

PRESS KIT

The essential role and benefits of copper in building a sustainable world

USAGE, KEY FIGURES AND NEW APPLICATIONS

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Press contact

Anna Macdougald - GSM : + 32 (0) 477 60 26 74 – anna@eu4u.be

Evelyn Gessler - GSM: + 32 (0) 475 23 53 92

Evelyn.gessler@deciders.eu

Lorraine de Fierlant – GSM : + 32 (0) 485 33 33 33

Lorraine.defierlant@deciders.eu

European Copper Institute

Christian de Barrin,

Communications Manager

Tel. +32 (0) 2 777 70 82 / GSM: + 32 (0) 476 30 99 60

cdb@eurocopper.org

I. COPPER'S LIFECYCLE

A. Where does copper come from?

▶ The origins of copper

Copper is a metal that is naturally present in the earth's crust and it is essential to the development of all forms of life. It is the oldest metal used by man: the first copper coins date from 8,700 BC. Together with tin, it led to a technological revolution known as 'the Bronze Age', around 2,300 BC. At the turn of the 10th century BC, the legendary wealth of King Solomon was said to have been generated from the operation of mines, rich in copper, in the Sinai desert.

The history of copper is closely linked to that of Cyprus, because it was on the island of Cyprus that the first open-pit copper mines were operated, and which enabled the Hellenic, Mycenaean and Phoenician civilisations to prosper. They organised the red metal's trade in the Mediterranean, although the Romans called it '*aes cyprium*' (literally: 'metal from Cyprus'). Over time, the term changed and became 'copper'.

▶ The various sources of copper supply

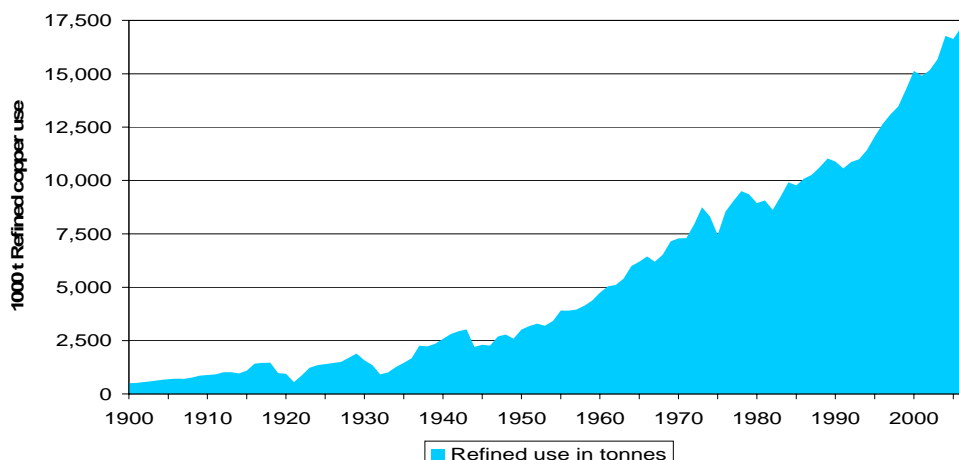
Copper is produced from three sources:

- The extraction and processing (refining) of the raw material, called '**primary production**'
- The recycling of end-of-life products, called '**secondary production**'
- The direct recycling of 'new scrap' (waste resulting from the manufacturing process).

B. Global demand and evolution of production

▶ Demand for refined copper: historical overview and geographic breakdown

Since the beginning of the 20th century, global demand for refined copper has risen from 0.5 million tonnes (1900 figure) to more than 17 million tonnes - see graph below. In 2006, demand was 17.160 million (an increase of 3.3% over 2005¹) and it is expected to rise by 4.2% to 17.884 million tonnes in 2007, according to the International Copper Study Group².



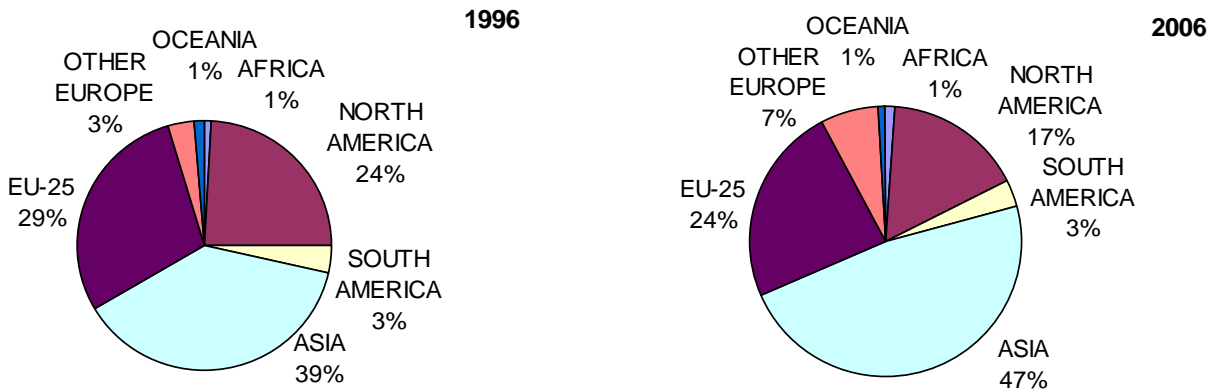
¹ ICSG estimation.

² The International Copper Study Group (ICSG) is an inter-governmental organisation, based in Lisbon that publishes copper production and demand statistics.

In 2006, the geographies using the most refined copper were the countries of the former EU15, China and the United States, followed by Japan and South Korea. Over the past ten years, Europe's share of global refined copper use has been relatively stable, at around 31%, although lower demand in the European Union has been compensated for by an increase in other countries, such as Russia and Turkey.

Refined Copper Demand by Major Geography

Comparison: 1996-2006

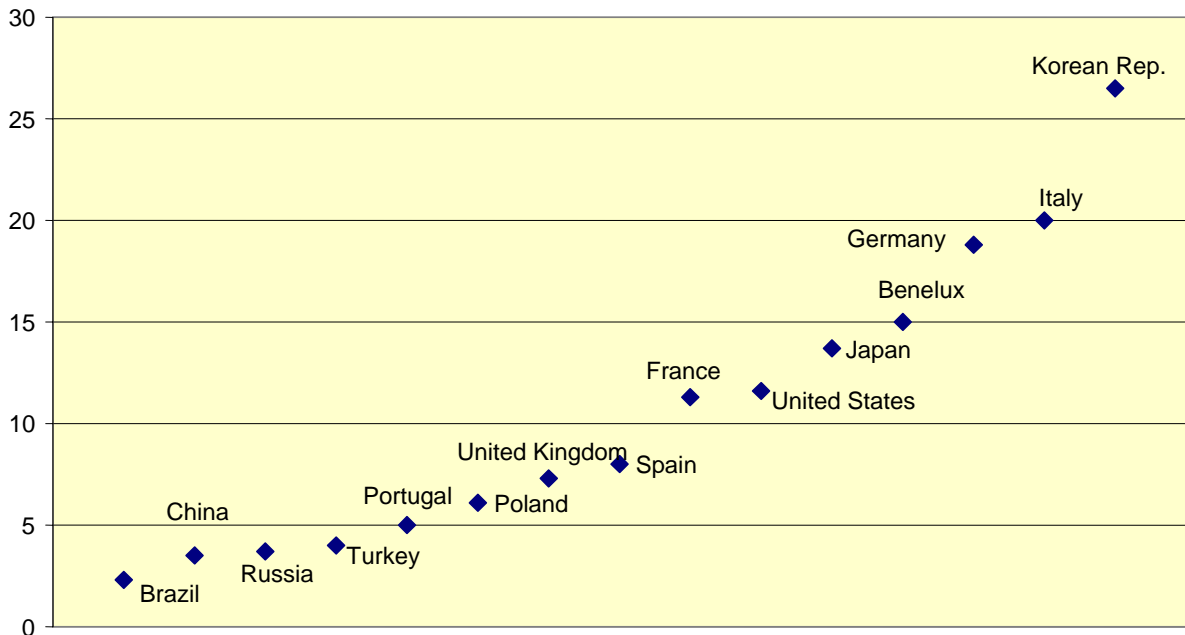


In 2002, China emerged as the world's largest country user of refined copper (10% of global use in 1996, 21% in 2006), ahead of the United States.

