COPPER'S CONTRIBUTION TO A LOW-CARBON FUTURE

A PLAN TO DECARBONISE EUROPE BY 25 PERCENT

European Copper Institute
Copper Alliance

For the latest information about the European Copper Institute's low-carbon strategies please visit http://copperalliance.eu/Decarbonise-Europe/

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SUMMARY

It is not a pipe dream. By 2050, copper can reduce the European Union's carbon emissions by 25% – more than 1,100 million tonnes per year. With proper investment in this oldest of mined metals, copper can help achieve the decarbonisation goals of the European Commission's Roadmap and make a real and lasting difference to our society and our world. The European Copper Institute has compiled this report to demonstrate our industry's dedication to overcoming the biggest environmental challenge of our time and to show that we are indeed your partner in this effort.

We cannot overstate the importance of copper's role in decarbonisation. Some four million tonnes of copper are produced, recycled or converted into value-added products across Europe each year. Of course these activities require energy. However, they also provide the building blocks on which to base industrialised economic recovery and the new technologies a low-carbon economy will require.

The copper industry has developed strategies that will both trigger and support substantial carbon reductions in the downstream industrial, residential and service sectors. By 2020, these strategies could deliver 130 million tonnes of CO_2 savings per year. This amount would grow steadily, and by 2050, total EU CO_2 emissions could be reduced by 25% – more than 1,100 million tonnes per year – relative to 2011 levels.

We have also developed and are advancing strategies within our own businesses. Through significant capital investments, the copper producing industry has successfully reduced its CO_2 emissions by cutting its unit energy consumption by 60% versus 1990. Copper producers are united in their dedication to continuing this effort and will report on their progress.

The success of the EC's Roadmap for a competitive, low-carbon economy depends on the more rigorous adoption of existing solutions, plus the leveraging of innovative technologies that will rely, at least in part, on copper. It is clear then that the EU must strike a well-considered balance between the energy needed to manufacture our economy's building block materials and the reduction in energy demand and carbon emissions that these will deliver.

The copper industry urges the European Commission and other policymakers to acknowledge and support such a balance as they work toward the reconciliation of policies focused on energy, climate change and industrial output.

INTRODUCTION

The Roadmap for a competitive, low-carbon economy by 2050[1] issued by the European Commission (EC) sets out a plan to achieve extremely ambitious cuts in CO_2 emissions. One element of this plan is the setting of reduction targets for the different economic sectors responsible for Europe's emissions. The EC expects each sector to align itself with the plan and has invited them to present their own roadmap based on their specific technological and economic potential.

With this document, the European Copper Institute (ECI) presents the Roadmap for the European copper industry and its products. Our vision is based on two separate but equally important approaches. The first focuses on strategies that our industry is developing to trigger and support CO_2 reduction technologies across the multitude of downstream economic activities, including power generation, manufacturing, services and households.

The second approach focuses on strategies being developed within the industry itself. We conducted in-depth interviews with copper companies across Europe and with the industry's representative bodies. Based on these interviews, we present the significant CO_2 emission reductions that the sector has achieved since the mid-1990s along with the outlook for lower-carbon production in 2050.

Although the European copper industry is of rather modest size, copper products are omnipresent in the wide array of electrical and energy systems used in all human activity. Thanks to its inherently superior electrical and thermal conductivities, copper saves primary energy, CO_2 emissions and money. Therefore, the copper industry is of genuine importance to the entire economy, and vital to the low-carbon economy of the future.

1. THE EUROPEAN 2050 CO_2 CHALLENGE

1.1. OBJECTIVES

In 2010, CO_2 emissions of the 15 EU Member States, that signed the Kyoto Protocol, were 11% below the reference year (1990 for most countries), although some of this reduction can be attributed to the economic crisis that began in late 2008 and continues today. Estimates indicate that emissions have decreased further in 2011 and 2012 and that the Member States, which joined the EU after the Kyoto Protocol agreement, are also contributing to this collective effort.

It has become clear that all of the world's major economies must cut their emissions dramatically to prevent global temperatures rising by more than 2°C over pre-industrial times. The European Commission (EC) has looked beyond the 2020 horizon and, in March 2011, published a Roadmap for a competitive, low-carbon economy that, by 2050, will reduce emissions by 80% versus 1990 levels.

On October 24th 2014, the European Council agreed to ambitious targets for 2030[2]:

- A binding 40% reduction in EU greenhouse gas emissions from 1990 levels;
- Raising the share of EU energy consumption produced from renewable resources to a binding 27%;
- An indicative target of at least 27% improvement in the EU's energy efficiency.

1.2. MILESTONES

As shown in Table 1 below, the EC Roadmap allocates reductions between the economic sectors primarily responsible for Europe's emissions: power generation, industry, transport, residential and services, and agriculture. Target milestones for 2030 and 2050 are established for each sector. In absolute terms, total EU CO_2 emissions have already decreased 18%: from 5,574 million tonnes in 1990 to 4,550 in 2011.[3]

CO_2 REDUCTIONS (VERSUS 1990)	2005	2030	2050
Total	-7%	-40 to -44%	-79 to -82%
Power (CO_2)	-7%	-54 to -68%	-93 to -99%
Industry (CO_2)	**-20%**	**-34 to -40%**	**- 83 to -87%**
Transport (incl. CO_2 aviation, excl. maritime)	+30%	+20% to -9%	-54 to -67%
Residential and services (CO_2)	-12%	-37 to -53%	-88 to -91%
Agriculture (non-CO_2)	- 20%	-36 to -37%	-42 to -49%
Other non-CO_2 emissions	-30%	- 72 to -73%	-70 to -78%

With its emissions almost totally eliminated by 2050, the Roadmap requires the greatest reduction from the power sector. While industry is expected to make an 85% reduction, through the use of cleaner and more energy-efficient technologies, it has already made substantial progress, reducing its carbon footprint by one-third since 1990: from 1,312 to 895 million tonnes in 2011.[4]

It should also be noted that, in October 2012, the EC issued a communication encouraging the resurgence of European manufacturing industry. The EC's ambition is that industry's share in Gross Domestic Product increases to 20% by 2020, up from its current 16%.[5]

Estimates indicate that emissions have decreased further in 2011 and 2012 and that the Member States, which joined the EU after the Kyoto Protocol agreement, are also contributing to this collective effort.

