Press Kit

COPPER: SOLAR ENERGY'S PERFECT PARTNER

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Contents

Information :
European Copper Institute
Christian de BARRIN
Communications Manager
Tel.: + 32 2 777 70 82
Cel: +32 (0)476 30 99 60
cdb@eurocopper.org

Press contacts:
YULUKA
Christophe KONINCKX
Tel. : +32 2 347 09 11
Cel : +32 (0)476 44 05 15
christophe@yuluka.com

1. The production of electricity from solar sources

Sunlight can be transformed into electricity by means of two very different types of technologies:

1) using photovoltaic panels which convert solar energy directly into electricity
2) by solar thermoelectric generation: the sun's rays are concentrated on a focal point by means of mirrors to obtain a very high temperature which produces water vapour, which is then transformed into electricity.

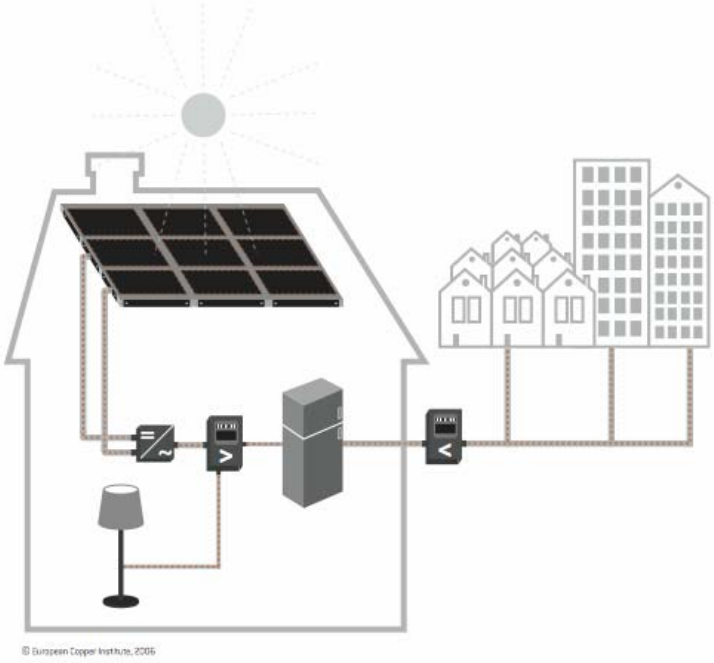
Solar electricity using the photovoltaic effect

Semi-conductors, such as silicon, have the capacity to transform light into electricity. This is known as the photovoltaic effect, which was discovered by Edmond Becquerel in 1839.

Silicon, a widely-found, non-toxic element, is the semi-conductor used in most photovoltaic cells produced around the world today. Such silicon, which is artificially modified by a very complex technological process, transforms light directly from the sun's rays into electrical energy. The silicon is processed to form a large p-n junction area. When light particles (photons) strike the material, electron-hole pairs are freed and move to opposite surfaces. When the two surfaces are joined by a connector, electricity flows as direct current.

It should be noted here that very thin layers of photovoltaic cells, using new semi-conductor materials such as a combination of copper-indium-gallium-selenium (C165), currently account for 7% of the market. This material, which is cheaper to produce, has huge commercial potential.

The power output of a single cell is approximately 1.5 watts . Therefore, in order to obtain usable amounts of electricity, many cells are interconnected in series and in parallel and inserted in a device that allows solar radiation to flow, and protects the cells from the environment. Such a device is known as a photovoltaic "module" or "panel". Panels can then be connected together, in an array, to give the desired electrical output. The cells can also be integrated within the structure of a building, between glass panels or in the roof tiles, thereby offering architects new aesthetic possibilities.



In stand-alone systems, the current produced is stored in batteries, to compensate for the intermittent nature of solar energy, and may also be used to run dc loads directly or ac loads using an inverter.

In grid-connected systems, the power generated is used first to satisfy local needs. Any excess is exported to the grid (or any deficit imported from the grid) via a meter which measures energy transfers to and from the grid for billing and invoicing purposes.

