

International Copper
Association
Copper Alliance

2013 Annual Report



OUR MISSION STATEMENT

Our mission is to defend and grow markets for copper based on its superior technical performance and its contribution to a higher quality of life worldwide.



MEMBERS**(AS OF 31 DECEMBER 2013)**

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

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ICA: ITS POWER AND ITS VALUE

We present a strong, united voice for the world's copper industry

- Our members represent a majority of the copper value chain
- We partner with more than 500 organizations globally
- We actively work for the industry in nearly 60 countries



Together, we are protecting the long-term viability and growth of the global copper industry.

- Our programs create 200,000 incremental tonnes of demand for copper each year
- We deliver a 10x return on investment to our members

We focus our efforts in three areas: Market Growth, Market Defense and Market Access

- We provide the industry with a license to operate
- We protect market access and develop strategies that drive demand
- We develop new copper markets
- We reposition existing copper applications more favorably versus competitive materials
- We connect copper and the copper industry in a positive way with critical areas of societal concern

Championing a better future for copper.

MESSAGE TO MEMBERSHIP FROM ICA'S CHAIRMAN AND PRESIDENT

Copper and the copper industry are positioned to make a positive impact on many of society's greatest challenges. Despite the superior characteristics of copper and its positive impact on the world, the copper value chain was under increased pressure in 2013. The upstream mining sector was challenged to reduce costs across all phases of production, while the downstream fabricators continued to suffer from substitution of competing materials and the resultant erosion of some end-use copper markets.

In line with these supply chain challenges, ICA responded by presenting a reduction in its 2014 budget of 14 percent, or \$10 million, which the Board approved last October. ICA management remained highly focused on delivering on its Value Proposition to members. Central to this are actions that will positively impact global copper demand by one million tonnes over the next five years. This provides members with a return on investment of ten to one. Throughout this report you will see examples of ICA's tonnage impact on copper markets worldwide. We highlight a significant tonnage-related success below.

ICA through the Copper Alliance™ advocates for codes and standards that ensure copper's role in the future. In China ICA worked with government officials and electrical engineering experts to develop the first-ever code for electrical standards in rural dwellings in this rapidly expanding market. The new code specifies copper for indoor wiring systems and this applies to all types of residential dwellings, which will increase copper consumption by 30,000 tonnes per year based on this standard alone. The code also calls for the increase of

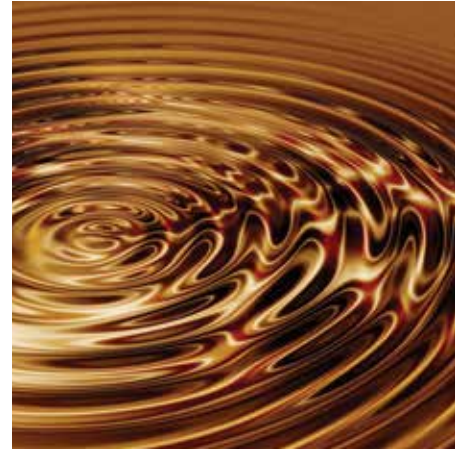
copper wire density from 0.06 to 0.09 kilograms-per-square-meter in rural dwellings by 2020. This is a good example of how ICA protects not only today's copper demand, but demand in the long term as this increased density could result in 150,000 additional tonnes of copper demand.

The complete ICA Value Proposition cannot be articulated purely in tonnes of copper. When we speak about maintaining the long-term viability of the copper industry, a key component relates to ICA's leadership on market access issues. Case in point: the International Maritime Organization (IMO) proposed legislation for the transport of bulk cargoes across open water. Through these new regulations copper concentrates were in danger of being classified as hazardous substances, and the additional costs for complying with IMO classifications would be significant. Through ICA's leadership and its credibility among the regulatory community, and with the body of science it has developed over the years, nearly all the concentrates in question were not declared to be hazardous. The associated cost savings to industry amount

to as much as \$100 million per year—every year. Without ICA, this would not have been possible and this successful effort on behalf of industry is a sterling example of the value of ICA membership.

Another essential element of ICA's Value Proposition is the ability to provide a credible, noncommercial voice for the copper industry. For many years, ICA has been able to successfully partner with governments, nongovernment organizations (NGOs), financial institutions and other groups in multiple areas of importance to copper. These partnerships have provided the copper industry with a stellar reputation as thought leaders in a number of important areas of societal concern, including energy efficiency, public health, sustainable development, and more. As an example, ICA was invited to participate in a panel discussion at the United Nations on energy efficiency. The event was chaired by the UN Undersecretary General, and the panelists included UN Ambassadors and other high-level speakers. The main purpose of the panel was to discuss the need for increased partnerships with industry on efforts to reduce global energy consumption. *ICA was the only organization asked to participate on behalf of industry, a real testament to the credibility the copper industry has achieved in the area of energy efficiency.*

To ensure that ICA continually sharpens its focus to best represent its members and make a difference for copper, we embarked on a listening tour of the membership and more than 70 member company representatives—from across the copper value chain and from all levels of the ICA governance structure—provided their perceptions of ICA and its Copper Alliance™ partners. The survey results were shared with the Board of Directors last October. This member feedback is the basis of a project to sharpen the focus of the ICA and what it does for its members, and its value to the industry as a whole. This project continues as of this writing. Crucially, this effort will help to refine the ICA Value Proposition



and to reshape its activities so that the long-term viability of the world's copper industry is more secure.