However, the use of refined copper per inhabitant is still much higher in developed countries, such as the former EU15, the United States and Japan, compared with many developing or transition countries:

Use of Refined Copper per Capita

(kg / capita / year)



► In 2006, refined copper production met demand

Mining production and total refined production
2007 estimates, figures from the *International Copper Study Group*

REGIONS	MINE PRODUCTION			REFINED PRODUCTION		
	2005	2006	2007 (forecast)	2005	2006	2007 (forecast)
Africa	676	830	1 003	513	614	746
N. America	2 181	2 233	2 473	2 168	2 238	2 382
Latin America	6 651	6 793	7 225	3 559	3 568	4 227
Asean - 10	1 148	906	888	514	539	603
Asia ex Asean/ CIS	1 049	1 135	1 193	5 225	5 853	6 204
Asia - CIS	510	545	569	534	538	565
EU - 25	711	713	716	2 329	2 330	2 386
Europe Others	831	872	902	1 198	1 278	1 298
Oceania	1 120	1 140	1 235	471	483	550
TOTAL	14 877	15 166	16 204	16 512	17 441	18 961
Adjustment for Primary Feed Shortage*					0	-818
Allowance for Disruptions**					-43	-84
WORLD	14 877	15 166	16 204	16 512	17 398	18 059
% change		+1,9%	+6,8%		+5,4%	+3,8%

* based on a formula for the difference between the projected copper availability in concentrates and the projected use in primary refined production

** based on capacity utilisation of mines and refineries

The sum of primary production and secondary production gives the total production of refined copper. For example, in 2006, global primary copper production amounted to 15.2 million tonnes. Based on this figure and 2.2 million tonnes of secondary copper, the total production of refined copper amounted to **17.4 million tonnes**.

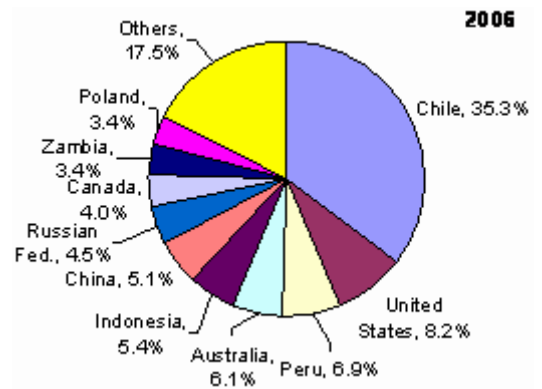
Total production of refined copper is sometimes slightly higher than demand and the difference is kept in the form of stocks. For example, in 2006, global demand came in at 17.160 million tonnes, compared to a production of 17.4 million, resulting in a surplus of 240 thousand tonnes.

The ICSG estimates global refined copper production for 2007 at **18.059 million tonnes**, an increase of 3.8 % on 2006.

► The leading mining countries: South America dominates

Chile has by far the largest copper mining output. It represented more than one third of the world's copper extraction in 2006, compared to only one-quarter 10 years earlier. The world's second largest copper extractor is the United States, although its share halved from 17.6% to 8.2% over the same period. While mining capacity in Chile rose by 1 million tonnes between 1996 and 2006, it fell by 750,000 tonnes in the United States.

The world's other leading mining countries include Peru, Australia, Indonesia, China and Russia. **South America accounts for 44% of global copper extraction.**

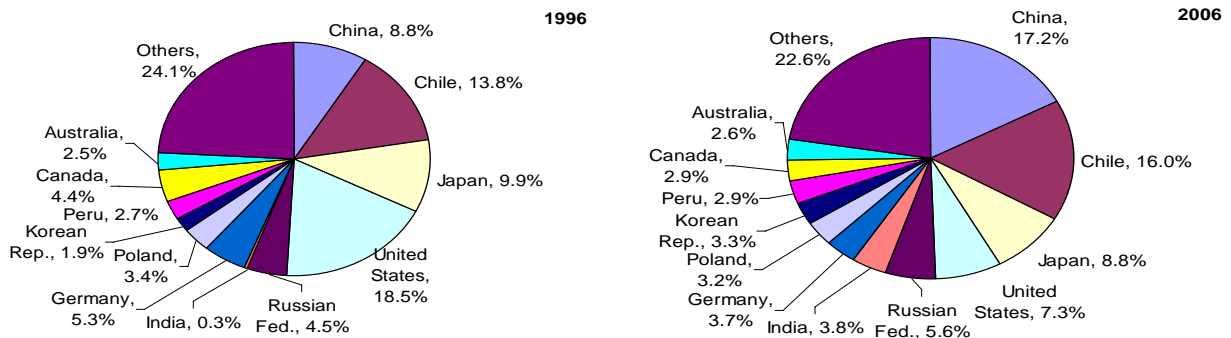


► The world's leading refined copper producer countries: Chile and China come out on top

In 2006, the world's global refined copper production was dominated by Chile (16 %) and China (17.2 %), two countries whose production has risen significantly since 1996. Japan, the United States and Germany, which together accounted for 35% of global refined production 10 years ago, now represent less than 20 %.

In the European Union, as mining production (700,000 tonnes) falls short of the refining industry's capacity (2.3 million tonnes), the leading refined copper producers have to import raw materials, with the notable exception of Poland.

World's leading refined copper producers, as a share of total production (comparison: 1996-2006)

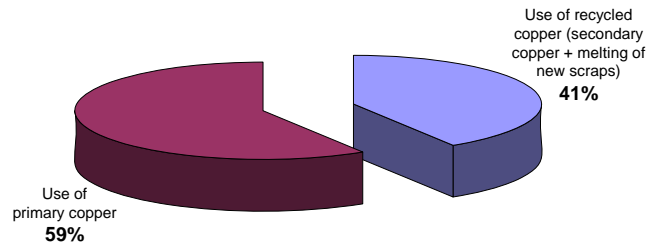


C. Recycling: a major resource

Copper recycling limits the use of natural resources, reduces energy consumption and decreases waste disposal problems.

In 2004, **34 % of the world's copper usage came from recycling (in Europe, this figure is 41%)**, including both secondary copper production and the direct recycling of 'new scrap'. According to the ICSG, the 2005 global figures are expected to show an increase in the proportion of world copper usage which comes from recycling.

Where does the copper used in Europe come from?
distribution of **recycled copper & primary copper**
(as a % of total european copper use, 2004 figures)



► Copper is a sustainable material that is 100% recyclable, time and time again

Copper is both durable (copper products have useful lives ranging from a few years to several hundred, depending on the application) and is 100% recyclable, ad infinitum. It is one of the few materials that does not decompose or lose its chemical or physical properties during the recycling process. There is no difference between recycled copper and copper produced through mining extraction.

Europeans will generate 45% more waste in 2020 than they did in 1995, according to the European Environmental Agency. A part of it contains copper, especially electrical and electronic equipment (computers, mobile phones, etc.), which may contain up to 20% of their weight in copper. Moreover, this type of waste, called 'WEEE', is covered by a specific European Directive³ which stipulates, for each EU member country, an average recovery objective of 4 kg/inhabitant/year.

As a consequence, copper recycling should increase during the 21st century.

The recycling champion

- The use of copper, which is extremely durable, helps to limit waste volumes from the outset.
- It is estimated that 80% of the copper used since antiquity is still in circulation.
- The recycling process results in energy savings of up to 85% compared to primary production.
- 100% recyclable, time and time again, without loss of properties, recycled copper is indistinguishable from primary copper.

► The share of copper usage met from recycling

If we add to the total use of refined copper the direct recycling of 'new scrap' (produced by the manufacturing process), the result is **a total worldwide copper use of 22.450 million tonnes** (2004 figure), broken down as follows:

- **66% of refined primary copper**
- **9% of refined secondary copper (recycling of end-of-life products)**
- **25% of scrap melted directly (recycling of 'new' process scrap)**

► Europe and Asia: the leading users of recycled copper

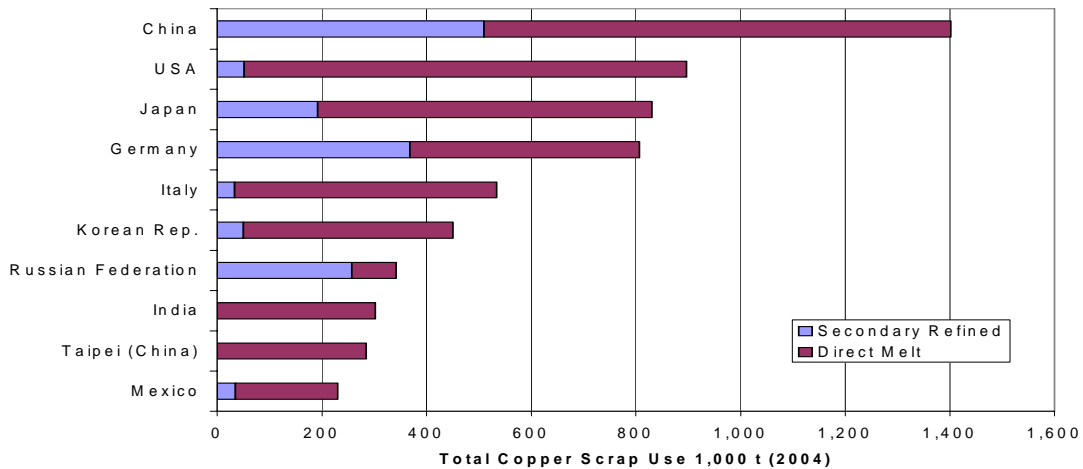
At a regional level, 41% of the copper usage in Europe is met via recycling, 33% in Asia, 29% in North America and 22% in the rest of the world.