The photovoltaic module's power is measured in peak power (Peak Watt/hour: Whp): this is the maximum power produced by the module under a referenced solar radiation of 1 000 W per square meter , and at a temperature of 25° C. These conditions are rarely met, but serve as a valid reference in order to buy equipment or to dimension installations.

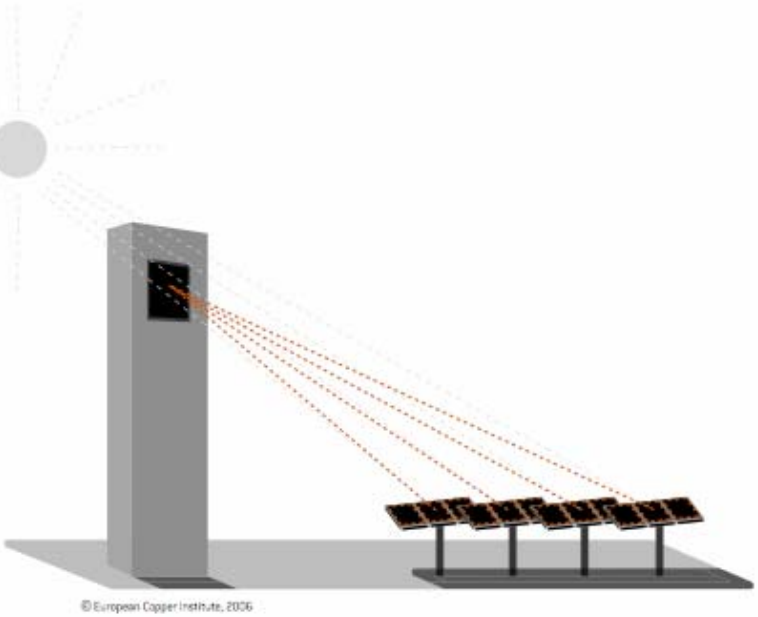
Solar thermoelectric energy

In the case of solar thermoelectric power stations, electricity is produced by obtaining very high temperatures through the concentration of sunlight in a specially designed device called a "receiver" or an "absorber".

The sunbeams are concentrated on one point in order to produce intense heat. This energy is then used to convert water into steam, which operates turbines and alternators to generate electricity.

There are several types of solar power station; they differ in the way they focus the solar radiation, and include:

- Stations with cylindrical-parabolic collectors which concentrate the rays 20 to 80 times on the receiver, in order to increase the temperature to up to 500°C
- Parabolic dish collectors which concentrate the solar radiation from 200 to 3 000 times on the receiver. They are permanently oriented towards the sun and direct the rays onto the focal point of this dish
- Tower-type power stations, which are like belvederes surrounded by a field of sun-tracking mirrors on the ground ("heliostats") which direct the sun's rays to a boiler in the top of the tower.



These types of installations are the only technologies currently capable of providing power similar to that of fossil fuel or nuclear power stations. Solar power stations are currently profitable given excellent atmospheric transparency and solar radiation of more than 1,900 KWh per square metre per year, conditions typically occurring in Southern Europe and the Mediterranean basin, amongst other places in the world.

Copper as a conductor of electricity

Copper is the best conductor of electricity of all non-precious metals. It is malleable and yet durable, and as such is the ideal material for all electrical applications: wires, plugs, generators, motors and, of course, electrical appliances. Modern solar technology logically makes use of the exceptional qualities of copper. Nearly 60% of the absorbent surfaces of the solar collectors are made up of fine copper sheets approximately 0.2 mm thick. Copper is also found in supply lines, heat exchangers, pumps, electrical cables, shut-down mechanisms and in photovoltaic cells (thin film technology).