TABLE 1:
EUROPEAN COMMISSION EMISSION REDUCTION TARGETS BY SECTOR

1.3. STRATEGIES FOR REDUCING CO_2 EMISSIONS

Fossil fuel based energy consumption is by far the primary source of emissions in the power, industrial, transport and residential sectors. For this reason, the copper industry focuses on supporting the following strategies: energy efficiency; the use of renewable energy sources; appropriate technologies for mitigation; and the transition to electricity as the primary source of energy.

1.3.1. ENERGY EFFICIENCY

As demonstrated by many EC, non-governmental organisation and academic studies, improving the energy efficiency of installations and systems should be the first priority in efforts to reduce CO_2 emissions. These improvements will also contribute to boosting employment and competitiveness. While the importance of energy efficiency to emission reduction may diminish over time, as the share of renewable sources in the energy mix gradually increases, total energy consumption will remain very important for reasons of both energy security and competitiveness.

1.3.2. USE OF RENEWABLE ENERGY SOURCES

The second priority in efforts to reduce CO_2 emissions is to replace fossils fuels with renewable energy sources. Therefore, the European Copper Institute is committed to promoting the benefits of copper components in renewable energy systems.

1.3.3. APPROPRIATE TECHNOLOGIES FOR MITIGATION

Demand side management, storage and hybrid systems also can contribute to CO_2 reductions and should be considered in future policy developments and financing mechanisms.

In cases where 100% electrification is possible, the need to invest in a costly parallel natural gas infrastructure would be eliminated.

1.3.4. ELECTRIFICATION

The electricity sector is expected to be able to eliminate virtually all of its CO_2 emissions by 2050 by discontinuing fossil fuel-fired power generation in favour of renewable power production. Electrification of equipment, systems and processes currently powered by fossil fuels, particularly in the transportation and industrial sectors, has the additional benefit of reducing EU dependence on oil and gas producing economies. In cases where 100% electrification is possible, the need to invest in a costly parallel natural gas infrastructure would be eliminated.

Many electrification efforts are well underway. Electrified modes of transportation, such as hybrid vehicles and high speed trains, already hold a higher priority in the EU, the US, Japan, China and Korea than in other countries. Electrically powered heat pumps are increasingly used for space heating in office, commercial and domestic buildings. Electricity is also becoming the energy carrier for an increasing number of industrial activities, although to make these economically viable, technologies require further development.

2. THE ROLE OF THE COPPER INDUSTRY

2.1. PROFILE OF THE EUROPEAN COPPER INDUSTRY

The European copper industry, which comprises mining companies, metal producers and semi-fabricated product manufacturers, is relatively small in terms of turnover (approximately €45 billion, although the actual value is highly dependent on the global commodity prices for metals); the number of companies (about 500); and the number of jobs (about 45,000).

Like all metal industries, the copper industry consumes energy, accounting for between 25% and 35% of the industry's total operating costs.[6] Nevertheless, the CO_2 emissions of the European copper industry, estimated at around 4.5 million tonnes of CO_2 per year[7,25], are modest at 0.1% of total EU CO_2 emissions.

Copper can be recycled without any loss in performance … two-thirds of the copper produced since 1900 — more than 350 million tonnes — is still in productive use.

2.2. A RESOURCE FOR TOMORROW'S ECONOMY

Despite its modest size, the copper industry is critically important to the entire EU, and indeed the world's economy. Copper is primarily a business-to-business value-chain that enables economic development across a very wide variety of applications in virtually all economic sectors. Copper is the oldest metal known to man, dating back more than 10,000 years. It is the best conductor of electricity and heat, amongst all the non-precious metals, and possesses a wide array of characteristics that make it of strategic importance for a more sustainable future. Copper reduces CO_2 emissions by being the material of choice for insulated electric wires and cables, busbars, voltage transformers and electric motor windings. It plays a vital role in the miniaturisation of small, high-tech electronics applications. It is also widely used in telecommunications, plumbing and heating systems, heat-exchange, aquaculture, architecture and design applications.

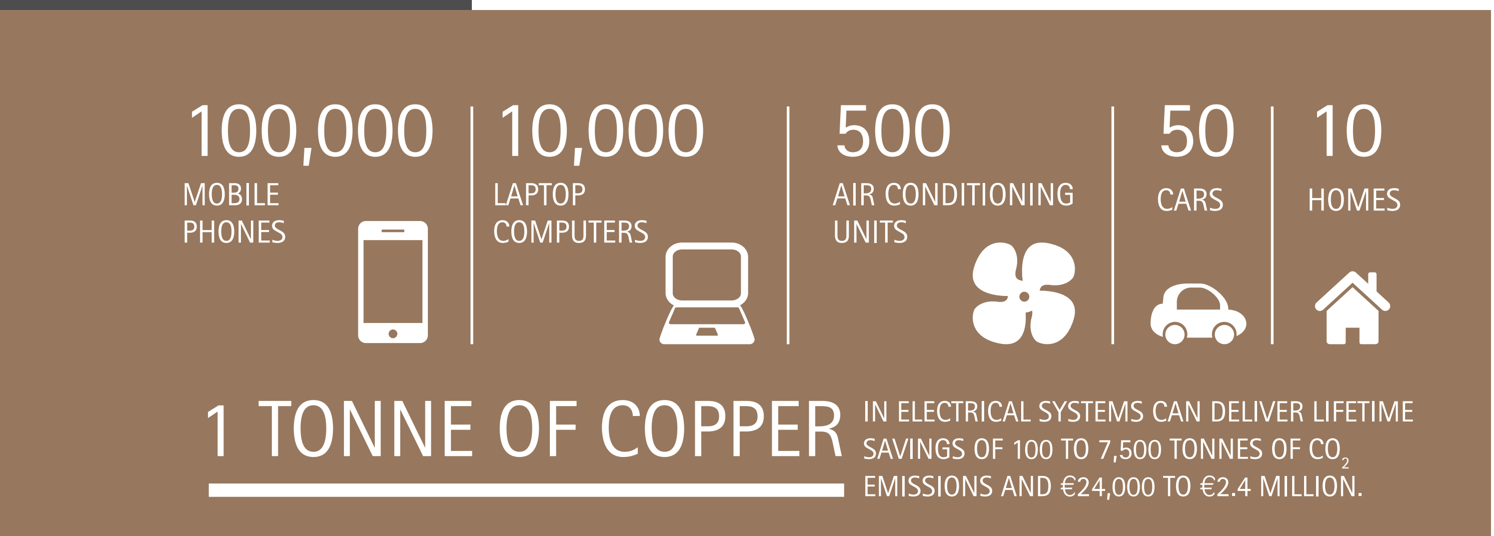
There is no better indicator of copper's role in the development of modern society than the growth in its demand over the past 20 years. Driven in part by the boom in China's economy, global copper usage has nearly doubled from 14 million tonnes in 1990 to 26 million tonnes in 2013 – a compound growth of 2.7% per year. The EU represents nearly 15% of the global market with 3.8 million tonnes in 2013.