Asia alone accounted for nearly one-half of the global copper scrap recycled in 2004, followed by Europe (35%) and the United States (18%), with less than 1% coming from the world's other regions. The leading users of

³ Directive 2002/96/EC concerning the recovery and recycling of Waste from Electrical and Electronic Equipment (WEEE).

copper bearing scraps include China (1.4 million tonnes), the United States, Japan, Germany and Italy. This 'Top 5' accounted for about 58% of global use of copper scrap in 2004.

Total use of recycled copper, by country, in millions of tonnes (2004 figures)



► **Will there be enough copper for future generations?**

Natural copper mining reserves are estimated at 3 billion tonnes, to which we must add roughly 700 million tonnes of mineral contained in the polymetallic nodules at the bottom of the oceans⁴.

The world's extraction capacity is currently 16.9 million tonnes per year (of which 89% is used), with a global refining capacity of 20.7 million tonnes per year (of which 84% is used).

In general, economic, technological and societal factors influence the supply of and demand for copper. As society's need for copper increases, the balance between supply and demand depends on a variety of factors, such as exploration efforts, technological developments, product innovations, and the selection and substitution of materials.

In any case, recycling will be a major resource in the coming decades.

D. Which industries use the most copper?

Refined copper is sold in the form of cathodes, large copper plates ready to be used by the processing industry. This sector buys these to make copper semi-products, an intermediate phase in the value chain. The latter are in turn used to manufacture a variety of finished products needed for the manufacture of marketable goods.

► **The manufacturing of semi-products and the use of finished products**

During the last 20 years, the production of semi-products has more than doubled, primarily as a result of the growing increase of outlets in electrical and electronic applications. The largest copper semi-product producing regions and countries are the 15 Member States of the European Union (26% in 2006), China, the United States and Japan, which together represent more than 80% of the world's production of semi-products.

After manufacture and distribution, the final goods may be used in society for between 1 and 100 years. In general, the copper contained in finished products will become recyclable once they have reached the end of their service lives. As a result, finished products in use represent a reserve comparable to a huge mineral deposit that can be available for future use, which is sometimes called 'urban mining'.

► **The largest industry users of refined copper: energy and building**

The use of refined copper in Europe is broken down as follows⁵:

- **Electricity and energy** (including wires and cables in building): **58%**
- **Building Construction** (including architecture and tubes): **26%**

⁴ Source: *International Copper Study Group*.

⁵ Source: *International Wrought Copper Council (IWCC)*.



- Engineering (industrial plant and machinery, furniture, coinage): 10%
- Transport: 5%
- Other: 1%

▶ **A few examples of final applications**

Copper is everywhere in our day-to-day lives... although it is not always visible. Here are a few examples of 'hidden' copper:

1. Underground: power cables, lighting, gas pipes, water distribution network, underground transportation systems, etc.
2. Behind walls: telephone lines, data cabling, electricity network, domestic water pipes, valves and fire sprinkler systems
3. Inside household appliances: as wires, transformers, motors, ventilators, switches, refrigeration tubes, air conditioners, printed circuit boards, etc.

Beyond its hidden presence, copper is used in many household objects that are part of our everyday lives: taps, radiators, door handles, furniture, saucepans, etc.

▶ **Copper in electrical systems and the energy sector (overview)**

Copper can improve the efficiency of energy production and distribution systems. Electricity conducted by copper encounters much less resistance compared with any other commonly used metal. This is the reason why copper is found in wires and cables, as well as in generators, motors, transformers, and renewable energy production systems. All household electrical appliances, electronic and telecommunications devices also contain significant quantities of copper.

▶ **Copper and its alloys in construction (overview)**

As an example, in France, the use of copper-bearing metals in architecture has increased by 600% in 15 years. Builders, architects and decorators are fond of these metals because of their malleability, their resistance to corrosion, their durability and their aesthetic qualities. They use them in two forms:

- Architectural Bronze (brass) shapes used to build façades, curtain walls, canopies, doors and window frames
- Copper sheets for roofs and cladding. Copper is used for roughly 10% of metallic roofing, as well as for façades and as a decorative element.

Lastly, as a naturally antibacterial material, copper is often used to ensure the health and safety of water distribution systems and in heating and air-conditioning systems.

▶ **Copper in telecommunications and high-tech products (overview)**

Copper is a key component of new information and communications technologies. Present in computer chips, printed circuits and mobile telephones, copper offers excellent conductivity and heat removal. New technologies have also dramatically improved data transmission speeds, e.g. ADSL, through existing lines made of copper wire. Copper is also one of the components of superconductor cables used in nuclear research and contributes to the operation of MRI scanners in hospitals.

II. NEW APPLICATIONS FOR SUSTAINABLE DEVELOPMENT

Copper has contributed to many recent innovations, in environmental, technological and health research, as part of efforts to increase sustainable development. Copper can improve energy efficiency (and hence reduce CO₂ emissions), limit waste and is essential for human health. The benefits copper brings to all of its major areas of application make it a key material in building a sustainable world.

A. Copper's key role in the conservation, production and distribution of sustainable energy

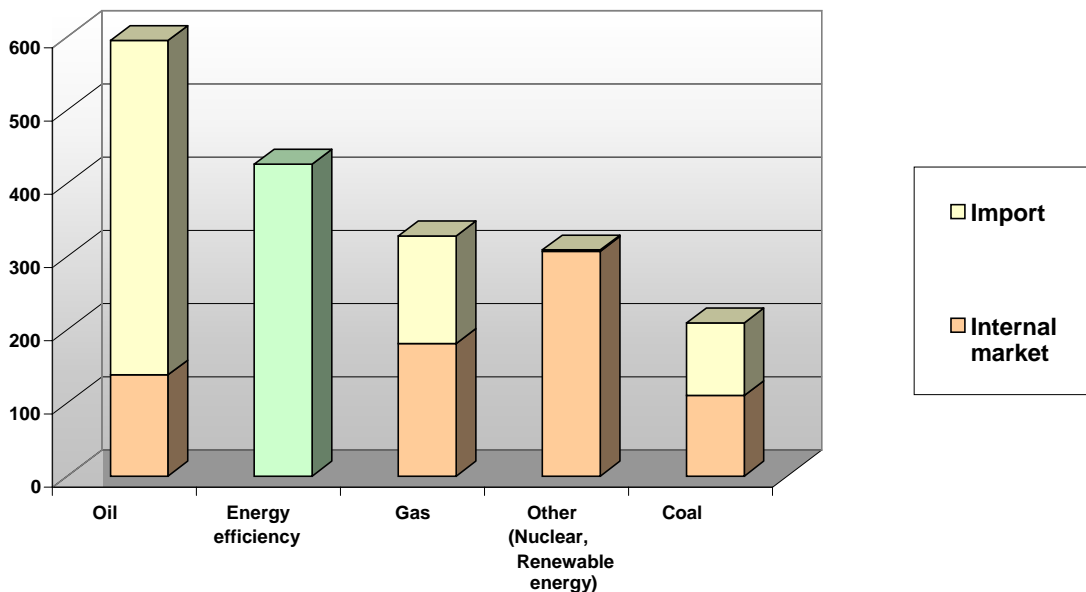
The European Union's primary environmental goals are: the rational use of energy, the reduction of CO₂ emissions and an increase in the percentage of electricity resulting from renewable energies. **Copper is the best conductor of electricity among non-precious metals**, 65% higher than its main competitor (aluminium). This essential property makes it critical to energy production and distribution, as well as, for example, in solar and wind power plants. It also makes copper the main provider of electrical energy efficiency, essential for energy savings and reductions in CO₂ emissions.