As a result, going forward ICA will focus its energies on compelling, high-impact actions that deliver measurable value to the industry. This report takes this guidance to heart and readers of previous ICA Annual Reports will notice the 2013 report is much more concise, and content is limited to key achievements. Not all ICA initiatives are represented in the report, but that is not a reflection on their contributions to the complete ICA Strategic Plan.

As always we call upon our members to support efforts to increase participation in ICA. Current membership represents approximately 60 percent of global copper production, but ICA's programs benefit the whole of the copper industry. ICA's Value Proposition is strong and it is incumbent on the organization—members and management alike—to speak as a collective voice in support of copper markets worldwide and to ensure the long-term viability of the industry.

Member dues are critical in enabling ICA to protect the long-term viability of the copper industry. Of equal importance, to ensure ICA functions at its highest level, is active member involvement in the organization's governance. We encourage our member company representatives to

collaborate with ICA program managers in any and all areas of importance to your organizations. ICA's network of partners continues to grow and, as always, we offer thanks to all these valued partners, and to the Copper Alliance™ employees worldwide. We invite you to learn more about the ICA. The Copper Alliance™ and the Value Proposition in the following pages of this report, and through your continued support of the organization's ongoing mission.



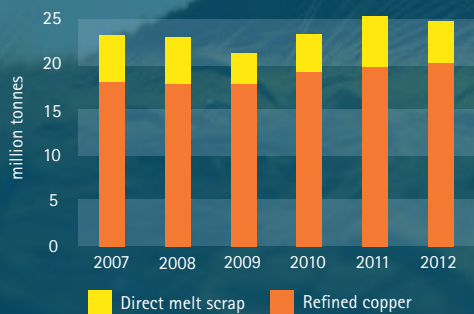
Peter Beaven
Chairman



John J. Holland
President

UNQUESTIONABLE VALUE TO THE COPPER INDUSTRY

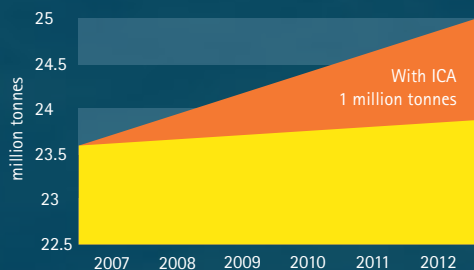
Our programs impact copper tonnage by ensuring access for copper products and by growing and defending copper use in individual markets



PERSPECTIVE: GLOBAL COPPER USE

Copper demand is met primarily through the supply of refined copper and through the use of direct melt scrap. Our programs do not distinguish between these two critical supply sources.

As indicated in the chart, copper end use has fully recovered from the 2009 downturn caused by the global financial crisis, reaching an all-time high in 2011, followed by a slight decline in 2012.



OUR ADDED VALUE

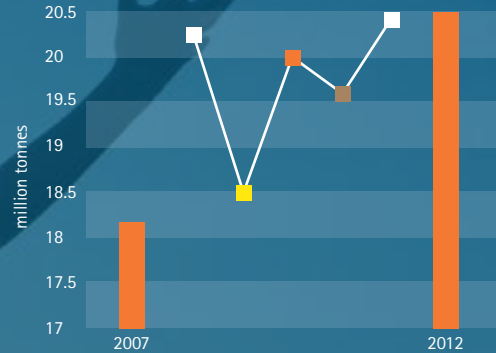
In any given year, we estimate our positive influence on the market to be 200,000 tonnes.

We think about our programs in five-year intervals, the most recently assessed being 2007 – 2012. Accordingly, the total market in 2012 was 1.0 million tonnes more than it would have been without our programs over the past five years.

MARKET PERFORMANCE INDICATORS

Focusing on the market for refined copper, the changes in demand have been driven by:

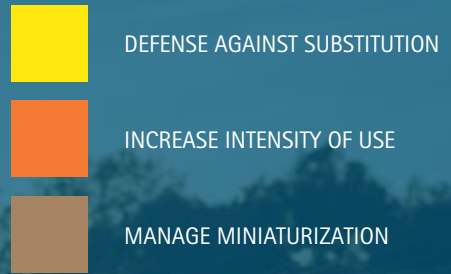
- Global economic growth and the growth in China, in particular.
- A reduction in demand due to substitution.
- Increases in intensity of copper use, for example, caused by the gradual trend to increase energy efficiency in electrical equipment by adding more copper. This is a source of significant copper growth.
- While some people put more copper in to make items more efficient, others reduce the amount of copper. This is not necessarily negative, as it can make copper-containing products more competitive.
- A switch from scrap to refined use over this time period.