2. Thermal solar technology: the most widespread

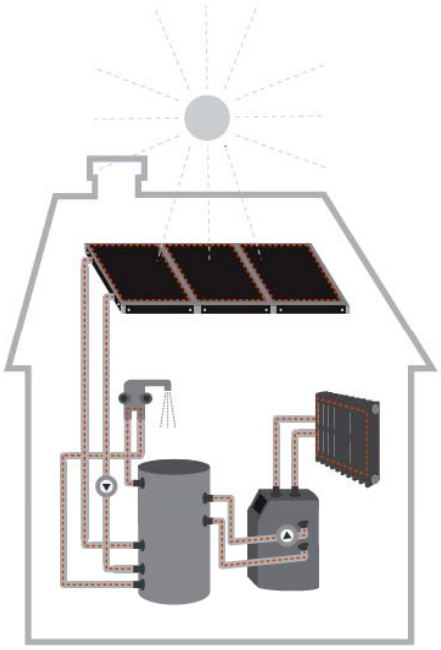
Thermal solar energy is essentially used to heat water to temperatures of 60°C to 70°C, which is then mainly used in homes, hospitals, hotels and other buildings. Buildings account for around 40% of energy consumption in the EU, and most of this energy is used for heating and air-conditioning[1]. Thermal solar energy therefore represents a major source of sustainable energy, to produce:

- **heat**, which applies equally for the heating of homes and swimming pools, and the production of domestic hot water, as well as for agricultural purposes such as drying cereals.
- **cold**, with solar cooling systems mainly through absorption refrigerating machines.

In terms of an individual home, thermal solar energy production systems can cover 50 to 70% of domestic hot water requirements.

How does thermal solar energy work?

Sunlight is converted directly into internal energy in the solar receivers, which operate like mini-greenhouses.
- The sunlight passes through a glass panel and is collected by an absorber in which solar radiation is transformed into thermal energy.
- The working fluid (water containing antifreeze and antioxidant) which circulates in the absorber transmits this accumulated heat through a circuit of insulated copper pipes to a water tank (accumulator), via an exchanger.



The system can also be connected to a copper tube under-floor-heating system to help heat the building. The excellent thermal conductivity and high resistance to corrosion, makes copper a first-rate material for the pipes in these systems.

Through a well-planned combination of architecture and home automation, thermal solar energy is becoming an essential element of energy efficiency in buildings. Owing to the specific requirements of thermal solar energy, copper and its particular properties not only make it the principal material used in this technology, but also the best.

Copper as a conductor of heat

The excellent thermal conductivity and durability of copper make it an ideal material for a thermal solar installation. Copper is used:

- in the absorber - the part of the collector, made of blackened copper plate, which collects solar radiation and converts it to heat
- in the copper pipes which contain the working fluid (carrier of the thermal energy)
- in the pump which enables the working fluid to circulate in a loop in the circuit
- in the entire heating and domestic water supply system in the home.

[1] Source: EU

Copper as a guarantee of water quality

The algaecide, fungicide and bacteriostatic properties of copper help to preserve the hygienic qualities of water. Copper is impermeable to external pollution, including solvents, and so provides a protective barrier, a benefit for thermal solar technologies and drinking water systems.

European markets in terms of capacity (kW_{th})

IN OPERATION		MARKET (= NEWLY INSTALLED)			MARKET GROWTH	MARKET FORECAST
	2005	2003	2004	2005	2005/2004	2006
	Total (kW_{th})	Total (kW_{th})	Total (kW_{th})	Total (kW_{th})	Total (kW_{th})	Total (kW_{th})
AT	1 623 271	116 844	127 816	163 429	28%	196 000
BE	47 938	6 333	10 290	14 164	38%	15 400
CH	2 714 114	18 774	21 747	27 392	26%	32 900
DE	4 587 800	504 000	525 000	665 000	27%	840 000
ES	369 016	49 000	63 000	74 760	19%	126 000
FR	276 920	27 230	36 400	85 050	134%	126 000
IT	361 400	35 000	40 600	50 400	24%	63 000
NL	212 629	19 380	18 410	14 174	-23%	15 400
PT	112 665	4 200	7 000	11 200	60%	14 000
SE	145 873	13 479	14 041	15 835	13%	17 500
UK	137 844	15 400	17 500	19 600	12%	25 200
TOTAL	**11 175 465**	**993 158**	**1 112 954**	**1 399 129**	**26%**	**1 762 233**