► The main provider of electrical energy efficiency, in response to the Kyoto objectives

The Kyoto Protocol sets out an overall objective for industrialised countries of a 5% reduction in greenhouse gas emissions by 2010, with an objective of 8 % for the EU (compared with the 1990 level). One of the most effective ways to attain these objectives is to improve energy yields. Doing so reduces operating expenses while decreasing CO₂ emissions.

Called '*second fuel*' by researchers, energy efficiency is a source of savings that, by itself, could satisfy all the Kyoto objectives applicable to the European Union (roughly 270 million tonnes less CO₂ per year), according to Professor R. Belmans of the University of Louvain. He estimates that **each tonne of copper used efficiently in improving the yield from energy systems leads to a saving of 200 tonnes of CO₂**.

Sources of energy in Europe
(including the potential component of energy efficiency)
in million tonnes equivalent oil/year



Source: Prof. R. Belmans, University of Louvain. Figures based on the potential improvement of energy efficiency of 30 %

► Copper: a key component of high efficiency electric motors

The optimisation of the amount of copper in electrical applications, especially the most energy-consuming, improves efficiency and reduces energy losses by up to 70%. This is the case with industrial high efficiency electric motors, which contain 30% more copper than the average motor.

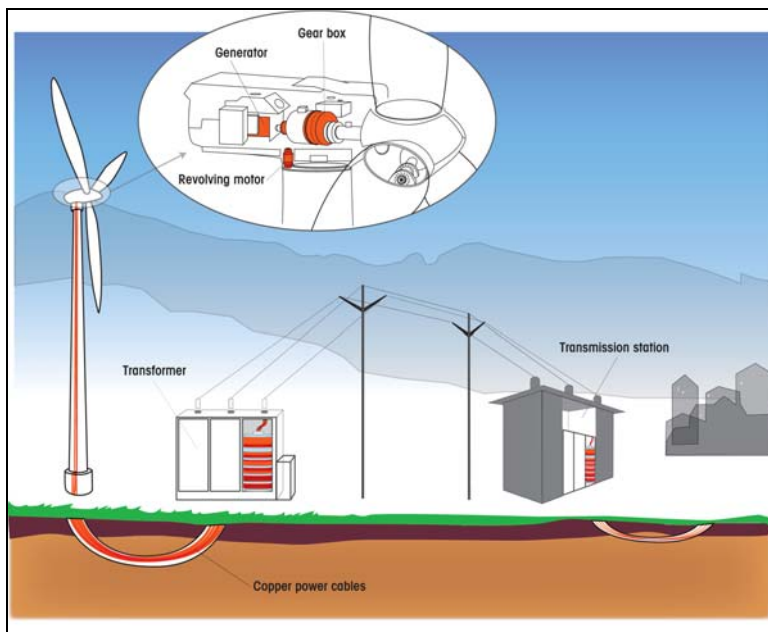
The modernisation of electric motors is the primary driving force to enable the EU, over time, to comply with its international commitments to reduce greenhouse gases. The studies carried out under the *'Motor Challenge Programme'* initiated by the European Commission⁶ show that the **use of high efficiency electric motor driven systems would lead to savings of more than 200 TWh per year within the EU, i.e. 100 million tonnes of CO₂ less** in the atmosphere... and energy savings of 6 EUR billion for industry.

Europe and the United States have established high-efficiency motor standards to meet this challenge: the *'EFF 1'* standard in Europe and the *'NEMA Premium'* standard in the United States. One way to achieve such efficiency levels is to replace the large quantities of aluminium contained in motor rotors with copper. FAVI, a French company, has developed technology that is unique (see enclosed interview).

► Copper, the cornerstone of green design

The challenge of reducing CO₂ emissions does not only concern industry. Taking a 15-minute shower, cooking with gas for 20 minutes, driving 4 km in a car... each of these daily activities produces 1 kg of CO₂, according to the *Leonardo Energy* (www.leonardo-energy.org) programme. It is clear that the lifestyle of Europeans and **the performance of the products and goods used every day** have a significant impact on energy consumption and therefore on the pressure that human activity exerts on the environment. This is why green design has become an essential component of the EU's strategy. **For example, a European Directive of 2005⁷ aims to require consideration of the environmental impact of products, sold in the EU, during the design phase.** It identifies requirements to consider improving the environmental characteristics of products, such as energy and water consumption, the production of waste and the extension of their lifetime. What is true for industrial motors is also true for household appliances. An increase in the copper content leads to a significant improvement in performance and therefore to a reduction of their environmental impact over the long-term. According to the *Leonardo Energy programme*, Re-designing a 1.5 kW motor to contain more copper could cause an additional 18 kg CO₂ emissions in production, but can save more than 650 kg CO₂ during 10 years use'.

► Copper, an essential component of renewable energies: the wind turbine example



According to the objectives set by the European Union for the application of the Kyoto Protocol, 12% of total electricity consumption in Europe will have to be of a renewable origin by 2010⁸, and 20% by 2020. Wind turbines are likely to be one of the biggest contributors.

Copper is present in all the components of the wind turbine energy production chain, including the generator, the transformer, the rotor and the cables. **For example, a 1 MW wind turbine contains 3 tonnes of copper** and avoids emissions of 1,000 tonne CO₂ per year⁹.

See opposite picture: copper in wind turbine energy.

⁶ *Motor Challenge* is a voluntary European programme aimed at helping companies to improve the energy efficiency of their systems which contain electric motors. <http://energyefficiency.jrc.ec.eu.int/Motorchallenge>

⁷ Directive 2005/32/EC of 6 July 2005, establishing a framework for the determination of green design requirements applicable to energy consuming products.

⁸ Directive 2001/77/EC of 27 September 2001, concerning the promotion of the electricity produced from renewable sources of energy on the internal electricity market.

⁹ Source: University of Louvain, Belgium.

Installed wind turbine capacity in various EU countries, in MW:

	2004	2005	Change
Germany	16,628.8	18,427.5	+ 11%
Spain	8,317.0	9,911.0	+ 19%
Denmark	3,125.0	3,129.0	-
Italy	1,131.5	1,639.0	+ 45%
United Kingdom	933.2	1,565.0	+ 68%
Netherlands	1,073.0	1,224.0	+ 14%
Portugal	537.0	1,047.0	+ 95%
Austria	594.6	816.9	+ 37%
France	382.3	755.6	+ 98%
Greece	472.6	573.3	+ 21%
Sweden	452.0	493.0	+ 9%
Ireland	326.9	480.2	+ 47%
Belgium	96.0	167.4	+ 74%
Finland	82.0	82.0	-
Poland	68.1	71.8	+ 5%
Luxembourg	35.3	35.3	-
Estonia	5.7	32.0	+ 461%
Latvia	24.0	24.0	-
Czech Republic	16.5	20.3	+ 23%
Hungary	3.3	17.5	+ 430%
Slovakia	5.1	5.1	-
Lithuania	0.9	0.9	-
Total EU	34,310.7	40,517.8	+ 18%

Source: baromètre EurObserv'ER 2006



The wind turbine capacity in Europe increased by 18% between 2004 and 2005. At the end of 2005, installed capacity in the European Union exceeded **40,000 MW: i.e. a European stock of more than 120,000 tonnes of copper.**

The countries with the greatest installed capacity are: Germany (18,400 MW), Spain (9,911 MW) and Denmark (3,129 MW).

A few noteworthy recent and future wind farm projects in Europe:

- The largest offshore wind farm: the Nysted windfarm in Denmark. This wind farm, which is comprised of 8 rows of 9 wind turbines, is located approximately 10 km to the south of the town of Nysted, in the south-east of Denmark. Its 72 wind turbines of a unit capacity of 2.3 MW total 165.5 MW. The wind farm's annual electricity production covers the electricity needs of 145,000 Danish households.
- The largest onshore wind farm: the Scottish Power wind farm in Scotland, with its 140 2.3 MW wind turbines (in the process of being built by Siemens), boasts a total capacity of 322 MW.
- The world's largest wind turbine: the Bergbausee wind turbine, in Brandenburg, Germany, is 205 m tall (Seeba Technik GmbH).

► No copper = no electronics

New information and communication technologies could not work without copper. The red metal is found everywhere in these technologies, including in electronic products for the general public, and in household appliances and telecommunications devices.