WHERE THE ICA OPERATES

We operate within the middle three squares.

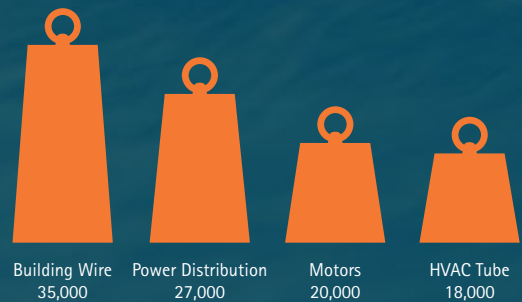
- Our programs keep substitution down.
- We work to increase intensity of use through promotion of energy efficiency and lobbying for improvements in building wire codes.
- Our technology programs are instrumental in managing miniaturization and in doing so, making copper more competitive.



HOW WE MEASURE

To determine the effectiveness of our programs, we have conducted 43 tonnage impact assessments since 2004.

The 26 assessments conducted since 2009 account for about 40 percent of our tonnage delivery programs with an impact of 148,000 tonnes per year. Thus, the estimated 200,000 tonnes in positive influence is conservative.



ASPIRATIONS AND PROBABILITY FOR SUCCESS

Our 2014 operating plan indicates an expected tonnage delivery of approximately 1.5 million tonnes or about 300,000 tonnes per year over the next five years.

ICA management assumes a conservative 66 percent probability of success, meaning that the projected positive tonnage impact is around 200,000 tonnes, consistent with historic performance.





ICA: STRENGTH THROUGH COLLABORATION

The most important assets a member can provide to ICA are time, knowledge and expertise.

ICA is a member-driven organization with a robust governance structure. Our members work directly with ICA staff to shape critical programmatic content throughout the whole of the global network.

The ICA governance structure provides for bottom-up direct member interaction that begins at the local copper centers collectively branded as the Copper Alliance™. Regional Councils in each of ICA's four geographic areas (Asia, Europe and Africa, Latin America and North America) provide oversight into the regional programs, and these groups are supported by regional steering committees and working groups. Some of the more complex, globally focused initiatives have global-level members' steering committees. All these groups collectively guide the organization's highest-level governance bodies: the Program Review Committee (supported by the Advisory Committee) and the Board of Directors (supported by the Executive Committee).

2013 was the second year in a five-year Strategic Plan developed through strong collaboration between the members and management of ICA. Although this plan sets out a long-range vision, its strength lies in ICA's ability to be nimble—to recognize that the industry is constantly changing—and to respond quickly to the changing needs of its members.

ICA's structure provides members with multiple touch points where they have ongoing input into the strategic plan. The Advisory Committee reviews the plan annually and programmatic shifts are made: some initiatives are deprioritized while others are augmented, based on multiple

criteria including market conditions, threats and opportunities. Ultimately the Program Review Committee (PRC) is responsible for reviewing progress against the ICA Strategic Plan. At the beginning of each year ICA management develops key milestones that align with the objectives in the 2012 – 2016 Strategic Plan and deliver against the ICA Value Proposition. PRC members need to approve these milestones and assess progress against them before the end of the year. This governance process continues to evolve; going forward, the PRC will focus its attention on core initiatives that represent a vast majority of ICA's tonnage-impact programs. The Management Committee will review progress against the core support initiatives and under-performing programs will be revised to meet planned objectives or the program will be terminated.

The most important assets a member can provide to ICA are time, knowledge and expertise. An active membership ensures investments made in ICA result in a positive return. The collective support and guidance of the membership ensures continuing value is realized, and that the long-term viability of the world's copper industry is protected.



COPPER ALLIANCE™ PROJECT DELIVERS INDUSTRY SAVINGS OF \$50 TO \$100 MILLION PER YEAR



ICA and the Copper Alliance™ advocate and influence decision makers on behalf of the copper industry. Success is manifested in the activities related to preserving and expanding the critical position of copper in codes, standards and broad regulatory frameworks. This work has been essential in maintaining the copper industry's license to operate and in ensuring market access for copper products.

The Copper Alliance™ is strong, built upon collaborative relationships both within and beyond the copper industry allowing the Alliance to leverage expertise to achieve positive results and provide value for its members.

The Challenge

In early 2012 the International Maritime Organization, under the auspices of its MARPOL convention, adopted new global regulations covering the discharging of residues from solid bulk cargoes. Suppliers/shippers of solid bulk materials were required, by year end 2012, to comply with the revised regulations, designed to prevent marine pollution.

The main business consequence of these regulations was that the residues of solid bulk cargoes, which require classification as "harmful to the marine environment" (HME), could no longer be discharged into the sea (a traditional practice) after 1 January 2013. Classified dry residues and/or wash water would have to be discharged at specialized port reception facilities.

