23 April 2018

Long-term trajectory towards a low carbon economy in 2050 – Non Ferrous Metals

1. Historical figures on emissions and electricity consumption: data in key milestone years (1990, 2005, 2015); if you have more detailed information (e.g. fuel mix), please provide it.

Aluminium

Year	Al production	Electricity	kt CO2 emissions	
	tonnes	*TWh*	*t CO2/t Al*	*evolution*
1990			15	100%
1997	3,732,000	58.33		
2010	4,091,000	61.59	8.5	57%
2015	4,244,000	63.15	6.7	45%

Zinc

Year	Zn production	Electricity	kt CO2 emissions				
	tonnes	*TWh*	*direct*	*indirect*	*total*	*t CO2/t Zn*	*evolution*
1990	2,173,000	7	2,343	3,158	5,501	3	100%
2005	2,294,000	9	1,080	3,122	4,202	2	92%
2015	2,286,500	9	910	2,484	3,394	1	62%

**In the period 2004-2009, zinc refining has shifted from the coke intensive pyrometallurgical ISF process towards the more energy efficient electrolytic RLE process. In 2015, there was 1 ISF plant left in the EU providing only 3% of the EU production, down from 18% in 2004. This switch resulted in a 38% reduction of total CO2 emissions since 1990. In 2015, indirect emission were 40% related to coal (mainly from ISF) and 60% to gas and fuel (RLE process).*

Copper

Year	Cu production	Electricity	kt CO2 emissions				
	tonnes	*TWh*	*direct*	*indirect*	*total*	*t CO2/t Zn*	*evolution*
1990	1,945,000	2	3,222	1,981	5,203	3	100%
2005	2,434,000	3	2,107	2,664	4,771	2	92%
2015	2,731,000	3	1,946	2,493	4,439	2	85%

Nickel

Year	Ni production	Electricity	kt CO2 emissions				
	tonnes	TWh	direct	indirect	total	t CO2/t Ni	evolution
1999	176,700	1	1,300	1,260	2,560	15	100%
2011	193,000	1	675	830	1,505	8	53%

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23 April 2018

Silicon, Ferro-Silicon and Ferro-Manganese

Data per tonne produced (EU + EEA)		1997	2005	2013
Silicon	Electricity input (MWh)	13.2	12.1	12.4
	Direct emissions (CO_2/t)	4.7	4.2	4.3
Ferro-silicon	Electricity input (MWh)	9.2	9.3	8.9
	Direct emissions (CO_2/t)	3.6	3.3	3.3
Ferro-manganese	Electricity input (MWh)	2.9	3.0	3.0
	Direct emissions (CO_2/t)	1.1	0.6	0.5

2. Key mitigation technologies: short description of the main decarbonisation technologies identified so far by each sector (e.g. 5-6 technologies maximum); please indicate the level of maturity/TRL and the relevant timeframe for industrial application;

I. Indirect emissions – decarbonised electricity

European non-ferrous metals production is now largely electricity-intensive. Over the last four decades, large parts of the metals sector have set an important step towards decarbonisation by switching from fossil-fuel-based CO2 emitting processes to more energy efficient electric processes (with 100% decarbonization potential for the power generation sector).

Overall, the non-ferrous metals industry now uses over 91 TWh of electricity per year. Our CO2 footprint is influenced more by indirect emissions from electricity than from the direct use of carbon.

	Electricity consumption	Percentage of production costs	Split – Indirect vs Direct emissions
Aluminium	63 TWh	30-40%	85% indirect, 15% direct
Copper	3.1 TWh		56% indirect, 44% direct
Nickel	0.6 TWh	15%	55% indirect, 45% direct
Ferro-Alloys & Silicon		35-40%	65% indirect, 35% direct
Zinc	9 TWh	40%	73% indirect, 27% direct

Given the electro-intensive nature of non-ferrous metals production, the major decarbonisation potential for the sector is to reduce its indirect emissions through the shift towards less carbon intensive electricity (provided by power generators).