- More than 10 million ADSL copper wire lines are installed each year and, in the United States, the copper network represents 3 billion km, i.e. nearly 7,800 times the distance from the earth to the moon.
- Some 14% of the weight of a mobile telephone is comprised of copper (as much as 19% if we count the battery and the charger cable). Worldwide, the number of users of mobile telephones continues to rise. In 2006, more than 1 billion mobile telephones were sold¹⁰, the equivalent of 20,000 tonnes of copper. In France, there are 51 million active mobile telephones¹¹, and more than 4 out of every 5 French people have a mobile phone. Moreover, the average user changes mobile phone every 20 months.¹²
- A computer contains an average of 1.5 kg of copper. Given that 240 million computers are sold worldwide each year (2006 figure), recycling these computers will yield the equivalent of a mine producing 360,000 tonnes of copper per year.

¹⁰ Source : Strategy Analytics.

¹¹ Source : Arcep, Dec. 2006.

¹² Source : Etude TNS Sofres-Afom, Nov. 2005.

B. Copper's contribution to green building

Extremely durable and 100% recyclable, ad infinitum, without any loss of performance, copper is an important part of a global, environmentally-friendly approach throughout the lifetime of buildings. For example, many architectural projects are currently emerging in Europe that make the most of copper's qualities, taking advantage of both its aesthetic qualities for roofs and façades and its high environmental value.

▶ Copper is used to satisfy High Environmental Quality® ['HQE'] standards: the new Illkirch-Graffenstaden media library (in France's Alsace region)

Built between 2004 and 2006, for a total investment of EUR 8.95 M, the new Illkirch-Graffenstaden media library, in the inner suburbs of Strasbourg, is representative of the HQE® approach.



• The media library in figures:

- 1,600 m² of facade cladding in copper
- 1,500 m² of copper roofing
- 610 m of copper pipes
- 4 m² of thermal solar panels

• From the washroom facilities to the façade : an 'all-copper' media library

The building takes full advantage of copper's technical and environmental qualities, the properties of which contribute to attaining 6 HQE targets:

- The **entire roof and façade** of the media library have been adorned with copper, thereby giving the building an attractive green appearance on the outside, fully consistent with its immediate surroundings (HQE target No. 1: relationship with the environment)
- Copper **solar thermal equipment** was selected to heat washroom water, thereby optimising the building's energy efficiency (HQE target No. 4: efficient energy management)
- The **entire media library's hot and cold water network** was built using copper tubes, known for their naturally antibacterial properties (HQE target Nos. 12 and 14: health and water quality).
- The choice of copper as a favourite material also satisfies the need for **full compatibility between the various materials** used in the project's structure and finishing, such as plaster, mortar and concrete (HQE target No. 2: integrated choice of construction processes and materials)
- Lastly, the use of copper **limits the quantity of non-recyclable project waste**. When copper is recovered, it can be reintegrated into the production cycle (HQE target No. 6: optimal waste management).

▶ Copper combined with design and architecture: the new Chelsea FC Academy



The new buildings of the *Chelsea Football Academy* are expected to be completed by the end of 2007.

The main pavilion is clad with bronze wing panels whose shade gradually changes from golden yellow (the colour of brass) to hazel brown, through natural weathering.



This training centre will be used as a 'breeding ground for talent' for the *Blues*, England's current football champions. And each year, the *Chelsea Academy* hosts a television reality show called '*Football Icon*', where the most talented young English footballers are selected.

Architect: Atherden Fuller Leng /Project manager: Richardson Roofing.

► **Copper's contribution to reducing the energy costs of public infrastructures: the example of skating rinks in Sweden: opening of a pilot skating rink at the end of 2006**

Sweden has 201 indoor and 144 outdoor skating rinks. Although these sports infrastructures are highly developed, they consume a great deal of energy and cause large-scale emissions of CO₂.

A Swedish invention developed by Sveriges Energi & Kylcentrum, now reduces the energy bill of new skating rinks by 150,000 kWh/year (11 tonnes fewer of CO₂ emissions), using 18 km of copper tubes.

The energy savings are such that, given the initial additional cost incurred as a result of the infrastructure (between EUR 82,000 and EUR 110,000), the return on investment is obtained after 5 to 7 years. Given that the physical lifetime of a skating rink is between 20 and 40 years, the financial benefit is obvious.



A technological innovation with considerable environmental benefits

The base of a skating rink is comprised of pipes in which a salt water refrigerant fluid circulates, thereby keeping the ice at a temperature of roughly -10°C. Until now, the challenge was that the system required a very high capacity pump to circulate this fluid. However, by circulating high-pressure carbon dioxide (40 bars) in copper tubes, capable of withstanding such pressure, it was possible to use pumps with 90% less capacity, thereby reducing energy consumption.

In addition to its optimised cooling technique, this new type of skating rink is able to recycle heat from the cooling system, to supply the city network or to heat public buildings. This 'thermal recycling' enables the community to save an additional 400,000 kWh each year. This innovation was awarded a prize by the Swedish National Environment Protection Board for its remarkable effectiveness in protecting the environment.

In the field of ecology, the question of the building's end-of-life is also essential. When skating rinks are dismantled or rebuilt, the copper tubes can be fully recycled and re-integrated into the production cycle.

This new technology has the potential to be exported on a large-scale to international markets.

C. Copper's key role in future transport

Copper's electrical conductivity (the best among all non-precious metals) makes it critical for future transport, including high-speed trains and new generation vehicles.

► **The key component of high-speed trains: the example of the Vélaro – January 2007**

Since 2007, the *Velaro* has been the world's fastest commercial service train. Ordered by Renfe (Spain's national railway company) from Siemens, to serve the new Madrid-Barcelona line, it is comprised of multiple-unit trains inspired from the new *Inter-City Express* (ICE 3), the German high-speed train.

While traditional electrical trains use between 1 and 2 tonnes of copper, and high-speed trains between 2 and 3 tonnes, **the *Velaro* requires between 3 and 4 tonnes of copper** due to a traction system based on an impressive number of engines: no fewer than 16.



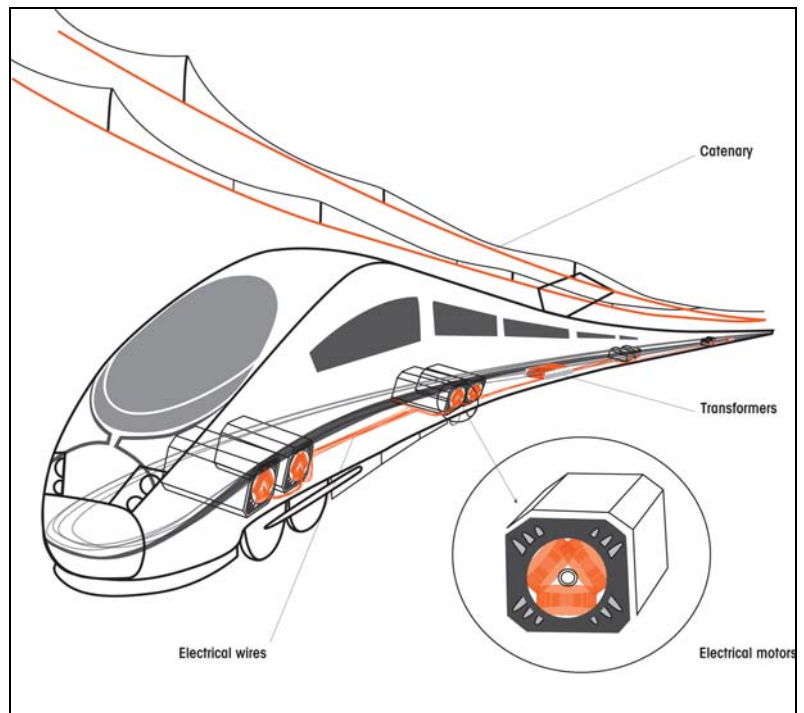
The Vélaro's main characteristics:

- The Velaro is capable of travelling at 350 km/h under a copper catenary of 25 000 V at 50 Hz, on normal gauge tracks (1435 mm).
- Each km of catenary cable contains an average of 2.5 tonnes of copper, i.e. **10 tonnes/km in total**. A catenary is comprised of one upper conductor and one lower conductor, and both tracks are equipped with it.
- The power of the train is 8,800 kW. The electrical equipment and drive motors are distributed along the train based on the principles applied for the ICEs: 16 traction engines placed under the train.

The lower cables of the catenaries, which remain in constant contact with the pantograph on the roof of the train as it travels, are made from an alloy of copper and magnesium, which is suitable for speeds up to 400km/hour (compared to 160km/hour for traditional cables), and have a lifetime 4 times longer than traditional conductors.

Siemens' research and development teams are already working on the creation of new conductors using copper-chrome-zirconium alloys which are expected to result in even better wear resistance and longer lifetimes.

See opposite picture: copper in high-speed train Velaro.