The Assignment

In May 2012 members asked us to help them meet these new obligations. Specifically, to lead a project on how to appropriately classify solid bulk cargoes, such as copper concentrates, and identify those that justify classification as HME.

In addition, members wanted to utilize the Copper Alliance™'s relationship with regulators and asked us to develop a unified position that could be used by nonmembers. We created a business venture, and as of 31 December 2013, seven nonmembers have accepted this service.

Working with member experts, the Copper Alliance™ tested a representative set of concentrates and developed a novel scientific approach to determine the HME classification. Of the 117 concentrates tested, the vast majority (96 percent) did not merit classification. To complement this, we created a briefing document for regulators, along with a generic Excel model which allows any member to quickly determine if a shipment's chemical composition warrants HME classification. To complete the circuit, the model automatically prepares a standardized IMO statement for the shipper.

The Value for Members, Return on Investment

The International Copper Study Group reports an annual trade in copper concentrates of +/- 20 million tonnes (+/- 6 million tonnes contained copper). Assuming that 90 percent goes by sea, this equates to 1,800 cargoes. Based on individual member experiences (cleaning costs and vessel delays), and assuming that 96 percent of cargoes are exempt across the whole industry, the avoided costs range from \$50 to \$100 million per year.

Because the Copper Alliance™ led this program, member companies were also able to save funds (e.g., avoid individual consultancy expenditures) and, even more importantly, present a common classification protocol across the bulk of the global copper concentrates business. This has already been of significant value during individual member discussions with regulators, port authorities, ships' captains, etc.

Given the diversity of copper concentrates, it is important that we find a robust process to differentiate between classified and nonclassified shipments.

The Successful Outcomes

The IMO Marine Environment Protection Committee agreed (16 May 2013) that under very specific conditions and until 31 December 2015, wash water from holds, previously containing solid bulk cargoes classified as HME, may be discharged outside special areas. This provides a benefit for members, whose products may be affected by these new regulations, to work with their ship masters and port authorities to implement the necessary safeguards.

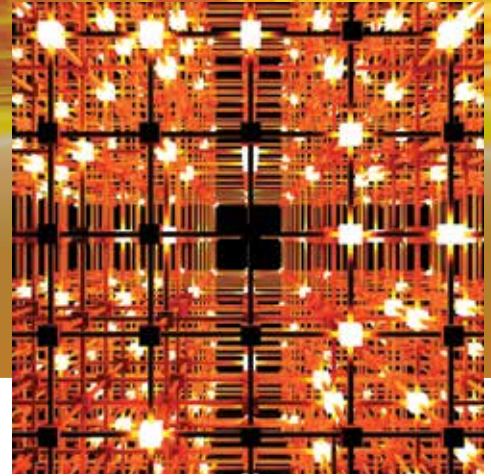
As part of our efforts to gain regulatory acceptance of our technical approach, bi-lateral meetings have been held with key IMO countries. In addition, the IMO wants to develop lists showing whether or not a material is HME. Given the diversity of copper concentrates, it is important that we find a robust process to differentiate between classified and nonclassified shipments. ICMM is coordinating this multi-metal work.

We are now supporting member compliance with the equivalents for human-health and physical-chemical (e.g., corrosivity and flammability) classifications. The International Maritime Solid Bulk Cargoes Code efforts on identifying "Materials Hazardous in Bulk" are underway, with proposals required by year end 2014. The emphasis will be on the safety of ship workers as well as of those loading and unloading cargoes. The current regulatory pressures, on lowering safe limit values for lead, could influence this work's outcome.



In 1973, International Maritime Organization (IMO) adopted the International Convention for the Prevention of Pollution from Ships, known as MARPOL. This is the main international agreement covering prevention of pollution in the marine environment by ships from operational or accidental causes.

INCREASING COPPER IN TRANSFORMERS LEADS TO ADDED PROFITS AND EFFICIENCY GAINS



Much has been said about the world's growing need for energy, from expanding markets in Asia and Latin America to higher efficiency standards in North America and Europe.

Electricity is one of the world's most sought-after commodities for the power and opportunities it provides. While everyone needs electricity, getting access to it safely, reliably and efficiently can be difficult. Globally, approximately 9 percent of the electricity generated is lost from start to finish.

Copper Increases Efficiency

Transformers channel the flow of electrical energy. In a typical network, voltage is transformed, i.e., increased or reduced, six to eight times from the power station to the consumer. With large amounts of this valuable resource getting lost in the transfer, the natural question is: how can this process run more efficiently? A simple fix involves adding more copper to increase efficiency and reliability. Most losses occur in the transformer core made up of magnetic steel or in the electrical coils or windings constructed from either aluminum or copper. Our programs support the reduction of energy losses by increasing the amount of copper used in transformers.