Copper is one of the few materials than can be recycled, again and again, without any loss in performance. Recycled copper can be used in the same way as primary (mined) metal. In addition, end-of-life products (scrap) containing copper are much more likely to be collected for recycling because of their residual economic value.

Globally, it is estimated that two-thirds of the 550 million tonnes of copper produced since 1900 is still in productive use. Of this amount, approximately 70% has been used for electrical and 30% for non-electrical applications. Around 55% is in buildings, 15% in infrastructure, 10% in industry, 10% in transport and 10% in equipment manufacture.[8]

The EU's Eco-Design Directive, among other tools, shows that increasing the use of copper generally reduces the environmental impact of electricity consuming equipment, such as motors and transformers. Studies show that adding one tonne of copper, in such systems, can save 100 to 7,500 tonnes of CO_2 emissions, 500 to 50,000 MWh of primary energy, and €24,000 to €2.4 million[9] over their lifetime.

The Power of One Tonne of Copper



Based on data from environdec, European Commission and Leonardo ENERGY

3. COPPER-BASED TECHNOLOGIES TRIGGERING DOWNSTREAM CO_2 REDUCTIONS

Clearly, copper is a vital material in today's society and, because of its unique combination of high conductivity, durability and recyclability, it is expected to be even more vital in the future. In this chapter, we present examples of copper-based technologies that can reduce CO_2 emissions either across industry, in the residential sector, or both. All the technologies discussed rely strongly on the specific performance characteristics of copper. We are convinced that their implementation will be "a must" if the EU is to meet its 2050 targets. While some of the suggested technologies can be applied immediately, others require further research and development. All are actively supported by the copper industry. We conclude the chapter with a summary of the technologies, their status and their CO_2 reduction potentials.

Industry's conversion to energy-efficient motor-driven systems could save up to 202 TWh of electricity and 79 million tonnes of CO_2 per year.

Accelerated replacement of transformers could save more than 12 TWh per year and reduce CO_2 emissions by almost 4 million tonnes per year by 2025.

3.1. MOTOR EFFICIENCY

Electric motors account for approximately 65% of the electricity consumed by EU industry. In 2004, a report summarising five studies from the EC's SAVE Programme stated that switching to energy-efficient motor driven systems could save Europe up to 202 TWh per year in electricity consumption, equivalent to €10 billion per year in savings for industry.[10] Additional savings would come from reduced maintenance, improved operations and reduced environmental costs. For EU-15, CO_2 savings were estimated at 79 million tonnes per year[11], the annual amount that a forest the size of Finland transforms into oxygen. Based on these studies and other considerations, on 23rd July 2009, the Commission adopted Regulation (EC) No 640/2009 with regard to ecodesign requirements (Minimum Efficiency Performance Standards – MEPS) for electric motors.[12]

However, because they have a typical lifetime of 20 years, many electric motors in current use are not optimised for energy efficiency.[13] For this reason, the European Copper Institute has been actively promoting that industries view motors as assets, that need to be replaced when they have reached their estimated useful life, rather than waiting until they fail.

Based on minimising the Total Cost of Ownership (TCO), early replacement aligns with the Ecodesign Directive (see the policy recommendation 'Think "life-cycle"' in Section 3.9.1). The European Copper Institute demonstrates in its reports, business cases and seminars that the payback period for early replacement is generally short: three months to three years under typical working conditions. Furthermore, the payback comprises not only improved energy efficiency, but also reduced maintenance costs and avoidance of unplanned outages and their associated losses. Without a significant early replacement effort, it will take 10 to 20 years to realise the full potential of improving motor efficiency within industrial plants.

3.2. TRANSFORMER EFFICIENCY

Transformers in distribution networks are among the most important "hidden" consumers of electricity. They convert electrical energy supplied at medium voltage levels, typically 10 - 36 kV, to voltage levels appropriate for residential, commercial and some industrial loads. European electricity distribution networks contain about 4.5 million transformers owned by electricity distribution companies, industry and commerce. The 2008 Strategies for development and diffusion of Energy Efficient Distribution Transformers (SEEDT) consortium report revealed that EU transformer losses amounted to 33.4 TWh per year.[14]

This report stated that more than half of these losses could have been avoided by replacing all transformers with the most energy-efficient ones available at that time. SEEDT also calculated that an accelerated replacement of transformers could save more than 12 TWh per year and reduce CO_2 emissions by almost 4 million tonnes per year by 2025.

SEEDT proposed a number of elements to incorporate into the policy mix. These include:

- Changes in regulatory schemes to make investments in energy-efficient transformers economically attractive for electricity distribution companies. Separate financial or fiscal support could be used as a transitional measure.
- A bundle of soft measures designed to influence the purchasing behaviour of market actors:
    - Introduction of a labelling scheme that further develops the EN50464 and HD538 loss class schemes
    - Information campaigns and training
    - Promotion of SEEDT's Transformer Loss Calculator (TLCalc)
    - Encourage and stimulate the cooperative procurement of energy-efficient transformers as a method of reducing investment costs
- Promotion of a mandatory European standard for energy-efficient transformers
- Inclusion of distribution transformers on the list of products covered by the Ecodesign Directive
- Provision of R&D support to manufacturers and large buyers

The Ecodesign Regulation, adopted by the European Commission on May 21st 2014[15], will ensure that transformers become progressively more efficient as new power transformers put into service in the EU internal market will have to fulfill minimum energy efficiency requirements from 1st July 2015.