This shift to more green electricity will be dependent on:

23 April 2018

i. Availability of reliable green electricity

ii. Affordable prices for green electricity

iii. Continued compensation of indirect costs since also renewable Purchase Power Agreements contain carbon costs due to the power market characteristics.

a) Continued innovation to reduce electricity consumption

European companies have already made significant investments into reducing their electricity consumption. This has been achieved and is ongoing through continuous technology upgrades (i.e. high-yield transformers and rectifiers, and frequency converters to reduce power for pumps, mixers, blowers, cranes etc.)

However, the future margin for efficiency improvements is relatively small, because metals sectors are already operating very close to their maximum efficiency limits (according to scientific laws). Incremental improvements will continue to be made through continuous technology upgrades.

For example, in the aluminium sector, incremental technology for primary is making important progress in Europe through one of the recent pilot projects located in Karmoy, Norway. Still in pilot stage, this is the ultimate technology to reduce electricity consumption with carbon anodes, with a potential of 15% electricity consumption reduction compared to today's global figures.

b) Integration of renewable energy sources

Europe's non-ferrous metals industry is a leading industry user of renewables power purchase agreements. In markets where hydro and nuclear based energy is available and costs competitive, we have a long history of non-ferrous metals production using close to CO2 free electricity.

Although non-ferrous metals industries are baseload consumers, with predictable update in electricity, we have in recent years been able to sign long-term power purchase agreements with more variable wind energy production profile. In countries where market conditions are supportive, this allows for a limited supply of wind and/or solar-based electricity into our production processes.

Recent examples of PPAs with more intermittent renewable sources include:

- Norsk Hydro – Norway – Wind – 1.65 TWh baseload supply for 19 years
- Alcoa – Norway – Wind – 0.8 TWh baseload supply
- Nyrstar – Belgium – Solar – 85 GWh annual production for 25 years

c) Long-term: Making use of a 2050 decarbonised EU power system

A decarbonised EU power system is the biggest long-term driver in lowering the non-ferrous metals industry's CO2 footprint. The European Commission (93-97% according to their roadmap) and European electricity industry Eurelectric (carbon neutral before mid-century) have both set a target for decarbonised EU power by 2050. This would eliminate our industry's indirect emissions, reducing our overall carbon footprint.

d) Electricity – Demand response

In an increasingly decarbonised power system, metals smelters offer opportunities for grid stabilisation and peak attenuation. Metals smelters are contracted by TSOs due to their high electricity consumption and ability to reduce demand at short notice.

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23 April 2018

Competitive services are already being provided in countries including France, Belgium, Netherlands and Germany. This is largely a consequence of each Member State's market framework.

- Zinc – Zinc smelters can reduce their power needs to 15% of the nominal value, within a very short period (i.e. seconds), and for a duration of 1-2 hours. Their power need is 36 to 230 MW. They can offer 100 % of the tankhouse for an unlimited time span. For example, in Germany the zinc smelter offers 48 hour breaks of 80 % of its demand.
- Aluminium- Aluminium smelters can reduce for 1 hour every two days.
- Copper – Copper facilities can modulate electricity demand. In the future, their capacity is expected two increase by 2-4 times.

An important pre-requisite is that Europe's decarbonised power is secure and competitive in 2050. Since we largely do not generate our own electricity, we remain dependent on power power operators to make this happen (although we are supportive of decarbonisation and enable it through PPAs with renewable developers and providing demand response to intermittent renewables sources),

II. Direct CO2 emissions – Various technologies

Direct CO2 emissions are still present in the non-ferrous metals sector in a limited capacity, compared with indirect emissions (i.e. fossil carbon is now not a primary input for most European metals production processes). Technology breakthroughs will require significant levels of investment.

In addition, there are several available technologies whose implementation will be pushed by collaboration with other energy-intensive industries (e.g. CCU, hydrogen). For that reason, we recommend continued horizontal cooperation, collaboration and greater synergies across European industrial sectors, as well continued breakthrough through a regulatory framework.