Copper Increases Profit Margins

How do we do this? One way is to promote the "total cost of ownership" instead of the initial cost of ownership. The argument "but copper costs more," is easily countered by a few simple facts. Copper reduces load loss because it is a more efficient conductor. By reducing load loss, copper helps increase profit margins. Power utilities may initially pay more upfront for copper, but lower losses of electricity

throughout the life of the equipment lead to a higher return on investment. Additionally, utilities are usually subject to government penalties if their service is unreliable. Some countries impose penalties on utilities when blackouts or similar events occur. Therefore, it would seem obvious for utilities to seek the most reliable metal, copper.

Any system change results in extra costs for the utility company, so it is important that the end result is a more efficient energy transfer and, therefore, more profit in the long run.

The ICA Strengthens the Case for Copper

In order to help solidify copper's place in U.S. electric systems, the ICA, through Copper Development Association U.S., took part in discussions to increase the efficiency requirements for transformers led by the Department of Energy. Along with other stakeholders, the CDA explained that energy efficiency gains would be made by increasing the amount of copper in transformers. Our efforts paid off. In the words of Zolaikha Strong, Director of Sustainable Energy at the CDA, this program has strengthened copper's market share, "Our efforts helped raise MEPS (minimum energy performance standards) from 12 to 28 percent in the U.S. over previous levels, boosting the need for copper in transformers and potentially increasing the amount of copper required." ICA's work in the transformer market will have an annual impact of 62,000 tonnes globally.

While all global economies are not ready to support MEPS-like standards, U.S. Dept. of Energy estimates that 32 TWh of energy could be saved yearly in the 21 APEC (Asian-Pacific Economic Cooperation) countries (not including China) if MEPS for distribution transformers were implemented at cost-effective levels. Another way of saying this: MEPS implementation would mean an 18 million ton CO₂ reduction. All this would be possible without spending extra capital over the lifecycle of the equipment. In fact, there would be a savings of \$19 billion for consumers of electricity taken at the net present value.

In addition, according to the U.N., "adopting cost-effective standards for a wide range of technologies could, by 2030, reduce global projected electricity consumption by buildings and industry by 14 percent, avoiding the need for about 1,300 mid-size power plants."

The ICA—Global Sustainable Energy Advocate

The copper market share in transformers remains strong because the use of appropriately sized copper conductors is key to reducing load losses in transformers. We promote energy savings, not copper—a fact that enables the Alliance to remain credible as a sustainable energy advocate. With increased use of copper, the world's governments cannot only meet their CO₂ reduction goals, but they can meet their energy efficiency goals and make an investment in a clean-energy future.

A MORE SUSTAINABLE FUTURE DEPENDS ON COPPER



The history of copper is over 10,000 years old, yet copper is key to meeting the challenges of tomorrow. Copper is the metal that will drive sustainable development, innovation, technology and a safer and healthier world for generations to come.

A recent United Nations study predicts that the global population will increase by almost two billion people to 9.6 billion by 2050. This additional growth brings additional demands—the need for more energy, food and healthcare. These societal challenges are not limited to a single region or socio-economic background. Their impact will be felt by all global citizens.

We Are in This Together.

Sustainable development is everywhere—the media discusses it, government officials debate it, companies seek it and families try to understand it.

When it comes to sustainable development, copper has a unique story to tell. While other materials need to communicate about the sustainability of the material itself, with copper we can honestly say that its inclusion improves technology and makes applications containing it more sustainable. Society as a whole benefits from copper and its uses.

In 2012, the United Nations declared 2014 – 2024 as "The Decade of Sustainable Energy for All". This global initiative has three stated goals (all to be achieved by 2030): universal access, doubling the rate of renewable energy, and doubling the rate of energy efficiency. ICA and the copper industry can make a positive contribution to all of these important goals. The essence of their mandate states that "Sustainable development is not possible without sustainable energy."

The ICA and its copper centers, under the trademark banner the Copper Alliance™, support this mandate.

Copper is an Essential Material in Building the Energy Systems of the Future

Sustainable solutions need copper to cope with climate change, the continuous growth of world energy consumption and fossil fuel depletion. Renewable energy systems rely on copper to generate and transmit the energy with maximum efficiency and minimum environmental impact.

- Copper makes systems run cleaner. With increased use, copper can reduce CO₂ emissions by more than 1.25 gigatonnes globally. In more practical terms, presently there are more than one billion cars on the road, this activity is equivalent to taking more than half a billion cars off the road.
- Copper makes motors run more effectively. If all the world's economies were to adopt best practices for motor-driven systems by 2030, electricity consumption would decrease by as much as 10 percent worldwide.
- Copper drives tomorrow's energy technologies. Because of its superior conductivity and long life, copper makes energy systems more efficient.
- All the world's governments can meet all their energy-efficiency goals—today—using existing technologies. Copper powers these technologies.

Copper Applications Can Support an Ever-growing Population

Our expanding population needs sustenance. The global demand for fish as a protein source is expected to reach to 80 percent by 2030 (UN Food and Agriculture Organization). Centuries of unsustainable open-water fishing means aquaculture—or farm-raised fish—will be the only source to meet this growing demand.