Source : European Solar Thermal Industry Federation – June 2006

3. The development of solar energy

Europe is becoming increasingly dependent on producer countries for its energy, with all the associated geopolitical risks that this entails.
The demand for energy continues to increase and so the supply of energy to meet this growing demand presents a real challenge as:

1) Traditional energy sources are going to run out sooner or later (some experts say in less than 50 years for oil!)
2) price fluctuations cause widespread instability in the markets

The advantages of solar power

Underestimated for a long time, solar energy now plays a crucial role in the essential development of renewable energies.

Although it still only makes a minor contribution to electricity consumption from renewable energies, solar energy has many advantages in terms of energy and the environment:

- It is inexhaustible
- It is renewable
- It is available almost everywhere (with a resulting reduction in costs and impact of distribution), particularly in countries situated between the equator and a 45° strip on either side of it
- It enables consumption to take place at the installation site, with no distribution.

Solar electricity production

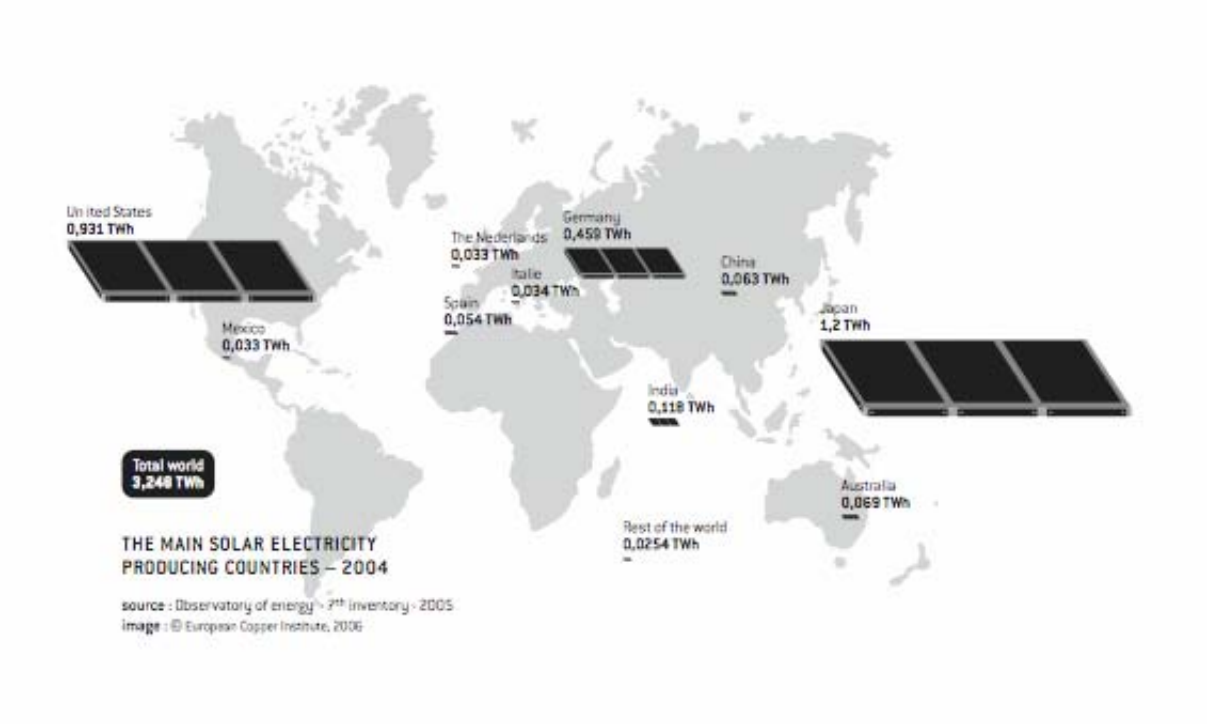
Global solar electricity production totalled 3.2 TWh in 2004: some 82.2% was generated by photovoltaic power plants and 17.8% by solar thermoelectric plants.