► The 'nervous system' of smart cars

The automobile, which in one century has become a consumer object *par excellence*, has greatly benefited from technological innovations and has now become a 'smart' object ensuring its users safety and comfort.

Thanks to its remarkable electrical conductivity and its resistance to corrosion, copper is a key contributor in this development. Nowadays, an average car contains 2 km of copper and alloy cables, and a luxury car 3 km. In all, the quantity of copper in passenger cars ranges from 20 kg for small cars to 45 kg for luxury models and new hybrid vehicles¹³.

A few examples of new automobile applications involving copper:

- EBD (*Electronic Brake-force Distribution*) results in improved distribution of brake force, and ESP (*Electronic Stability Programme*) optimises stability control. These 2 technologies take full advantage of copper, the 'nervous system' connecting the sensors to the on-board computer and then to the mechanical applications
- Based on copper's natural data transmission qualities, certain models already have on-board computers with high-speed internet access, enabling the user to consult traffic or weather information on-line, or even to receive faxes and e-mails
- Lastly, the automatic adaptation of seats to the passenger's size and build through miniature copper-based electric motors results in significantly improved passenger comfort

A European Directive to recycle end-of-life vehicles

According to a European Directive of September 2000¹⁴, 85 % of the weight of each vehicle must be recovered and 80% must be recycled or re-used. Starting in 2015, 95 % of the weight of each vehicle must be recovered and recycled and the re-use percentage will rise to 85%.

At one point or another, car owners will have to think about having their cars recycled. When buying a new vehicle and trading in the old car, just after having had an accident, or if their car has been driven for many kilometres. The age of 'car cemeteries' that lined national motorways is now over. Nowadays, accredited professionals (scrap yards, scrap metal merchants and demolition contractors) clean up and then grind the bodies of automobiles at the end of their life in order to extract the recyclable materials, such as copper. This process currently maximises the quantity of materials recycled and means that only 10 to 15 % of the vehicle's total weight is discarded¹⁵.

¹³ Source : French Ministry of Industry.

¹⁴ Directive 2000/53/EC of 18 September 2000, concerning vehicles with outdated engines.

¹⁵ Source : Qualicert.

D. Copper's antimicrobial properties - essential for human health

► Medicinal virtues known since the dawn of time

Even before the existence of micro-organisms was discovered, the Egyptians, Greeks, Romans and Aztecs used copper-based preparations to treat their infections (sore throats and skin rashes) and for day-to-day hygiene. In the 19th century, after the discovery of the cause-and-effect relationship between the development of pathogenic germs and the occurrence of diseases, scientists began to understand how copper's antimicrobial properties could be fully used.

Nowadays, copper is used by the entire pharmaceutical industry in applications ranging from antiseptics and anti-fungal products to healthcare and hygiene products (creams, vials containing trace elements), etc.

► Using copper and its alloys to fight hospital-acquired infections

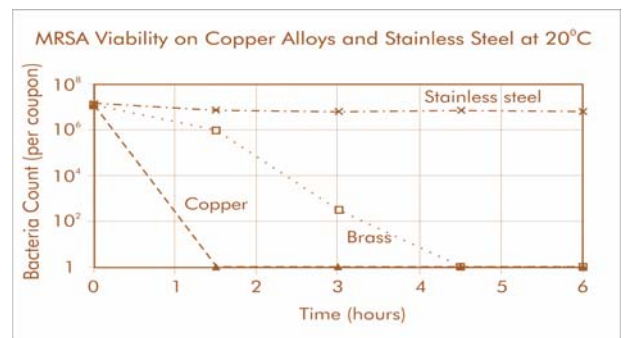
Some 80% of infectious diseases are transmitted by contact. To the naked eye, aluminium door handles and stainless steel trolleys, generally used in hospitals today, appear to be clean, but they can still harbour deadly microbes¹⁶. Among the micro-organisms most frequently identified in hospital-acquired infections are **Methicillin-resistant Staphylococcus aureus (MRSA)**, coliforms such as *Escherichia coli*, *Klebsiella pneumoniae*, as well as *Clostridium difficile*. These germs cause infections in patients: urinary infections are the most common (25%), followed closely by lower respiratory infections (23%), infections from surgical wounds (11%), skin infections (10%) and blood-flow infections (6%).

It is only in the light of recent research on MRSA that copper has been identified as having a role in combating hospital acquired infections. The germs causing these infections can remain viable on the surfaces in the ward environment, where healthcare workers, patients and visitors can come into contact with them, for days and even months. Frequently touched items such as door handles, light switches, trolleys, bed heads, over-bed tables, bedside cabinets, grab rails, etc can all be readily made from copper and copper alloys and benefit from copper's intrinsic antimicrobial properties. It is even possible to use textiles containing copper fibres for cubicle curtains, bedding, patient gowns and healthcare workers' uniforms.

► 1 cm² of copper eradicates 10 million staphylococcus aureus in 90 minutes

Professor C W Keevil, Head of the Environmental Care Unit in the School of Biological Sciences at the University of Southampton¹⁷, and Dr J Noyce have examined survival rates of MRSA deposits in a dry environment on stainless steel (the metal most commonly used in healthcare institutions), and on a range of copper alloys¹⁸.

The results show that **the staphylococci are completely deactivated** after only 1½ hours on the copper and 4½ hours on the brass (alloy of copper and zinc), while they are completely unaffected by stainless steel.



Survival of MRSA bacteria on different surfaces (stainless steel, brass, copper)

As the quantities of MRSA normally measured on hospital door handles are in the order of 10³/cm² (10,000 times less than the concentration tested during the laboratory experiment), they would be completely eradicated in only 30 minutes on copper surfaces. According to Professor Keevil, '*The use of copper alloys in applications such as door handles, trolleys or any other working surface would considerably reduce the presence of MRSA in hospitals, and would reduce the risk of cross-contamination between employees and patients in intensive care units.*'

¹⁶ Kuhn P J. Doorknobs: a source of nosocomial infection? *Diagnostic Medicine* (1983), Nov/Dec.

¹⁷ In England, the University of Southampton is well known for its scientific expertise. Elsewhere, it is known as a centre of research and excellence. Prof. Keevil is Head of the Microbiology Group and Director of the Environmental Healthcare Unit, at the University's School of Biological Sciences. Given a 5 (highest possible rating) by the *Research Assessment Exercise* (RAE), this laboratory's research is mainly focused on the ability of pathogenic organisms to adapt and survive in a given environment.

¹⁸ Noyce J O, Michels H, Keevil C W. *Potential use of copper surfaces to reduce survival of epidemic methicillin-resistant Staphylococcus aureus in the healthcare environment.* *Journal of Hospital Infection* (2006) 63, 289.



More advanced research has shown that, for a significant antimicrobial effect, the surface in question should have a copper content of more than 65% making alloys such as bronzes and high-copper brasses suitable. Copper and copper alloy products are homogenous and solid so the antimicrobial effect lasts throughout a product's extensive lifetime (25 years for door furniture), irrespective of how much wear and scratching they sustain. Copper alloys are available in a range of colours from silver through gold to bronze, and are 100% recyclable at the end of their lives.

April 2007 start of Copper Clinical trial at a Birmingham hospital, England

Each year, hospital-acquired infections in England cost the National Health Service in the region of 1 billion pounds (infections result in an average extension to a hospital stay of 11 days per patient) and at least 5,000 patients die of complications from infections that they contracted in hospitals, according to a report by the *National Audit Office*¹⁹. At any given time, 9% of hospitalised patients in the UK i.e. 300,000, have an infection that they did not have before they arrived. Not all hospital-acquired infections are preventable but UK infection control teams recognise that a 15% reduction could be achieved through a series of infection control measures, including improved hygiene, which would lead to savings of approximately 150 million pounds a year.

A Copper Clinical Trial will commence in April 2007 at Selly Oak Hospital, part of the University Hospital Birmingham NHS Trust, to assess copper's ability to reduce reservoirs of infection and therefore have a role in reducing the transmission of infection when it is directly integrated in a hospital environment. This study will cover two medical wards comparable in every way and located next to one another in the main building. One of the wards will serve as the control: no additional copper-containing items will be placed there. In the test ward, frequently touched surfaces have been identified and will be replaced with copper-based items: door handles, sink taps, grab rails in bathrooms, dressing trolleys, waste bin lids, toilet flush handles, alcohol gel- paper towel- and toilet paper-dispensers. These items will be used and evaluated over a period of 18 months, in order to observe the effects on environmental microbial loads.