- Copper-alloy aquaculture pens offer a healthier, stronger and safer environment for farm-raised fish
- Copper-alloy nets provide lower energy costs, greater durability in adverse weather, extended net life and 100 percent recyclability
- Copper-alloy nets promote better fish health and improved Feed Conversion Rate (FCR), decreasing operating costs

Aquaculture is the fastest growing animal-food producing sector worldwide, and we are a leader in the advancement of sustainable and environmentally sound fish-farming practices to benefit consumers.

Copper Can Combat a Global Epidemic

Hospital-Acquired Infections (HAIs) impose significant consequences on patients and their families and economic burdens on national healthcare systems. Studies show bacteria to be the perpetrator. These bacteria are transferred to handrails, door knobs and other fixtures. Despite hand washing protocol and hygienic practices, about 80 percent of infectious diseases are transferred by touch.

- HAIs kill more than 1,000 people per day worldwide; more than HIV and breast cancer combined
- Approximately 25 million people acquire a HAI each year
- In the US alone, HAIs cause an estimated 100,000 deaths annually and account for up to \$45 billion in healthcare costs

- The opportunities for Antimicrobial Copper go beyond the traditional healthcare setting to include schools, mass transit systems and public places.

Antimicrobial Copper* is scientifically proven to be the most effective touch surface material, killing greater than 99.9 percent of bacteria.

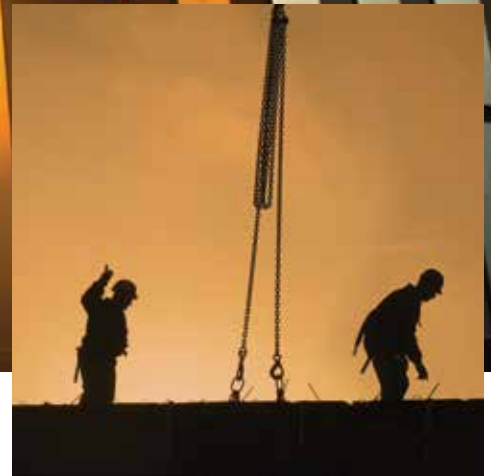
Copper, Our Future Relies on it.

* Laboratory testing shows that, when cleaned regularly, Antimicrobial Copper® kills greater than 99.9% of the following bacteria within 2 hours of exposure: MRSA, Vancomycin-Resistant *Enterococcus faecalis* (VRE), *Staphylococcus aureus*, *Enterobacter aerogenes*, *Pseudomonas aeruginosa*, and *E. coli* O157:H7. Antimicrobial Copper surfaces are a supplement to and not a substitute for standard infection control practices and have been shown to reduce microbial contamination, but do not necessarily prevent cross contamination; users must continue to follow all current infection control practices. Michels et al, *Lett Appl Microbiol*, 49 (2009) 191-195 demonstrated that Antimicrobial Copper® outperforms two commercially available silver-containing coatings under typical indoor conditions.



Copper is the metal that will drive sustainable development, innovation, technology and a safer and healthier world for generations to come.

COPPER: BUILDING A BETTER TOMORROW



According to World Bank Group President, Jim Yong Kim, "Energy is the golden thread that connects economic growth, increased social equity and an environment that allows the world to thrive." And copper is essential to energy.

One of the world's most important sources of energy, and one the most problematic, is electricity. The reliability of an electrical installation depends on three parameters: good design, qualified professionals, and suitable, quality materials. Problems with electrical wiring cause about half of all residential electrical fires. Fire departments around the world report that inadequate electrical installations are a primary cause of fires and accidents in the home.

In the last few years electrical consumption in homes has quadrupled, due to widespread use of appliances. As electrical use expands, the number of electrical fires also grows. It is estimated that 70 percent of structural fires are caused by an overheating of electrical conductors. These challenges become more critical in rural areas where standards are nonexistent, and safety is often forgotten next to the enormous demand for power.

Productivity Gains Reached with Copper

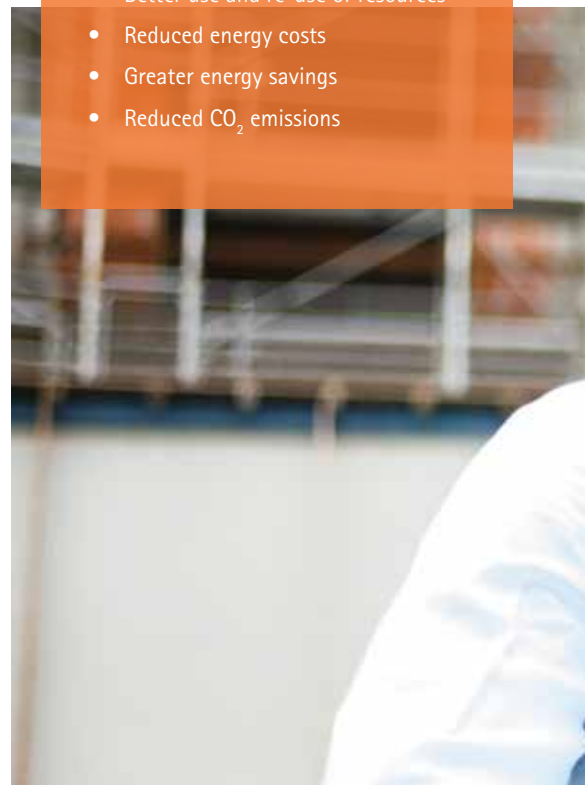
Throughout the world, inefficient energy use harms economic productivity. The world's oldest metal is key to making tomorrow better, integral to emerging technologies and essential to an energy-starved world. The adoption of copper wire helps reduce electrical fires that result in real property loss and human casualties.