3.3. CABLE EFFICIENCY

Like transformers, electric cables are also hidden consumers of electricity. In 2011, the European Copper Institute commissioned a study that revealed that the average losses from cables and wires in small offices and logistics centres is more than 2.5% of the electricity consumed. The situation is a bit better in large offices (1.37%) and large industrial plants (1.80%).

The study demonstrated that significant savings could be made by optimising cable and wire diameters. Standards and codes that currently define the minimum cable cross section tend to be optimised based on minimum material use. However, a greater cross section would reduce the voltage drop and, hence, the power loss.

Assuming a typical financial investment horizon of 10 years, investing in larger diameter cables reduces the Total Cost of Ownership (TCO). While tripling the diameter would double the investment cost, it would reduce the TCO by 20 to 40% and save 50 to 70% of CO_2 emissions. While it is technically possible to go even further and thereby further reduce the carbon footprint, increasing cable diameters beyond three times the current minimums would not be economical.

In conclusion, the study showed that optimising cable diameters based on voltage drop could deliver EU electricity savings of 35 TWh and 14 million tonnes of CO_2 emissions per year.

Optimising cable diameters could save 35 TWh of electricity and 14 million tonnes of CO_2 emissions per year.

3.4. SOLAR THERMAL TECHNOLOGIES

The solar heating and cooling technologies discussed below offer a wide range of mature solutions that could deliver 750 TWh of energy savings and reduce CO_2 emissions by 300 million tonnes per year.[16,17]

Solar thermal technologies hold enormous potential for meeting future energy needs. In fact, they have the potential to fully meet the demand for heating and cooling in the residential sector and to meet much of the demand within the commercial and industrial sectors.

Solar heating, solar-assisted cooling and the use of solar energy for industrial processes offer a combined potential of 750 TWh of energy savings and reduce CO_2 emissions by 300 million tonnes per year.

3.4.1. SOLAR HEATING

Passive solar heating, in combination with energy-efficient building construction practices, can reduce the demand for space heating by up to 30%. Active solar technologies could reduce the fuel demand for hot water by 50% to 70% and for space heating by 40% to 60%. Daylighting techniques have the potential to reduce the electricity demand for lighting by up to 50%.

Once technical solutions are found for storing thermal heat for medium to long-term (seasonal) use, particularly with regards to costs and storage volume, residential applications for solar thermal energy will increase dramatically and further reduce the need for fossil-fuel generated power, and thus further reduce CO_2 emissions. Advanced storage systems utilising chemical and physical processes have shown promise, but require additional investment into research and development.

3.4.2. SOLAR ASSISTED COOLING

With increasing demand for higher comfort levels in offices and houses, the market for cooling has increased steadily in recent years and will continue to do so. Given that the greatest demand for cooling coincides with peak solar radiation, solar assisted cooling is another extremely promising technology. While its potential is greatest for large buildings, with central air-conditioning systems, the growing demand for air-conditioned homes and small office buildings is opening new sectors for this technology. Again, however, realisation of its potential will require continuing research and development along with support for the technology's commercialisation.

In many regions of the world, air conditioning consumes the dominant share of the electricity in buildings, and this share will only continue to grow. In particular, sales of air-conditioning equipment in Mediterranean countries are increasing dramatically and leading to electricity shortages in some areas during peak summer conditions. Because electrically driven chillers (currently the primary installed technology) create high peak loads, even if the system has a relatively high energy-efficiency standard, they cannot provide an acceptable answer to the problem. Using solar thermal energy as the primary energy for these cooling applications is an obvious solution, but this technology is still under development.

Over the past five years, the development of technical solutions to the increasing demand for cooling has been undertaken primarily by small and medium-scale businesses. Some very promising small-capacity water chillers, that use sorption technology, have emerged and opened a new market for solar thermal energy as a driving heat source for air conditioning. In addition, new system solutions for large capacity chillers have been developed to provide solar heat-driven air-conditioning in buildings.

3.4.3. INDUSTRIAL PROCESSES

Process heat accounts for about 40% of the primary energy supply within OECD countries. It is important to note that most commercial and industrial production, processing and production hall heating requires thermal energy of less than 250°C. These relatively low temperatures could easily be achieved using solar thermal collectors that are already on the market.

Obvious applications for solar heating can be found in the food and beverage, the textile and the chemical industries, as well as in simple cleaning processes, such as car washes. The low temperatures (generally 30°to 90°C) required mean that flat-plate collectors could be put to efficient and effective use.

Increasing shortages in fresh water supplies create an enormous market for the solar thermal desalination of seawater. The temperature ranges at which desalination processes can be operated are below 120°C and are thus well suited for solar thermal collectors. R&D is needed to develop appropriate systems and technologies for widespread application.

In total, across commercial and industrial production, processing and production hall heating within the OECD, approximately 30% to 40% of the process heat demand could be covered with low- to medium-temperature solar collector systems.

3.5. ELECTRIFICATION OF THERMAL PROCESSES

The electromagnetic processing of materials is a promising technology.[18] However, it is underutilised in most industries. With electricity likely to become based primarily on renewable energy sources by 2050, the electrification of thermal processes yields a significant CO_2 savings potential.

A 2013 study commissioned by the European Copper Institute investigated the possibility of transitioning thermal processes to electricity by 2050.[19] Five energy intensive industrial branches were investigated: the chemical industry; the iron and steel industry; the glass, pottery and building materials industry; the paper and printing industry; and the non-ferrous metals industry. The study assessed potential savings using two scenarios: a linear electrification scenario (100% electricity-based by 2050) and a shock scenario (100% electricity-based by 2025). The table below shows the cumulative results per sector for the linear scenario.

Industry Sector	Potential Cumulative CO_2 Emission Savings (2025 to 2050) (million tonnes)
Plastic	103
Steel	1,470
Grey iron	48
Glass	129
Roof tile	19
Brick	55
Cement	1,604
Lime	150
Paper	374
Aluminium casting	13

TABLE 2: CUMULATIVE SAVINGS POTENTIAL (2025 to 2050) – LINEAR TRANSITION TO 100% ELECTRICAL PROCESS ENERGY.