For more details on the various technologies to reduce direct CO2 emissions in the non-ferrous metals sector, please see Annex I 'Direct CO2 emissions – various technologies'.

3. Abatement potential: please indicate the relevant abatement potential of the identified technologies (if possible, by 2040 and 2050) ; if available, please provide the underlying data (emissions, energy consumption, production projections) used to identify the future abatement potential;

In terms of indirects emissions, given the electro-intensity nature of our industry, a 2050 decarbonised European power system would have a major impact in reducing the European non-ferrous metals industry's CO2 footprint because of our electricity-intensiveness. As a representative example, the German non-ferrous metals industry's CO2 emissions would be reduced by 75% if fully decarbonised electricity is made available and competitive, and challenges are overcome (indirect emissions: 7.5 million tonnes CO2 equivalent; direct emissions: 2.6 million tonnes CO2 equivalent)

Our industry's electricity consumption can be reduced in parallel through continuous incremental innovations (specific to individual commodity sectors). For example, in the aluminium sector, a simple simulation of the potential savings offered by the Karmoy based aluminium technology, assuming that Karmoy technology is integrated in all the 26 existing smelters operating in Europe (4,2 million tonnes per year) could eventually have a reduction of almost 10 TWh/y in Europe.

In terms of direct emissions, it is important to note that European metals production processes are close to the current scientific limits of efficiency. However, our direct emissions could potentially be mitigated by several breakthrough technologies. These pathways are in several cases specific to each commodity sector.

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23 April 2018

Many of these technologies are a long way from commercialisation, and will require significant investment levels. Several – such as CCS and hydrogen – are expected to first be commercialised by bigger carbon-intensive sectors, before being competitive for metals industry use.

4. Investment costs: please indicate data on investment costs necessary for the industrial deployment of low carbon technologies that are relevant for your sector;

N/A

5. Energy, feedstock and infrastructure needs: please provide information on future needs (electricity, hydrogen, biomass, transport & energy infrastructure –for goods, energy, feedstock, carbon, etc.);

Electricity

Our industry's main energy need for the future is that electricity will be low-carbon but also secure competitive electricity. Most metals sectors have already electrified their processes, and so we do not expect their per unit electricity demand to increase significantly. Sectors with potential for further electrification (i.e. copper, nickel) would have a resultantly higher electricity consumption.

It is also expected that Europe's low-carbon transition will increase the demand for most metals up until 2050. An increased European production of metals to fulfil this extra demand would result in a higher overall electricity consumption. We support the use decarbonised electricity in our production processes, if it is market competitive. European metals producers are already industry leaders in the use of Renewable Power Purchase agreements for wind and solar energy. We can benefit from a fully decarbonised power system if the challenges of variability, volatility and availability are overcome.

Other energy sources

In the future, there may be a need for hydrogen and biomass to replace fossil carbon in our production processes – although this would be at lower levels compared with carbon-intensive sectors. These sources would need to be readily available and competitive. For more details, please see Annex I 'Direct CO2 emissions – various technologies'.

6. Regulatory framework: please provide (in short bullet points) the currently available information on the main elements for an enabling regulatory framework (e.g. international level playing field/carbon leakage protection, competitive energy, long term energy contracts, support to industrial symbiosis, supportive innovation policy, raw materials strategy, etc.).

i. Ensure a global level playing field through full compensation of both direct and indirect carbon costs of the EU ETS until comparable industries in regions outside of Europe are subject to the same regulatory costs
ii. Competitive prices, predictability (e.g. the possibility to conclude long term power contracts), recognition of industry's role (demand response, adaptation potential during RES production peaks), affordable energy storage
iii. The necessary financial support and lower administrative burdens should be provided to promote research and innovation