Copper: A Material for Sustainable Construction

Copper products are strategic components that contribute to sustainable architectural and building construction practices.

This means:

- Better use and re-use of resources
- Reduced energy costs
- Greater energy savings
- Reduced CO₂ emissions



Reliable Electricity Means Safer Homes

Chinese government officials understand the need for safe, reliable electricity. Government officials, along with electrical engineering experts, and members of our building wire team in China, developed the first-ever code for electricity standards in rural dwellings. Prior to the code, rural home owners had no guidelines and any material could be used for wiring.

The new design code for rural dwellings requires indoor wiring systems to use copper. All power distribution circuits installed in homes, suites or flats (a single unit of dwelling) must be copper. Copper's exceptional strength, ductility and resistance to corrosion make it the safest conductor for residential, commercial and building wiring (International Copper Study Group, ICGS). Currently, aluminum has a 20 percent market share of newly constructed rural dwellings, which amounts to 30,000 tonnes/year of copper. This new standard excludes aluminum from the extensive expansion of rural China.

The code will also eventually increase the copper consumption density in rural China, to 0.09 kg/sqm in 2020—the equivalent of an additional 150,000 tonnes of copper by 2020.

Upgrading to copper indoor wiring allows rural homes to use more modern home appliances. In fact, thanks to copper, rural Chinese families can now enjoy safer living conditions and more functionality in their homes.

The establishment of the new standards was part of a targeted strategy developed by the building wire team. Gabriel Zhang, Project Manager, Electrical Safety and Connectivity, stated, "We worked for six years to be seen not only as experts but as individuals who cared about safe energy deployment." Through demonstrations, training, publications and advisory reports, they became known as proponents of health and safety.

Copper Sets the Bar Others Struggle to Reach

Global productivity requires effective, reliable energy sources. While there are other electrical conductors on the market, all have lower conductivities when compared to copper. This can reduce system safety and durability and increases end-user electricity costs. No wonder copper alloys are used as the standard in international codes. All other electrical conductors are judged on how their performance compares to copper (International Electrotechnical Commission).



Around the world the ICA has "feet on the street" explaining the virtues and benefits of copper in sustainable construction.

- In Mexico City and Sao Paulo our actions promoted the contributions of copper to LEED scoring systems
- In India we educated the government, electricians and consumers about the current carrying capacity of wires
- In Zacatecas, Mexico, we instructed residents about electrical safety and the benefit of preventive and voluntary inspections in commercial buildings and homes

TECHNOLOGY SPEARHEADED BY ICA TRANSFORMS THE AIR CONDITIONING INDUSTRY



In the high-volume residential air conditioner market, price competition is intense, and sales margins are small. The global air conditioning and refrigeration (ACR) industry faces increasing pressure from government regulations to improve energy efficiency, reduce the environmental impact of refrigerants, and improve indoor air quality while facing constant pressure from consumers to keep prices low. For the copper industry, the size of the global market for heat exchanger and connector tube in room air conditioners—900,000 tonnes—makes it a critical prize to win. But are we capable of fighting off the competition? The answer is a definite "yes."

Microgrooved Surface Enhances Heat Transfer

With this new era of environmental and energy efficiency requirements, our MicroGroove® technology is proving to be well suited to handle the higher pressures of new refrigerants while meeting cost reduction goals and sustainability concerns. MicroGroove technology reduces cost by using less copper and requires no additional investment in existing manufacturing processes. Through research and development spearheaded by the ICA, air conditioner manufacturers can meet government-imposed standards and their own objectives by transitioning to smaller MicroGroove tubes, which are engineered with thin walls and internal micro-grooved surfaces to enhance heat transfer. In the words of Technology Transfer and Development Director, Hal Stillman, "This technology packs all the advantages of copper into more compact, more efficient, cost-effective heat exchangers."

Custom Software Enables MicroGroove® Specification

Designing high-performance air conditioners with smaller diameter tubes may sound difficult, but the MicroGroove team has developed heat exchanger system optimization software to enable manufacturers to design units based on MicroGroove copper tube.

The software is currently used to design residential air conditioning heat exchangers and is being adapted for commercial air conditioning and refrigeration systems in the European and North American markets. Tube suppliers will be able to access the software with their customers in early 2014.