Europe is the third largest solar energy producing region in the world, accounting for 20.7%, behind East Asia (41.2%, notably owing to Japan) and North America (29.4%, essentially produced by solar thermoelectric power stations)[2]

The main solar electricity producing countries – 2004

Country	2004 Production (TWh)	Share of global production (%)
Japan	1.200	36.93
United States	0.931	28.67
Germany	0.459	14.13
India	0.118	3.64
Australia	0.069	2.11
China	0.063	1.95
Spain	0.054	1.66
Italy	0.034	1.04
The Netherlands	0.033	1.02
Mexico	0.033	1.02
Rest of the world	0.0254	7.83
World total	3.248	100.0

[2] Source: Baromètre Observ'ER - 2005



Solar electricity in Europe

Most electricity produced in Europe comes from fossil fuel sources (53.0% - 2004 figures). Nuclear production accounts for 31.1%, derived from the major countries supplying nuclear energy (Latvia, France, Belgium, Slovakia and Sweden). Renewable energies account for just 14.4% of electricity production in the EU. Solar energy makes the smallest contribution, behind hydroelectric, biomass, wind energy and geothermal power.[3]

Nevertheless, the expansion of these various renewable energies is globally highly dynamic. Over the past decade, solar power in particular has expanded massively, with 650 GWh of photovoltaic electricity produced in 2004. In 2005, the European photovoltaic solar energy market grew by 18.2%. The total capacity of photovoltaic installations now stands at approximately 1,793.5 MWc, the equivalent of the electricity requirements of 600,000 homes (assuming an annual average consumption per home of 3,000 kWh per year, excluding electric heating). [4]

Germany is still the market leader in global photovoltaic production, far ahead of Japan and the United States, with over 600 MWp installed. In Europe, Italy and Spain follow close on its heels.[5]

The European Union is encouraging solar energy

This interest in electricity production based on clean energy sources forms part of the European effort to encourage renewable energies, notably:

- The directive on the promotion of electricity from renewable energy sources[6]
- The directive on energy efficiency in buildings[7]
- The directive on the taxation of energy products and electricity[8]

[3] Source: Photovoltaic Energy Barometer n °172 - April 2005 - EurObser'ER

[4] Source: Photovoltaic Energy Barometer n °172 - April 2005 - EurObser'ER

[5] Source: Photovoltaic Energy Barometer n °172 - April 2005 - EurObser'ER.

[6] 2001/77/EC - OJ L283/33 –

[7] 2002/91/EC - OJ L1/65 –

[8] 2003/96/EC - OJ L283/51 –

- The directive on eco-design requirements for energy-using products
- The directive on energy end-use efficiency and energy services

To reduce the Union's energy dependence [9] and respect European commitments in terms of the reduction of greenhouse gases under the Kyoto Protocol, a European directive on green energy sets an overall target of 21% for community electricity consumption from renewable energies by 2010.

Only four member States are likely to achieve their national objectives: Germany, Denmark, Finland and Spain. As investments currently stand, **only 18 or 19% of renewable energy targets will be achieved** by the other countries which recently introduced new legislation to achieve the 2010 objectives. [10]

Spain in particular is a reference, with several remarkable initiatives:

- Since 2000, as part of its energy improvement programme, Barcelona has decided to make the installation of thermal solar panels obligatory for hot water production in all newly built or renovated buildings. This initiative was followed by fifty other cities in Spain, including Madrid and Seville.
- The new "Technical construction code" adopted in March 2006, includes significant aspects relating to energy efficiency in buildings. Spain has therefore adopted some of the most far-reaching legislation on solar energy. All new constructions have to be equipped with a solar water heater, in order to cover between 30 and 70% of hot water requirements. New buildings of over 4,000m² also have to make use of photovoltaic energy.

