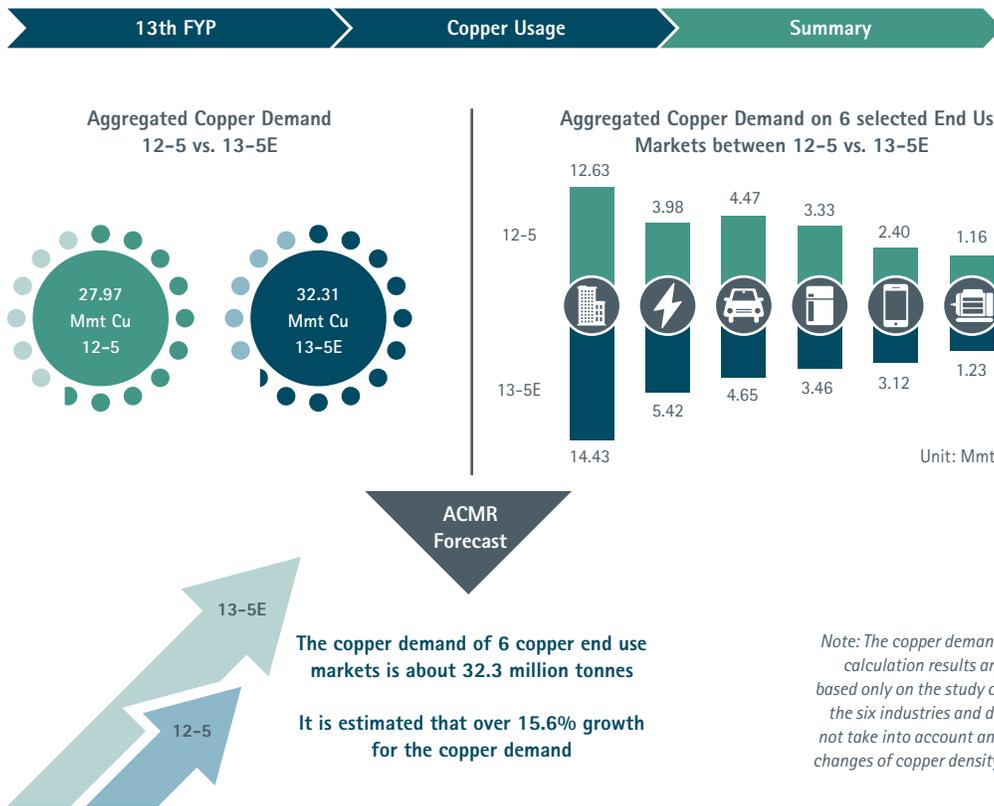
As China upgrades its industry through increased efficiency and the use of "smart factories," copper intensity is projected to rise in areas such as transportation, electric power equipment and industrial robots. The projected growth in demand is in addition to natural growth experienced by the market.

As China adopts higher-efficiency motor standards, copper intensity in this sector is forecast to increase from 0.87 kilograms of copper per kilowatt (kg/kw) in 2015 to 1.56 kg/kw in 2025. Similarly, higher-efficiency distribution transformers will use more copper.

Another potential boost for copper will come from the Made in China 2025 goal of developing a more advanced railway network. The study notes that more double-line railway construction in the future is likely to increase copper use per km, from the current 5.1 tonnes to 6 tonnes by 2025.

Overall, growth in these key sectors and others will be driven by the Made in China 2025 initiative. The plan's focus on efficiency creates a strong opportunity for increasing copper intensity of use.

Summary – Aggregated Copper Demand on 6 Selected End Use Markets between 12-5 and 13-5E



The plan's focus on efficiency creates a strong opportunity for increasing copper intensity of use.



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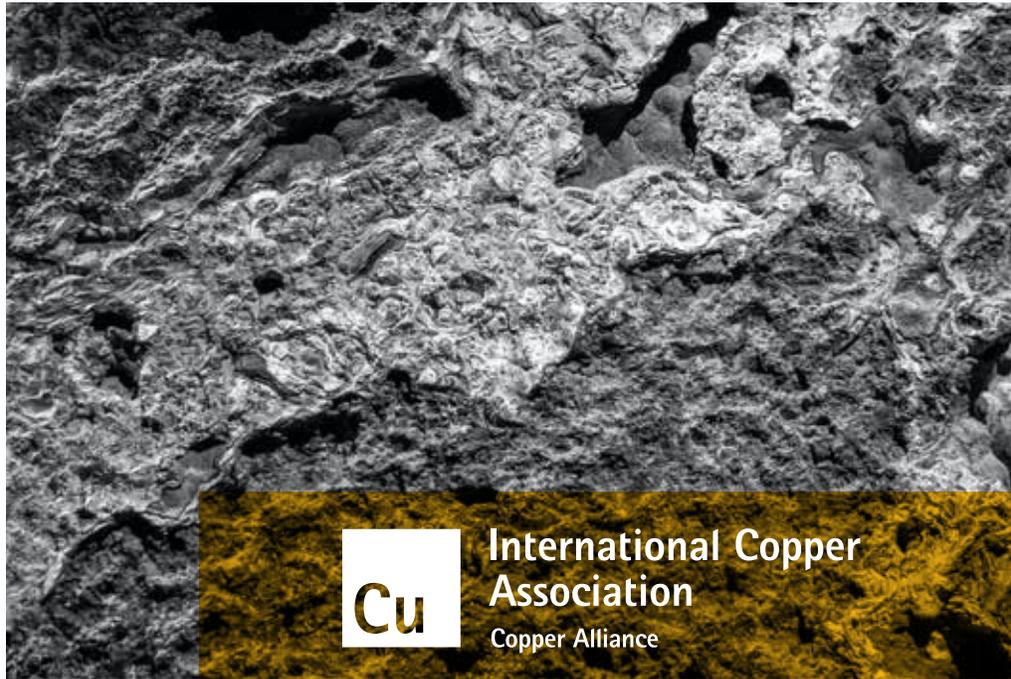
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