MicroGroove Technology Helps Respect the Environment

Like many industries, air conditioning is feeling international pressure to act in a manner that respects the environment. New designs adhere to these demands and reflect the use of refrigerants with lower GWP (global warming potential) and ODP (ozone depletion potential) ratings. Some of the new, so-called natural refrigerants, such as propane, are more cost-effective and abundant but come with drawbacks. Due to propane's flammability, regulations limit the refrigerant charge to be no more than 150 grams in each air conditioner. Units incorporating MicroGroove tube have enabled significant reductions in refrigerant charge on the order of 50+ percent using traditional and proposed refrigerants.

Copper's Antimicrobial Properties Enhance Energy Efficiency

Since the World Health Organization's report in 1984, much has been written and discussed about "sick building system." Causes are often attributed to flaws in the

heating, ventilation, and air conditioning (HVAC) systems. MicroGroove tubes not only present cost benefits to manufacturers, but they offer consumers the additional benefit of reduced mold growth due to copper's antimicrobial properties. Mold growth blocks heat transfer from fin surfaces and decreases heat exchanger performance in systems utilizing aluminum fins. Heat transfer potential is proportional to energy efficiency. After four years of operation, mold can cover 60 percent of fin surface area. In one controlled experiment on effects of mold growth, energy efficiency performance of heat exchangers with aluminum fins decreased by about 19 percent when mold covered 60 percent of fin surface. Performance of heat exchangers with copper fins, which exhibited no mold growth, was unchanged.

The Future of MicroGroove

The ICA Technology Transfer and Development team has pursued other air conditioning projects over the years; however, the team's MicroGroove project has created the largest quantifiable effect on copper demand to date, conservatively estimated at 142,500 tonnes cumulatively over six years (2007 – 2012). Looking ahead, it might just change a few more landscapes.

Compact, modular and scalable thermal energy storage systems are being developed for distributed applications in buildings where space is at a premium. Using MicroGroove heat exchangers in these applications may present a much higher energy storage density, deliver no energy leakage, and offer the potential for residential scale seasonal storage units. This work is still in the early R&D stage.

Commercial refrigeration system suppliers are considering natural refrigerants (propane, isobutane, and carbon dioxide) to meet regulatory imperatives requiring reduced refrigerant charge to cut the risk of refrigerant leakage and meet higher energy efficiency regulations. The design and optimization software developed for room air conditioning is being adapted for use with commercial refrigeration systems and will soon be in use as a design guide for refrigeration customers in Europe and North America.

By delaying a significant introduction and roll out of aluminum microchannel in several markets, MicroGroove has shown how the adaptability of copper keeps this material ahead of the competition.

MicroGroove has shown how the adaptability of copper keeps this material ahead of the competition.



The Story in Numbers

Chinese Manufacturers...

- Produced > 82 million residential air-conditioning systems worth < \$50 billion (in 2012)
- Gained 50 percent of ACR (copper air conditioning and refrigeration) and connector tube demand
- Produced 70 percent of global aircon units

After detailed technical and economic analyses, manufacturers decided against the uncertainty and costs of switching to substitute materials and moved instead to designs based on smaller copper tubes, 5mm in diameter.

Why?

- Less copper = Lower cost, decrease in expensive refrigerant charge required and identical performance and reliability
- No need for new manufacturing systems

Result

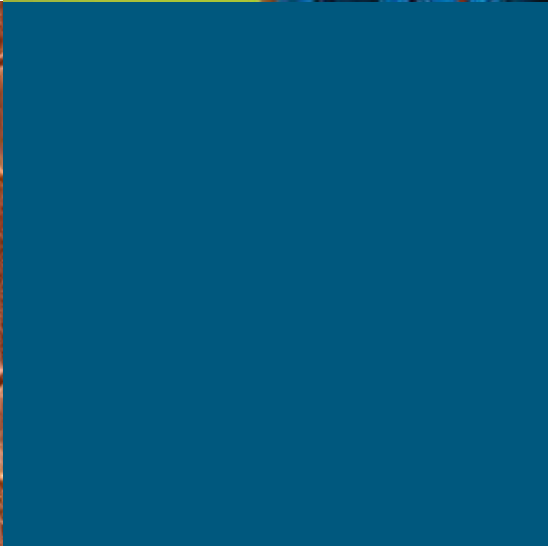
- Substitution rate for aluminum microchannel only 2 percent, down from the > 10 percent forecasted
- Copper 5mm tube in 18.8 million room air conditioner heat exchangers produced in 2013—a 35 percent increase over 2012
- 26,000 tonnes of MicroGroove tube used in room air conditioners in 2013



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Printed on 100% recycled paper (100% post-consumer fiber)



Paper meets the Forest Stewardship Council mark of responsible forestry



Paper mill production processes, including packaging, are environmentally preferable



Paper made with 100% renewable green energy



Paper manufactured from sustainable raw materials and are free of chlorine chemistry



Vegetable-based (as opposed to traditional petroleum-based) inks used throughout



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