Remarkable sites in Europe

In Spain, the solar thermal electric power plant at Sanlúcar la Mayor - PS10 near Seville is currently the largest in Europe. Over an area of 69 hectares, 624 mobile mirrors, each one measuring 120 m^2, project solar energy to the top of a 100-metre high tower.

With an output of 10 Megawatts (MW), it is able to generate 24 Gigawatthours per year and will be able to supply electricity to around 10,000 homes in Spain. It will thereby avoid 12,000 tonnes of CO_2 being emitted into the atmosphere per year.

This power station is the first in a series of eight plants which will be built at this site; over the next eight years, the project is estimated to reach a total capacity of 300 Megawatts (MW), thereby supplying 180,000 homes – the equivalent of the city of Seville. Not far from the PS-10 plant, the "Seville PV" low-concentration photovoltaic plant is under construction, with a capacity of 1.2 Megawatts (MW). The next plant, planned for the end of 2006 will be the PS-20 Plant, with a capacity of 20 Megawatts (MW).

In Germany, Pocking is for a short while still the world's largest solar energy production plant (10 MW). It was opened on April 27th 2006.

In Great Britain, the Eden Project, a vast environmental complex in Cornwall, has a new education centre, designed by Tim Smit and Grimshaw architects. Solar panels integrated into the immense copper roof are designed to supply 8% of the building's energy needs. Eden is famous for its remarkable biomes (huge greenhouses). The main source of heat is the sun, which provides the necessary energy for the recreation of three types of climates: a humid tropical biome, a warm Mediterranean-type biome and an exterior biome.

[9] As the Commission pointed out in its Green paper, current dependence on oil and gas imports accounts for 50% of consumption. Forecasts suggest that this figure will increase to 70% in 2030
[10] Source: Euractiv

The City of Malmö, Sweden's third city, has undertaken a vast programme to minimise its contribution to climate change, notably by developing programmes which provide massive incentives for renewable energies. The main innovations have been introduced in the construction sector, notably an extensive programme to integrate solar technology as a source of electricity production in public buildings. The city has also completely restructured the "Bo01" district, to transform it into a city of the future. The district is thus solely supplied with energy from renewable sources, including large photovoltaic installations.

In France: The CNRS laboratory and the European centre for international research teams in the field of concentrated solar energy, the Font-Romeu Odeillo site in the Eastern Pyrenees, house the largest solar furnace in France. The originality of the CNRS Odeillo installations and the scientific expertise of the IMP-CNRS laboratory in Perpignan have been recognised by the European Commission, which granted the solar installations the status of "Great European Infrastructure" in 2004 for a period of four years. Several research programmes supported by the EU were therefore started up in 2004, along with the creation of the associated European laboratory "SolLab" (Cologne/ Zurich).

This furnace is aimed at conducting research and promoting solar energy, as well as providing research-based training in the area of high temperatures (CNRS research laboratory). It also has a permanent exhibition on the subject of the sun, light and high solar and non-solar temperatures.

In Portugal, the Serpa Solar Project, whose construction was announced in April 2006, is set to become the world's largest photovoltaic solar power plant. Producing 11 megawatts, with 52,000 photovoltaic modules, it will be built on a single site at Serpa, in Portugal, 200km south west of Lisbon in one of Europe's sunniest regions. The project will cover 60 hectares on a south-facing hillside, which will remain productive farmland, and is scheduled to become operational in January 2007.

4. Copper, an environmentally-friendly metal at the service of sustainable energy

Copper is an essential material for the production and transportation of energy and is intrinsically at the service of clean, sustainable energy.

Copper and rational use of energy

In Europe, over a quarter of the electricity produced is consumed by households[11]. Energy consumption is continuing to rise by 1% per year. In order to meet this increase in demand, the first measure involves promoting the Rational Use of Energy (RUE), in other words, using the least possible amount of energy for the same level of comfort, notably by enhancing **energy efficiency**. Owing to its excellent conductivity, copper enables a significant reduction in energy losses. In the case of industry for example, a study published in April 2004[12] demonstrated that over 200 billion kWh per year could be saved in Europe simply by increasing the efficiency of electrical motor driven systems.