However, the economic and technological feasibility of this transition would require significant study and technological development. Therefore, the European Copper Institute considers a potential of 290 million tonnes of CO_2 savings per year by 2050 in this roadmap, and will continue to support efforts that promote and facilitate the electromagnetic processing of materials in industry (see the policy recommendation 'Stable and competitive energy pricing' in Section 4.9.4).

Implementing BAT and BEMS could save up to 380 million tonnes of CO_2 and result in savings of €54 billion per year.

3.6. BUILDING ENERGY MANAGEMENT

40% of Europe's energy use and one-third of its greenhouse gas emissions can be attributed to buildings, most of it related to heating and cooling. In the UK for example, 38% of all CO_2 emissions are related to heating activities.[20] Heating and cooling also account for about 10% of the energy consumption within European industry. Energy use and CO_2 emissions could be significantly reduced through sustainable heating and cooling – a combination of holistic design, integrated renewable energy and high efficiency systems. While thermal insulation must be a priority, the implementation of building management technologies will be able to reduce the CO_2 emissions from heating and cooling much further than what insulation alone can achieve.

Proven building automation technologies (BAT) and building energy management systems (BEMS) also have a crucial role to play in reducing the energy consumption and CO_2 emissions within residential housing and service sector buildings. The examples described in section 3.4, 'Solar thermal technologies', are complementary to envelope-related measures, such as insulation and insulated glazing. They:

- further increase the energy performance of an already well-insulated building;
- provide a good alternative where the envelope cannot be transitioned to state-of-the-art technology, for example when cultural or historic reasons prevent invasive actions; and
- facilitate the use of renewable energy sources.

In 2013, the European Copper Institute commissioned a study to assess the savings that could be realised through the increased adoption of building and energy management technologies in both the service and residential building stock.[21] It demonstrated that the energy savings potential is vast. Compared to a reference scenario, which assumes the continuation of current trends, savings could reach up to 13% of all building energy consumption by 2035, and would remain steady at that level thereafter.

In terms of actual energy usage, the study found an estimated peak annual savings for service buildings of between 469 and 578 TWh, which is between 16.5 and 20.3% of the total EU service building energy use. For residential buildings, the values would be between 570 and 1,141 TWh, or between 11.3 and 23.4%. This equates to combined savings of roughly 380 million tonnes of CO_2 per year.

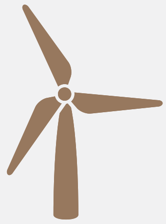
Over the study period, realisation of these savings would require an additional investment of approximately €136 billion (an average of €6.2 billion per year) in building automation technology and related services. As large as these incremental investments may sound, they are nine times less than the value of the resulting savings in energy bills, which would total €1,187 billion over the period: an average of €53.9 billion per year.

3.7. WIND POWERED INDUSTRIAL PROCESSES

Today, onshore wind power generation is a relatively mature technology. Sites with medium to good wind conditions are able to compete economically with conventional power generation. While many industrial companies have installed wind turbines on their sites, very few of them effectively use the power directly. Because of the unpredictable nature of supply, wind-generated power typically is not suitable for continuously operating industrial processes and is therefore fed into the transmission grid.

The European Copper Institute commissioned a study to assess, where, and in what types of industries, the direct use of onsite-generated wind power could be technically and economically feasible.[22] The study considered a number of common industrial processes that could be powered, at least in part, by variable wind power. These included chlorine-alkali-electrolysis, aluminium production, electro steel making, cold storage and desalination.

At a regional level, the study compared the grid tariff with estimated wind power generation costs based on wind speed distributions. The investigation revealed a potential of around 70 GW for on-site wind power capacity, which could supply about 90 TWh and deliver CO_2 savings of approximately 40 million tonnes per year.[23]



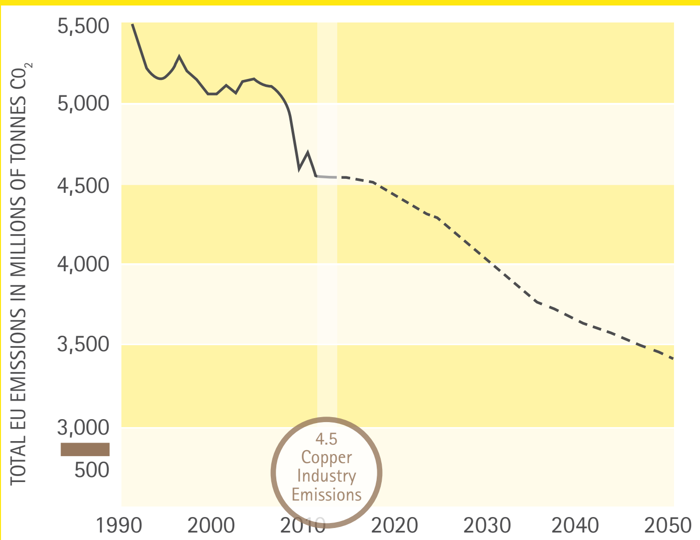
Using wind to generate power for industrial processes could eliminate 40 million tonnes of CO_2 per year.

3.8. COPPER-BASED TECHNOLOGIES SUMMARY

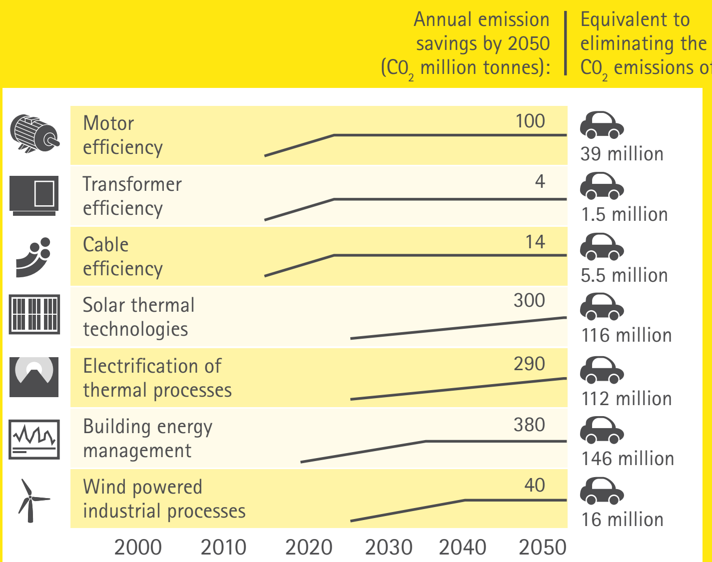
Within the next six years, the technologies presented in this roadmap could reduce CO_2 emissions by more than 150 million tonnes per year. We expect that these savings will grow steadily and could ultimately reduce total EU CO_2 emissions by 25% – more than 1,100 million tonnes per year – by 2050.