The two wards have similar groups of patients. Patients' microbial colonisation rates will be monitored. In addition, the regular samples taken on different surfaces in the control environment and the test environment will be used to identify pathogenic micro-organisms and to determine their genotype, in order to understand how they are spread. The comparison of these two indicators will be used to evaluate whether or not (and to what extent) the presence of copper reduces the risk of cross-contamination between patients.

Scientific team: study carried out jointly by the University Hospital Birmingham and Aston University, under the leadership of Professor Elliott and Professor Lambert.

► Copper's potential for limiting outbreaks of *Clostridium difficile*

Preliminary results from Keevil's team have demonstrated that copper has an antimicrobial effect on *Clostridium difficile* (*C. diff*), the bacteria behind hospital outbreaks of diarrhoea, particularly affecting the elderly, the debilitated and patients who have had antibiotic treatment. There were 42,625 cases of *C. diff* infection in patients aged 65 years and over in England in the first three quarters of 2006, representing an increase of 5.5 % over the same period in 2005. In 2005 there were 3,807 death certificates in England and Wales which mentioned *C. diff*, a 69 per cent increase from 2004. *C. diff* infection may be acquired directly from other infected patients, from healthcare staff or from the environment, where *C. diff* spores persist for long periods. Research into copper's effect on *Clostridium difficile* is ongoing, both at the University of Southampton and at the University of Aston, Birmingham.

► Copper's role in preventing epidemics: bird flu

The latest results from Keevil's team (in press²⁰) indicate a role for copper as an effective control barrier to reduce the spread of bird flu. The experiment consisted of placing 2 million active units of the *Influenza A* virus (a family to which the H5N1 virus belongs) on a C11000 (high purity) copper sheet, as well as on a S30400 stainless steel sheet.

Results:

- On the stainless steel sheet, the number of infectious virus units fell to 500,000 in 24 hours, a reduction of 75 %
- **On the copper sheet, only 500 infectious virus units survived after six hours, i.e. a reduction of 99.9%**

According to Prof. C W Keevil and Dr. J Noyce, *'The results are extremely interesting given current interest in curbing a potential bird flu epidemic'* and *'copper attacks the very integrity of the virus'*.

¹⁹ The Management and Control of Hospital Acquired Infection in Acute NHS Trusts in England, National Audit Office, 2000.

²⁰ Inactivation of Influenza A virus on Copper versus Stainless Steel Surfaces, J O Noyce, H Michels, and C W Keevil, Applied and Environmental Microbiology (in press) <http://aem.asm.org/cgi/content/abstract/AEM.01139-06v1>

APPENDIX 1: INTERVIEWS (INTRODUCTIONS POSSIBLE UPON REQUEST)

Interview with Jean-François Zobrist

Managing Director of FAVI, a manufacturer of highly energy efficient industrial motors
(Standards: *NEMA Premium* and *EFF 1*)

Located in Hallencourt, near Amiens, FAVI has developed know-how that is unique worldwide and that enables it to produce copper rotors by injection under pressure at a very high temperature. It mass produces rotors ranging from a few grams to more than 100 kg.

- ***How, specifically, do copper rotor motors differ from traditional aluminium-based motors?***

Since the 1920s, we have known that replacing aluminium with copper in electric motors increases their efficiency and torque, as a result of copper's superior conductivity. Nowadays, there are very strict energy efficiency standards governing industrial motors: the most demanding are those that apply to 'highly energy efficient' motors (*EFF 1* in Europe and *NEMA Premium* in the United States). American and European standards are most easily met by electric motors with copper rotors.

- ***What new contributions do they make in terms of efficiency and environmental impacts?***

A highly energy efficient motor reduces energy waste and consumes less electricity. Worldwide industrial consumption of electricity now represents 6,000 TWh/year, of which 60% is used by motors. An increase of a mere 3% in the efficiency of these industrial motors therefore represents savings of 108 TWh/year, or 70 million fewer tonnes of CO₂ in the atmosphere. This explains why both Europe and the United States will require highly efficient motors in all areas by 2008. Those industries that will not be equipped will have to pay a green tax, in accordance with the polluter-payer principle.

- ***Will copper replace aluminium, over time, in all electrical motor rotors?***

No, at least not in the short-term. We are currently the only company in the world to master high conductivity copper injection as an industrial process. In other words, this is a market that is still emerging, albeit one that promises very strong growth in the coming decades. Master-moulding copper rotors instead of aluminium doubles the lifetime of motors, reduces their operating temperature, decreases total motor volumes by nearly 30% and increases their torque by as much as 70%. In addition, comparative studies show that on an equivalent energy efficiency basis, the cost to manufacture a copper rotor motor is 16.4% to 22.6% lower than the cost of an aluminium rotor motor.

- ***Why has no one done this previously? What are the challenges?***

To begin with, you need to be able to keep copper in liquid form without oxidation. Although this is very simple in a laboratory setting, it is very complex in an industrial environment compatible with mass production. Secondly, injection is very difficult to get right, due to copper's crystalline structure and its metallurgical properties. It took us more than 10 years to develop our process, which resulted in non-porous, zero-defect rotors, which further increases copper's contribution to the motor's characteristics. Lastly, a further major constraint has to do with maintaining temperatures throughout the process. Our moulds must be able to withstand, over time, temperatures exceeding 1200°C. Given that steel melts at 1500°C, it is easy to see the challenge that this represents!

Interview with Prof. R. Belmans

Director of the department of electricity of the University of Louvain, President of the International Union of Electricity, Chairman of the Board of Elia

- ***Why energy efficiency has gained such an importance over the past year and what contribution can it make to build a sustainable energy future?***

Energy efficiency can contribute to the reduction of energy consumption while keeping the standard of living constant or even increasing it. It has to be stressed that energy efficiency should not be confused with less electric energy. Often an increased use of electric energy, for instance plug in hybrid cars or heat pumps, can significantly reduce the primary energy use, while increasing electricity consumption. An overall assessment is key.

- ***What challenge remains for developing renewable energy, particularly with respect to their integration into the electricity system?***

Storage and balancing. The intermittency is a very important issue. This has to be solved by linking more wind parks as such but also by linking wind with hydro. Demand side participation, in order to adapt demand to the availability, is another key issue.

- ***What contribution can copper provide to energy efficiency and to renewable energies and what role can it play in building a sustainable energy future?***

Small sized generation requires an increased use of material and copper as a very good conductor is key in energy efficiency, in generation, transmission, distribution and use.

Interview with Prof. C W Keevil

Head of the Environmental Healthcare Unit at University of Southampton's School of Biological Sciences

- ***Copper's antimicrobial properties have been used since antiquity. What does the situation look like today?***

Copper has continued to be exploited for its antimicrobial properties. Well known examples include French wine growers using "Bordeaux mixture" (a paste of copper sulphate) to fight fungal infections of vines, and Asian countries continuing to use copper vessels to store drinking water and keep it "fresh". The first observation of copper's role in the immune system was published in 1867 when it was reported that, during the cholera epidemics in Paris of 1832, 1849 and 1852, copper workers were immune to the disease. More recently copper's role in the immune system has been supported by observations that individuals suffering from Menke's disease (an inherited disease in which there is defective copper absorption and metabolism) generally die of immune system-related phenomena and other infections. Further, animals deficient in copper have been shown to have increased susceptibility to bacterial pathogens such as Salmonella and Listeria. Evidence such as this has led researchers to suggest strongly that copper compounds not only cure disease but also aid in the prevention of disease.

In 1885, the French physician, Luton, reported on using copper acetate in his practice to treat arthritic patients. For external application he made a salve of hog's lard and 30% neutral copper acetate. For internal treatment, he used pills containing 10 mg. of copper acetate. In 1895, Kobert published his review of the pharmacological actions of copper compounds. Copper arsenate had been used to treat acute and chronic diarrhea as well as dysentery and cholera. A variety of inorganic copper preparations were found to be effective in treating chronic adenitis, eczema, impetigo, scrophulosis, tubercular infections, lupus, syphilis, anemias, chorea and facial neuralgia. An organic complex of copper developed by Bayer was shown to have curative powers in the treatment of tuberculosis. Copper treatment for tuberculosis continued until the 1940s, and various physicians reported on their success in using copper preparations in intravenous injections.

In 1939, the German physician, Werner Hangarter, noticed that Finnish copper miners were unaffected by arthritis as long as they worked in the mining industry. This was particularly striking since rheumatism was a widespread disease in Finland, and workers in other industries and other towns had more rheumatic diseases than did the copper miners. This observation led Finnish medical researchers plus the Germans, Hangarter and Lübke, to begin their now classic clinical trials using an aqueous mixture of copper chloride and sodium salicylate. They successfully treated patients suffering from rheumatic fever, rheumatoid arthritis, neck and back problems, as well as sciatica.