Copper and wind energy

Copper is essential for solar technologies, but is also plays an essential role in wind energy. A 1.5 MW wind turbine contains no less than 3.4 tonnes of copper. Copper is present in all the elements of the wind energy production chain, particularly in the batteries which enable storage ofthe electricity produced.[13]

Copper, 100% recyclable

Durable, corrosion-resistant and easy to use, copper contributes upstream to the reduction of the volume of waste and minimises maintenance operations.

Copper is 100% recyclable and the material available on the market already includes recycled copper. The recycling process in no way alters the properties of copper: recycled copper is melted down with new copper and can be reused in exactly the same way. It is estimated that recycled copper satisfies over 41% of demand in Europe[14]. By reintegrating recycled copper in the overall volume of copper used, we save raw materials! The recycling process uses only 85% of the energy[15] required for the primary production of new copper, so recycling copper conserves both raw materials and energy.

[11] 664 645 GWh out of a total of 2 306 363 GWh - Source: European Environment Agency
[12] Study conducted by the European Copper Institute under the aegis of the European Commission *Motor Challenge* Programme, assisted by the Catholic University of Leuven, the University of Coimbra and the Fraunhofer Institute for Systems and Innovation Research (Karlsruhe).
[13] University of Leuven
[14] Source: International Copper Study Group – www.icsg.org
[15] Source: BIR (Bureau of International Recycling)

5. The Copper market

Copper is naturally present in the earth's crust and is essential for the development of life. It is the metal which has been used the longest by man: the first copper coins date back to 8700 B.C.

The world's natural copper resources are currently estimated at 2.3 billion tonnes.
Mining accounts for only 65% of the copper supply, the rest is provided through recycling.

A constantly expanding global market, dominated by Europe and China

On a global scale, the annual usage of copper amounted to 22,45 million tonnes at the end of 2004, compared to less than 10 million tonnes in 1970. Global copper demand has increased by 37% over the past decade (1995/2005), and by 5,4% in 2004 alone.

Europe is the region with the highest demand for copper in the world, accounting for 29% of global demand, and a region that's seen demand increased by 14% over the 1995-2005 period. The European copper recycling sector is very well-organised and effectively supplies 41% of the annual European demand for copper. Within the European Union, the four largest users of copper are currently, in decreasing order: Germany, Italy, France and Spain.

China has been the leading country in terms of copper use since 2002. In 2005, China's share of global copper use was 22% compared with 9% in 1995. Demand has also greatly increased in Russia and in most of the European Union accession countries.

The principal applications for copper are:

- Electricity and energy: 65% (including copper wires and cables used in construction)
- Construction: 25% (architecture and pipes)
- Transport: 7%
- Other: 3% (coins, sculptures, etc.)

Copper specifications

On the galvanic scale of metals, copper is one of the most noble metals, just behind platinum, gold and silver.

Symbol: Cu
Density: 8,930 kg/m3
Melting point: 1,083°C
Available in pipes, bars, profiles, wires, sheets or strips
Durability: over 700 years
100% recyclable with no loss of properties

6. The European Copper Institute

The European Copper Institute (ECI) is a European joint venture between the world's main copper producers (represented by the International Copper Association, Ltd) and the European copper industry. Its purpose is to promote the advantages of copper for modern society throughout Europe, from its headquarters in Brussels and its network of 11 copper promotion associations.

The ECI operates in four key areas in Europe:

1. Electricity and energy
2. Automotive and construction
3. The environment
4. Health

1) The ECI electricity and energy programme

The ECI electricity and energy programme aims to promote the rational use of energy, in the context of sustainable development, in 3 areas:

- **Energy efficiency**: by increasing the number of studies, awareness and market development campaigns, notably by taking part in Community action programmes such as the "Motor Challenge" which encourage industry to use systems driven by more efficient electrical motors, in order to increase energy efficiency.