While there are clearly many uncertainties, the following table summarises the possible CO_2 savings achievable in each category over time. However, it is also clear that the required electrification of society, and the provision of this electricity though renewable sources, will rely on the performance benefits delivered by products and systems containing copper. Although copper also plays an important role in the transport sector (e.g. in high-speed trains and electric vehicles), the European Copper Institute believes that other industrial sectors and materials will play a bigger role in this domain. Therefore, this roadmap includes no specific technology related to transportation.

Copper's Power to Slash EU Emissions by a Quarter



Source: Copper's contribution to a low-carbon future: a plan to decarbonise Europe by 25 percent



7 copper-based technologies that could reduce Europe's CO_2 emissions by more than 1,100 million tonnes per year

TABLE 3: ANNUAL POTENTIAL CO_2 SAVINGS OVER TIME, BY COPPER-BASED TECHNOLOGY

	ANNUAL CO_2 SAVINGS (million tonnes, rounded to 5)				
	2020	2025	2030	2040	2050
Motor efficiency	55	100	100	100	100
Transformer efficiency	<5	5	5	5	5
Cable efficiency	5	15	15	15	15
Solar thermal technologies		10	70	185	300
Electrification of thermal processes		10	65	180	290
Building energy management	65	170	275	380	380
Wind powered industrial processes		<5	15	40	40
Total	**130**	**310**	**545**	**905**	**1,130**
% savings vs. EU total emissions (2011)	3	7	12	20	25

3.9. POLICY RECOMMENDATIONS SUPPORTING COPPER-BASED TECHNOLOGIES

Targeted regulations and constructive policies will be instrumental in creating a favourable momentum for these technologies.

3.9.1. THINK "LIFE-CYCLE"

An appropriate account of a product's life-time operating costs and benefits must take into account its use, maintenance and recycling or disposal phases. Therefore, the European Copper Institute strongly advocates the systematic use of total cost of ownership, plus the integration of value chain concepts and life-cycle thinking, into industrial policies.

3.9.2. ADOPT AMBITIOUS MINIMUM EFFICIENCY PERFORMANCE STANDARDS

As demonstrated in the roadmap, minimum efficiency performance standards (MEPS) for electricity-using equipment can save significant amounts of energy. Using instruments such as the Energy-Related Products Directive, MEPS should be set at the minimum life-cycle costing point, or slightly higher, considering the carbon benefits of saving electricity.

3.9.3. PROMOTE ENERGY MANAGEMENT

As demonstrated in the European Copper Institute's report on building energy management[21], significant energy savings can be realised at a systems level. Policies[24] should strongly encourage the adoption of energy management technologies. Furthermore, financial incentives should be extended to early adopters of these technologies.

3.9.4. INTEGRATE MARKET FOR ENERGY SERVICES

The massive integration of renewable energy sources poses particular challenges to the stability of the electricity system. Electricity is an energy carrier that can be effectively managed, but the integration of the heat, electricity and transport sectors, plus the strengthening of Member State grid interconnections, are needed to enable sufficient flexibility in the system at affordable cost.

3.9.5. ADOPT POST-2020 TARGETS WITH SUPPORTIVE INDUSTRIAL POLICIES

To maintain a forward momentum towards a low-carbon economy by 2050, the European Copper Institute welcomes separate intermediate 2030 and 2040 targets for carbon emissions, renewable energy and, particularly, energy efficiency. These targets should be accompanied by supportive policies that will help the industry play its crucial role in fighting climate change (see the policy recommendations in Section 4.9.).

4. CO_2 REDUCTION OPPORTUNITIES WITHIN THE COPPER INDUSTRY

Given that all of the technologies outlined in the previous chapter rely strongly on the performance characteristics of copper, the copper industry needs to ensure that its own processes are also scrutinised and further optimised.

To that end, the European Copper Institute conducted interviews with the energy managers of the EU's six copper producers, along with two of their biggest customers, in order to build an assessment of further reduction opportunities. The companies involved were Atlantic Copper, Aurubis, Boliden, KGHM, KME, Metallo-Chimique, Montanwerke-Brixlegg and Wieland-Werke.

This chapter analyses the comments received and consolidates the views of these organisations into a future vision of low-carbon copper production in the EU.

Since 1990, EU copper producers have reduced their unit energy consumption by 60%.

4.1. ENERGY REDUCTION ACHIEVEMENTS SINCE THE 1990s

Copper production is a global business. Metal prices, the main revenue drivers of copper producers, are common around the world and published daily on the London Metal Exchange. Individual company competitiveness is therefore driven by local factors, such as labour and energy costs, plus costs associated with regulatory compliance, such as EU environmental, human health and waste policies, and the Emissions Trading Scheme.

Given the relatively high EU cost of energy, its efficient use is a very important factor in ensuring the continued competitiveness, even the survival, of European copper producers.

With energy costs representing 25 to 35% of total production costs[6], energy efficiency has long been, and will continue to be, a major focus for the sector. EU copper producers (typically referred to as smelters and refiners) have implemented a significant number of energy conservation measures during the past twenty years. The European Copper Institute has collected and aggregated data showing that the EU-based copper producers have reduced their unit energy consumption by 60% since 1990.[25]

While the contributions of individual measures are difficult to assess, the main technological advances include the following:

- Flash smelting technology. Implementation of flash smelting technology in the second half of the 1990s led to substantial energy savings, up to 35%, for copper smelters.[26]
- Waste heat recovery. Now in extensive use, all companies interviewed have set up systems to convert and reuse the heat released from the production process. This heat is used to produce steam for an array of uses, including elsewhere in the process, to supply office heating, to supply district heating in the winter and to drive combined heat and power systems that can export excess electricity to the local grid.
- Renewal of electrical equipment. Companies have also invested in equipment upgrades that result in improved energy efficiency. Electric motors have been rewound or replaced, and variable speed controls installed or renewed.
- New or adapted furnaces. Upgrades and replacement of furnaces have substantially lowered energy consumption. Many of the companies interviewed have improved the thermal insulation of their furnaces, buildings and steam networks. For a few companies, new flexibility, that emerged within the local energy supply mix, in the 1990s, facilitated the transition from petroleum to natural gas as the primary energy source.