- ***Can copper stop the epidemic dissemination of diseases, like influenza?***

The prevention of diseases requires multiple barriers for effective control, particularly where resistance to therapeutic antibiotics is increasing. These barriers include preventative measures such as regular contact surface washing (e.g. work surfaces, door handles, push plates), hand washing (particularly the frequent use of alcohol-based handrubs by staff in hospitals to control MRSA spread) and prophylaxis (e.g. vaccination or antibiotic treatment). Unfortunately these measures are not completely effective (either because contact surfaces are not regularly and thoroughly cleaned; handwashing is not well practiced or effective, or vaccination is not available or is ineffective for rapidly mutating pathogens). Therefore, additional barriers are required: the simplest, for example, is installing surfaces with inherent antimicrobial properties that do not require regular cleaning to remain effective. Our work to date has shown that copper and some of its alloys are able to kill bacteria, fungal and viral pathogens within minutes or hours when they come into contact. By contrast, stainless steel and modern plastics do not show this useful property.

- ***What does most recent scientific research say about new or future copper medical purposes?***

The work on the antimicrobial properties suggests that copper and some of its alloys could be beneficially included in the healthcare environment; for example, returning to the use of brass or more modern copper alloys for the fabrication of door furniture, sanitary ware and heating and ventilation (HVAC) systems that supply wards containing ill or immunocompromised patients who are more susceptible to pathogen invasion.

- ***Can you tell us more about the Selly Oak Hospital clinical trial?***

The laboratory work has shown great promise but, of course, cannot completely reproduce the real world. It is worth noting that the American physician, Dr Phyllis Kuhn, observed over 20 years ago that when her hospital in Philadelphia replaced copper or brass contact surfaces with other materials the rates of infection increased significantly¹⁶. Therefore it is important that trials be undertaken in hospitals where the effects of replacing contact surfaces with copper-based products on wards can be compared to equivalent wards that are unmodified to see if the numbers and types of infections reported decrease.



APPENDIX 2: SPOKESPERSONS AND CONTACT INFORMATION

Don Smale
Secretary General
International Copper Study Group
GSM : +351 917 298 808
Tel. : + 351 21 351 3873
Fax : + 351 21 352 40 35
E-mail : mail@icsg.org
www.icsg.org

Prof. Ronnie Belmans
Head of Department
University Catholic Leuven
GSM : + 32 475 48 36 64
Tel. : + 32 16 32 10 21
Fax : + 32 16 32 19 85
E-mail: Ronnie.belmans@esat.kuleuven.ac.be
www.esat.kuleuven.ac.be

Simon Payton
Secretary General
International Wrought Copper Council
GSM : +44 7785 390262
Tel. : + 44 20 7868 89 30
Fax : + 44 20 7868 88 19
E-mail : iwcc@coppercouncil.org
www.coppercouncil.org

Prof. Bill Keevil *PhD FIBiol FAAM*
Director of the Environmental Healthcare Unit
School of Biological Sciences
University of Southampton
Tel. : + 44 2380 594 726
Fax : + 44 2380 594 459
E-mail : cwk@soton.ac.uk
www.soton.ac.uk

John Schonenberger
Chief Executive
European Copper Institute
GSM : + 32 478 28 25 26
Tel. : + 32 2 777 70 70
Fax : + 32 2 777 70 79
E-mail : js@eurocopper.org
www.eurocopper.org

Jean-François Zobrist
Managing Director
FAVI
GSM : + 33 6 08 9094 21
Tel. : + 33 3 22 282051
Fax : + 33 3 2228 60 63
E-mail : jfzobrist@favi.com
www.favi.com

Christian de Barrin
Communication Manager
European Copper Institute
GSM : + 32 476 30 99 60
Tel. : + 32 2 777 70 82
Fax : + 32 2 777 70 79
E-mail : cdb@eurocopper.org
www.eurocopper.org

Prof. Tom Elliott B.M., B.S., B.Med.Sci., Ph.D.,
D.Sc., FRCPath
Divisional Director and Deputy Medical Director
**University Hospital Birmingham NHS
Foundation Trust**
Media Communications Manager: Louise Rowan
E-mail : Louise.Rowan@uhb.nhs.uk
Tel. : + 44 121 627 2978
www2.uhb.nhs.uk/



APPENDIX 3: THE EUROPEAN COPPER INSTITUTE

The *European Copper Institute* (ECI) is a joint venture between the world's mining companies (represented by the International Copper Association, Ltd.) and the European copper industry. Its mission is to promote copper's benefits to modern society, through its Brussels headquartered office, and its European network of 11 copper information centres.

ECI is active in four key areas in Europe:

1) ECI's electricity and energy programme

The purpose of ECI's electricity and energy programme is to promote the rational use of energy with a view to achieving sustainable development, based on 3 pillars:

- **Energy efficiency:** through market intelligence, participating in advocacy and education actions, and by participating in Community action programmes such as the 'Motor Challenge', which motivates industry to use systems using more efficient electric motors.
- **The quality of electric energy:** ECI is the founder of a Community vocational training action programme (LEONARDO Power Quality Initiative) to improve the quality of electrical energy by reducing electrical disturbances. Implemented in 12 countries, this programme involves more than 50 partners, including leading universities, companies and professional organisations. The goal is to save EUR 10 billion per year by reducing electrical disturbances.
- **Electric safety and comfort:** ECI has set up a European working group on improving domestic electrical safety, including the system's main players: the FEEDS (Forum for Enhanced Electrical Domestic Safety).

2) ECI's automotive and building programme

Construction is one of ECI's key sectors, as is the automobile industry. ECI's promotional efforts in these areas are organised around:

- **Architecture and piping systems:** the goal is to promote copper's aesthetics, as well as its durability and natural antimicrobial properties that are widely recognised in drinking water, heating and gas distribution systems.
- **Copper's role in solar power:** harness copper's remarkable thermal conductivity as a key factor in using solar energy.
- **Copper's advantages in automotive construction:** promote copper's role in improving the safety and comfort of modern cars and developing tomorrow's electric cars.

3) ECI's environmental programme

ECI's environmental programme is mainly focused on understanding the potential effects of copper on soil and water. The results are used to dialogue with regulators at both EU and national levels. All research is carried out with the assistance of eminent scientists.

4) ECI's health programme

ECI's health programme is mainly focused on understanding copper's role on health. Results are used to improve health by contributing to regulatory discussions.

Information:

Christian de Barrin, Communications Manager

Tel.: + 32 2 777 70 82 / E-mail : cdb@eurocopper.org / URL : www.eurocopper.org



APPENDIX 4: THE INTERNATIONAL WROUGHT COPPER COUNCIL

The International Wrought Copper Council (IWCC), which was founded in 1953, is a trade association for the copper fabricating industry. Currently, the IWCC has Members throughout Europe and Japan, Australia, China, India, Malaysia, South Africa, South Korea, Taiwan and the USA. Details of all Members can be found on the IWCC website.

The Council is governed by its members in the General Assembly, which is held annually. During the year its affairs are run by the Executive Board and by specialist Committees. Its role is to facilitate communication within the industry and to represent its interests. The IWCC therefore works closely with other organisations connected to the copper industry.

The copper and copper alloy fabricating industry produces wire, tube, sheet, strip and rods in copper, brass, bronze and other alloys which are used in thousands of applications in buildings, power transmission, communications, transport and industry.

Telephone: +44 (0)20 7868 8930

Fax: +44 (0)20 7868 8819

E-mail: iwcc@coppercouncil.org

Website: www.coppercouncil.org

APPENDIX 5: THE INTERNATIONAL COPPER STUDY GROUP

The International Copper Study Group (ICSG), established in 1992, is an intergovernmental organization of 22 member government representing copper producing and using countries and the EU. The mandate of the Study Group provides for enhanced co-operation on issues related to copper, greater market transparency, and a forum in which consultations on copper can be held between governments and industry.

ICSG's three main objectives are:

- *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 meetings of the Study Group are open to government members, their industry and invited observers.
- *Increase market transparency* through complete and reliable up-to-date statistics, through special investigations and studies, and through consultations and exchange of information on the international copper economy.

The ICSG maintains one of the world's most complete historical and current databases with statistics for production, consumption, stocks, prices, recycling and trade for copper products. It also maintains a database/directory assessing the future evolution of world copper mines, smelters and refineries production capacities.

Telephone: (351) 21-351-3870

Fax: (351) 21-352-4035

Email: mail@icsg.org

Website: <http://www.icsg.org>