- **The quality of electrical energy**: the ECI established a Community action programme for professional training (LEONARDO Power Quality Initiative) in order to improve the quality of electrical energy by reducing electrical interference. This programme is taught in 12 countries and involves over 50 organisations including renowned universities, companies and professional organisations. The target is to save 10 billion euros per year by reducing electrical interference.

- **Electrical safety and convenience**: the ECI has set up a European working group to improve electrical safety in the home, which brings together the sector's main players: FEEDS (the Forum for Enhanced Electrical Domestic Safety).

2) The ECI automotive and construction programme

Construction is one of the key sectors for ECI action, along with the automotive industry. ECI promotion action in these sectors focuses on 3 main areas:

- **Architecture and ducting systems**: the objective is to promote the aesthetic qualities of copper, its durability and natural antibacterial properties, which are notably required for drinking water distribution, heating and gas.

- **The role of copper in solar energy**: to promote the remarkable thermal conductivity of copper as a key factor in the use of solar energy.

- **The advantages of copper in automobile construction**: to promote the role of copper in improving modern vehicle safety and comfort and to turn the possibility of future electric cars into a reality.

3) The ECI environmental programme

The ECI environmental programme is mainly aimed at understanding the potential effects of copper on the soil and water. The results provide the basis for debates on EU and national regulations. All research is conducted with the assistance of eminent scientists.

4) The ECI health programme

The ECI health programme is mainly aimed at understanding the role of copper on health. Its results are used to improve health by contributing to debates on regulations.

Further information:

Christian de Barrin,
Communications Manager
Tel. + 32 2 777 70 82
E-mail: cdb@eurocopper.org – Website: www.eurocopper.org

7. Abengoa

Abengoa is a technology company applying innovative solutions for sustainable development in the infrastructures, environment and energy sectors. Abengoa is present in over 70 countries, operating through its five business units: Solar, Bioenergy, Environmental Services, Information Technologies and Industrial Engineering and Construction.

Solar

"Solucar Energía" is its holding company. This Business Unit's activity focuses on the design, promotion, finance attainment, construction and operation of electric energy generating plants that utilize the sun as their primary energy source. It possesses the know-how and technology required for thermoelectric solar power plants: plant receiver systems, parabolic cylinder and parabolic dish collectors, and for photovoltaic plants, with and without concentration.

Bioenergy

"Abengoa Bioenergía" is its holding company. The Business Unit is dedicated to the production and development of biofuels for transport, bioethanol and biodiesel, among others that utilize biomass (cereals, cellulosic biomass, and oleaginous seeds) as the raw material. The biofuels are utilized for ETBE production (gasoline additive), or for direct blending in gasoline or gas oil. Given that they are renewable energy sources, biofuels reduce CO2 emissions and contribute to the security and diversification of the energy supply while reducing the dependency on fossil fuels utilized in the transport sector and helping towards compliance with the Kyoto Protocol.

Environmental Services

"Befesa Medio Ambiente", the holding company of Abengoa's environmental services Business Unit, focuses its activity on providing environmental services for industry and
on the construction of environmental infrastructures, while conducting aluminium waste recycling, zinc recycling, industrial waste management and environmental engineering activities.

Information Technology

"Telvent", the holding company of Abengoa's businesses in the Information Technology sector, provides high value-added solutions in four industrial sectors (Energy, Traffic, Transport, and the Environment). Its technology allows companies to make real-time business decisions utilizing data control and acquisition systems, as well as leading-edge
operational applications that provide companies with secure and efficient information.

Industrial Engineering and Construction

"Abeinsa" is Abengoa's holding company for this Business Unit, whose activity focuses on engineering, construction and maintenance of electric, mechanical and instrumentation infrastructures for the energy, industry, transport and services sectors: Promotion, construction and operation of industrial and conventional (cogeneration and combined cycle) power plants, and renewable energy(bioethanol, biodiesel, biomass, wind, solar and geothermal) power plants. Turnkey projects.

www.abengoa.com