4.2. USE OF RENEWABLE ENERGY

At this time, only a few sites have installed renewable energy systems, such as photovoltaics and wind turbines. In all cases, however, the electricity generated is fed directly to the grid, because the output is too low and too unstable to power mainstream production processes.

Direct use of the electricity produced makes the most sense from both an economic and a sustainability point of view. However, because copper production is a base load process, it requires a sufficiently large and stable power supply. As a result, only hydroelectric, where geographically feasible, and biomass installations are being considered as possible investments. Clearly, technological breakthroughs in electricity storage would open up new opportunities for the direct use of solar and wind powered electricity. Support for increased research and development on electricity storage would be welcome and useful not only for copper producers, but for all industries.

4.3. RECYCLING AND THE CIRCULAR ECONOMY

Unlike many other materials, copper can be easily and endlessly recycled, back to its original performance, thereby avoiding the economic and environmental costs of down-cycling, such as those incurred in the recycling of plastic bottles or aluminium beverage cans.

Given its economic value, the presence of copper in an end-of-life (scrap or waste) stream can be an important factor in the decision to recycle. Copper produced from scrap saves approximately 80% of the energy necessary to produce primary copper from mining. As a result, increasing the recycling rate means significantly reducing both energy consumption and CO_2 emissions.

Nowadays, more than 40% of Europe's production of copper products (around 4 million tonnes in total) is sourced from recycling.[27] While this percentage could increase further, it will probably be at a slow pace for two main reasons: First, copper demand is expected to grow with economic growth, product innovation and the electrification of processes. Second, most copper can stay in use for several decades (e.g. in electricity infrastructure) before it becomes available for recycling. As a result, future demand, even beyond 2050, will continue to be a combination of primary copper and secondary scrap products from so-called "urban mines."

Several companies interviewed reported steady increases in scrap usage. Today, the EU has three production sites where scrap makes up 100% of the raw material inputs. In the USA, this business sector closed down more than 10 years ago. The energy and cost benefits of recycling around 2 million tonnes of copper scrap per year are critical to the competitiveness of the entire copper value chain.

To continue to improve resource efficiency and deliver on the circular economy, society will need to get better at recycling, particularly in the areas of collection and pre-sorting. Companies are aware that there are significant, informal scrap flows leaving Europe for recycling, especially to Asia. In the early 2000's, the EU's net trade of copper scrap was zero. In 2011, there were net exports of approximately 0.9 million tonnes (around 20% of EU total copper demand).[28]

Not only is this a loss in valuable raw materials (the EU needs to import more primary metal to meet demand), it is also a loss in energy, since the scrap importers can produce top quality copper with only 20% of the energy. Improved control over these flows is very necessary to maintain the EU industry's competitiveness.

- More than 40% of the European production of copper products is sourced from recycling.
- The EU has three production sites where 100% of the raw material is scrap.
- Copper produced from recycled scrap uses only 20% of the energy required for primary metal.

4.4. ENVIRONMENTAL EMISSIONS ABATEMENT

Today, the European copper industry uses around one-third of its electricity consumption to meet increasingly stringent environmental and human health standards.[29] Back in 2008, the European Commission and Member States endorsed the European Copper Institute's EU Voluntary Risk Assessment which covered the production, use and end-of life aspects of the copper value chain. This comprehensive assessment concluded that the existing legislative framework generally safeguards Europe's environment, the health of industry workers and the general public.[30] Before regulatory steps are taken to further reduce safe limit values, there must be a thorough analysis of the expected benefits for the environment and human health versus the impact on industry competitiveness.

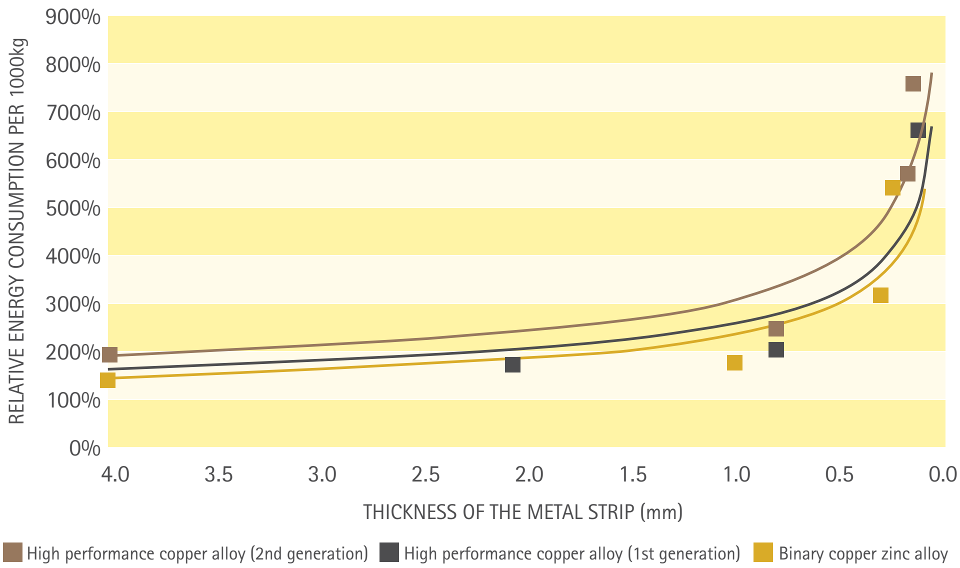
4.5. MINIATURISATION

As evidenced by the very visible downsizing of electric and electronic equipment, miniaturisation is both an opportunity and a threat to the copper industry. On one hand, miniaturisation extends the life of natural resources and improves resource efficiency, by enabling downstream sectors to get more performance out of the same amount of copper.

On the other hand, the copper industry must not be penalised, for example through the Emissions Trading Scheme, for the higher energy consumption required to both produce "thinner" products and then recycle the increasingly complex end-of-life products.