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23 April 2018

Annex

I. Direct CO2 emissions – Various technologies

Source of direct emissions	**Commodities concerned**					**Further information**
	Al	**Cu**	**Ni**	**Si**	**Zn**	
Raw material input (i.e. process emissions)		✓	✓	✓	✓	• The raw material input to metals production processes has varying levels of carbon content. This is released during the production process. • Even within a sector, the carbon content can vary according to the raw material's specific source mine/secondary bearing material (i.e. non-processed scrap vs. electronics scrap)
Carbon-based anodes	✓					• The primary aluminium industry's major source of direct emissions is the carbon-based anode, which is consumed during primary production.
Energy carrier for heating & melting	✓	✓	✓		✓	• Natural gas or other fossil-based fuels are used in the production processes of several metals as a heat source for metallurgical reactions. *NB. In several cases, consumption has already been optimised through heat recovery projects.*
Primary energy material/reduction agent in metallurgical processes		✓	✓	✓	✓	• Fossil-containing energy & reduction sources are present in metals smelting and further production processes, to aid melting of the metals and provide a reduction source in secondary materials processing

Further major reductions of the non-ferrous metals industry are now mostly dependent on technology breakthroughs.

	Applicability of innovation						
	Al	**Cu**	**Ni**	**Si**	**Zn**	**Availability**	**Indicative Timing (>10 years/ <10 years)**
Further electrification		✓	✓			• The technology is available for further electrification of European metals installations (i.e. to provide low and medium-temperature heat). • Technology is yet to be developed for high-temperature heat • In the nickel industry, Various sources of fossil fuels are used in	<10 years

23 April 2018

						the production of technical / industrial gases which might be replaced by electricity (longer-term) • Policy and market conditions should facilitate investments into further electrification (including through equivalent compensation of indirect costs vs direct costs)	
Replacement of fossil fuels with alternative low-carbon fuels (e.g. biofuels/biomass, hydrogen, synthetic fuel, alcohols)	✓	✓	✓	✓	✓	• Aluminium - Replacement of Carbon-based anodes with inert materials". NB *Aluminium Industry is evaluating options to use alternative raw materials in anode production, replacing carbon, to avoid emissions of CO2 during the electrolytic process* • Silicon – Furnaces can operate with a relatively high biocarbon content. Some installations already use some biocarbon, but there remain bottlenecks (i.e. technology, cost) • Copper – There is potential for low-carbon fuels to replace fossil fuels in copper production, once economically competitive and available in sufficient quality. • Nickel – There is potential for biofuels to replace fossil carbon in various stages of nickel production, once economically available competitive and available at a sufficient quality • Zinc – Hydrogen combustion or electric heating can be considered as a replacement to fossil fuel used for heating purposes in the hydrometallurical process, and coke as the reductant and combustible in the pyrometallurgical process (when cost-effective, and once safety challenges are overcome)	>10 years
Reuse of surplus heat		✓		✓	✓	• Surplus heat is already recovered and reused in metals production plants. This has allowed companies to reduce their gas/fuel consumption. • Further optimisation is possible, where geographical and economic conditions allow it. As well as reducing a company's direct emissions, there is great potential for using surplus heat for local	<10 years

23 April 2018

						district heating to reduce wider societal carbon emissions (i.e. Aurubis is providing heat to a Hamburg district).	
Carbon Capture Utilisation	✓	✓	✓	✓	✓	• New carbon capture storage/ utilisation (CCS/CCU) technologies are a potential breakthrough technology, but challenges must be overcome. • It is realistic to assume that these technologies would first be developed and commercialised by larger carbon-intensive industries. • *One example: Finnfjord's Norway silicon production plant is using recovered CO2 to farm algae and then produce biofuels*	>10 years

ABOUT EUROMETAUX

Eurometaux is the decisive voice of non-ferrous metals producers and recyclers in Europe. With 500,000 employees and an annual turnover of €120bn, our members represent an essential industry for European society that businesses in almost every sector depend on. Together, we are leading Europe towards a more circular future through the endlessly recyclable potential of metals.