Thinner and higher performing copper alloys are increasingly requested by downstream users in order to save both resources and energy during the useful life time of their products. However, as shown in the chart below, energy consumption increases exponentially with decreasing thickness and increasing complexity. For example, reducing a copper alloy strip from 1 to 0.25 mm requires three times more energy, and a high-performing, second-generation alloy needs 100% more energy, for the same thickness, as compared to a first-generation material (see Figure 3).

FIGURE 3: ENERGY CONSUMPTION VS. THICKNESS OF A COPPER STRIP



4.6. PLANNED MEASURES AND STRATEGIC CONSIDERATIONS

All copper producers will continue to optimise their energy use and reduce their CO_2 emissions, through the use of technologies described in section 4.1. However, all companies report that with the possible exception of some smaller waste heat recovery projects, the low-hanging fruit is definitely gone. This means that further energy conservation measures will require investments that carry a much longer return on investment period, between eight and ten years, which makes them far less attractive within a company's annual capital expenditure budget.

Market uncertainties, such as future energy, electricity and CO_2 prices will also play important roles in individual company decision-making (see the policy recommendations in Section 4.9.).

4.7. TECHNOLOGICAL INNOVATIONS AND ELECTRIFICATION

Copper production is a mature industry with processes that are largely governed by thermodynamic laws. Copper producing companies all agree that the production process itself has almost reached its technological plateau in terms of energy efficiency. While it is very unlikely that any future technological breakthrough will dramatically reduce the energy needed to produce copper, the sector could further reduce its indirect CO_2 emissions by gradually switching to renewable energy sources. This is something that will need to be addressed jointly with electricity suppliers and other big users in each local area.

Since electricity is expected to become CO_2 neutral in the future, the gradual electrification of the thermal processes of copper production is a strategy to be considered. However, this electrification will require a more predictable electricity market, further technological innovation and important investments (see Section 3.5 and the policy recommendations in Section 4.9.).

4.8. INDUSTRY SUMMARY

Through significant capital investments, the copper producing industry has successfully reduced its CO_2 emissions by cutting unit energy consumption by 60% versus 1990 levels. While these efforts will continue, our survey shows that further reductions will be much smaller and more challenging to justify economically.

Investigations into building renewable energy installations are ongoing at several sites and recycling rates are expected to slowly increase — both of which will reduce CO_2 emissions. Copper producers will continue their efforts to improve the efficiency of their processes and will report future progress.

Ultimately, however, full realisation of potential future reductions will require a clear, long-term, EU vision along with well-integrated and supportive policies on waste, energy efficiency, renewables and greenhouse gas emissions.

4.9. POLICY RECOMMENDATIONS SUPPORTING THE INDUSTRY

Well-formulated policies will be needed to raise the probabilities of success for sector-specific, low-carbon roadmaps for 2050. However, those policies will need to be consistent with the European Commission's ambition of having industry provide additional employment by growing towards a 20% share of Gross Domestic Product by 2020.

4.9.1. CO_2 REDUCTION AS PRIMARY INDICATOR

With fossil fuels, there is a very clear link between energy use and CO_2 emissions. As the trend towards more renewable energy sources continues, including the electrification of industrial processes, this link becomes less obvious. In some cases, a reduction of CO_2 emissions can mean an increase in primary energy consumption.[31] Therefore, the European Copper Institute advocates using CO_2 reduction rather than primary energy consumption as the key performance indicator for measuring progress towards a low-carbon society.

4.9.2. COMPETITIVENESS PROOFING

Future emission targets, along with any more stringent environmental and human health standards, must be scientifically justified and subject to transparent cost-benefit analyses. Key policy directions that might unilaterally affect the competitiveness of European enterprises must be reinforced by competitiveness proofing.

4.9.3. SUSTAINABLE ENERGY INVESTMENTS

Incentives to promote the use of low-carbon technologies will be necessary to support transition processes, and to encourage the massive investments needed in both deploying existing energy efficiency technologies, as well as in expanding renewable power generation. Therefore, the European Copper Institute advocates using Emissions Trading System revenues to co-fund such investments. Low-interest loans could help capital and energy-intensive industries to finance their next investment cycles. Adequate funding for research and development is also necessary to support breakthroughs in the production processes and energy supply technologies for energy-intensive industries.

4.9.4. STABLE AND COMPETITIVE ENERGY PRICING

Whatever the absolute level, keeping the price of EU electricity globally competitive is essential. To provide investment stability, policy measures should allow large electricity consumers to source electricity through long-term contracts. Energy Regulators and/or Transmission System Operators should effectively monitor marginal power pricing. Furthermore, the costs of all externalities, including environmental costs, should be fully accounted in EU energy market prices.

5. CONCLUSION

The copper industry and its products can both make extremely significant contributions towards tomorrow's low-carbon economy. In addition to the 60% unit energy efficiency improvement already achieved since 1990, copper producers are fully committed to making further, economically justified improvements in the efficiency of their processes. Investigations into building renewable energy installations are on-going in several plants, and recycling rates are expected to gradually increase. However, full realisation of the potential CO_2 savings will require significant industry investments along with a clear, long-term EU vision and well-integrated policies on pollution prevention, waste and recycling, energy efficiency, renewables and greenhouse gas emissions.

Far more significantly, the copper industry's products will play a very important role in reducing CO_2 emissions in the industrial, residential and service sectors. Efficiency programmes based on more copper-intensive motors in industry, transformers in the power sector and cables in the residential and services sector could save more than 100 million tonnes of CO_2 emissions per year over the next 10 to 20 years. Building energy management and solar thermal technologies could generate additional CO_2 savings of nearly 700 million tonnes per year.

Longer-term programmes, such as wind powered production processes and the electrification of thermal processes, are less certain and will require economic incentives and significantly more development to build technical viability. However, in light of the very large savings potentials, close to 300 million tonnes of CO_2 per year, they are worthy of further investment and investigation.

It should be clear then that Europe's copper industry shares the EC's vision for a low-carbon economy and will pursue it with all of the resources at its disposal. Once again, we urge the EC and other policymakers to support a reasoned balance between the energy needed to manufacture the building blocks of that new economy and the overarching goals for reduced energy demand and carbon emissions.

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