VUB

ies INSTITUTE FOR EUROPEAN STUDIES

Metals for a Climate Neutral Europe

A 2050 Blueprint

EXECUTIVE SUMMARY

Authors

Tomas Wyns
Senior Researcher, IES-VUB
Tomas.wyns@vub.be

Gauri Khandekar
Doctoral and Project Researcher, IES-VUB
Gauri.khandekar@vub.be

About the IES

The Institute for European Studies (IES) at the Vrije Universiteit Brussel (VUB) is an academic Jean Monnet Centre of Excellence and a policy think tank that focuses on the European Union in an international setting. The Institute advances academic education and research in various disciplines, and provides services to policy-makers, scholars, stakeholders and the general public.

A digital copy of the report *Metals in a Climate Neutral Europe - A 2050 Blueprint* (published October 2019) is available via either the QR code above or the following link: **bit.ly/metals2050**

Introduction

Europe's energy transition will require higher quantities of metals. Indeed, non-ferrous metals represent the building blocks of every conceivable climate technology including batteries, clean mobility, energy-efficient buildings, solar panels, and wind turbines.

The climate transition will challenge Europe's industries to decarbonise in only one business cycle. The European non-ferrous metals industry has already made significant step changes since 1990, resulting in high levels of electrification and circularity. The sector's further progress must now be supported by an EU industrial policy, which enables it to meet EU 2050 climate-neutrality objectives while thriving against global competition.

This study was commissioned by the non-ferrous metals industry and represents its consolidated contribution to the EU's 2050 climate-neutral strategy. The study provides a comprehensive assessment of the EU's industrial metals ecosystem, including the sector's potential in the transition to climate-neutrality, and the challenges and constraints that will be faced along the way.

Key Findings

The study reaches the following conclusions about Europe's non-ferrous metals ecosystem, and its prospects for contributing to the climate-neutral transition.

1 Europe's metals ecosystem - a frontrunner industry in the transition to climate-neutrality

- High levels of electrification (shifting away from carbon-intensive processes), with a 58% share of electricity in the sector's overall energy use
- High levels of historical emissions reduction, with a 61% improvement on 1990 levels
- High levels of circularity, with around 50% of Europe's production of base metals now coming from recycled sources

Historical progress

58% % electricity in energy mix[1]

61% overall GHG reduction since 1990[2]

50% of EU base metals production from recycling[3]

2 Europe's metals ecosystem - major potential to further reduce its carbon footprint, with the right framework conditions

- Potential for an 81% overall reduction in greenhouse gas emissions (vs. 1990 levels), once indirect emissions have been eradicated in a decarbonised EU power sector [5]
- Theoretical potential for further reducing direct GHG emissions, through the deployment of private and public support for incremental and breakthrough technologies. A detailed analysis of various technologies is provided in the report
- Higher volumes of recycled metals being made available, with a lower lifecycle CO_2 footprint compared to primary extraction and production

2050 potential

81% total GHG reduction (vs 1990) in a decarbonised power system [4]

8 priority technologies for reducing remaining emissions

50% projected increase in secondary aluminium & copper[6]

[1] Eurostat, 2018, [2] EEA & Eurostat, [3] UNEP 2013, [4 5] EEA & Eurostat. Assuming that indirect emissions will hence be reduced to zero and direct emissions stay at same level as in 2015 European Aluminium, 2018 & OECD, 2018,

3

Europe's metals ecosystem - exposed to significant levels of international competition, because metals are a globally traded commodity

The sector's strategic status and globally-set pricing mechanisms means it faces high international competition:

- Europe is already highly dependent on imports of primary raw materials, with other value chain stages under pressure
- China's share of non-ferrous metals production has grown dramatically in the last 15 years, largely based on coal-powered electricity
- This makes the threat of EU production being replaced by more carbon-intensive non-EU production very real.

Global competition

>60% import dependence for almost all metals[7]

30-54% - China's global market share for all base metals[8]

2.5 - 8 times more carbon-intensive Chinese production due to coal-powered electricity[9]

4

Europe's metals ecosystem - facing specific regulatory challenges from the transition of Europe's power sector

The sector's high electro-intensity means that while it has major potential for emissions reductions, it is also particularly susceptible to the impacts of a decarbonising EU power system.

- The industry's use of electricity is higher than any other energy-intensive sector (per tonne of product & as a percentage of production costs)
- Indirect carbon costs from the Emissions Trading System already disadvantage the sector vs. international competitors, and require adequate compensation
- Looking ahead, the sector's key enabling factor for the transition will be the abundant availability of carbon-neutral electricity at globally competitive prices.

Importance of electricity

4-15.4 MWh electricity used per tonne of product in primary production[10]

20-40% - Electricity as a percentage of metals production costs[11]

5X more impacted by electricity costs vs overall manufacturing sector[12]

5

Europe's metals ecosystem - a sector whose 2050 future can be secured with a dedicated industrial strategy

Europe can enable the non-ferrous metals sector's competitive transition to a climate-neutral economy - alongside its dependent value chains - through a horizontal industrial strategy ensuring:

- Competitively-priced and abundant carbon-free electricity,
- Innovation and investments support,
- Enhanced value chains & industrial symbiosis,
- Assertive trade and competition policies
- Ambitious Circular Economy policy

[7] European Commission 2018, [8] Quanxun, 2017, Xiuxia, 2017, Taube, 2017, [9] European Aluminium, The Nickel Institute et al., 2017 , [10] Eurostat, EU + EFTA, [11] CEPS, Ecofys, Ecorys, JRC, [12] CEPS, Ecofys, Ecorys, JRC

Introducing the Metals Ecosystem

An integrated network of operations

Europe's non-ferrous metals industry is an intricate ecosystem of mining, smelting, transformation, refining, and recycling operations across the continent. With around 500,000 employees across over 900 facilities, it produces and recycles the base, precious & specialty metals demanded by Europe's low-carbon value chains of the future[13].

Europe is mostly dependent on imports of its primary raw materials, accounting for only 1% of global mining production for base metals, while primary smelting and refining operations account for 6% of the global total but are increasingly pressurised by global competition & trade imbalances.

Europe's metals recycling industry however is a real world-leader with a 24% market share, although other regions are making significant investments into new capacity[14].

The non-ferrous metals sector is an eco-system in itself, given the strong interlinkages between diverse metals during smelting, refining and recycling processes. Metal ores consist of various elements that commonly co-exist, which means that during refining of base metals, a number of co-elements may be separated so long as their value outweighs the cost. Recovery also happens in recycling processes which provide secondary raw materials.

Non-ferrous base metals produced and/or recycled in the EU

EXTRACTION
Mining metal ores from the surface of the earth and separating them into concentrates

1% of world total*

SMELTING/REFINING
Treating primary ores and concentrates to separate the metals and refine into a purer form

6% of world total*

TRANSFORMATION
Processing pure metal into semi-finished and finished products (e.g. sheets, rods, extrusion)

figures not currently available

RECYCLING
Treating & refining secondary raw material (e.g. scrap, products)

24% of world total*

% Share of global production per metal

	Extraction	Smelting/Refining	Recycling
Al	0.6%	4.0%**	30%
Cu	4.1%	13.1%	23%
Ni	3.0%	9.6%	29%
Pb	9.7%	9.4%	18%
Zn	5.4%	13.4%	19%

€120 billion annual turnover

500 000 persons directly employed

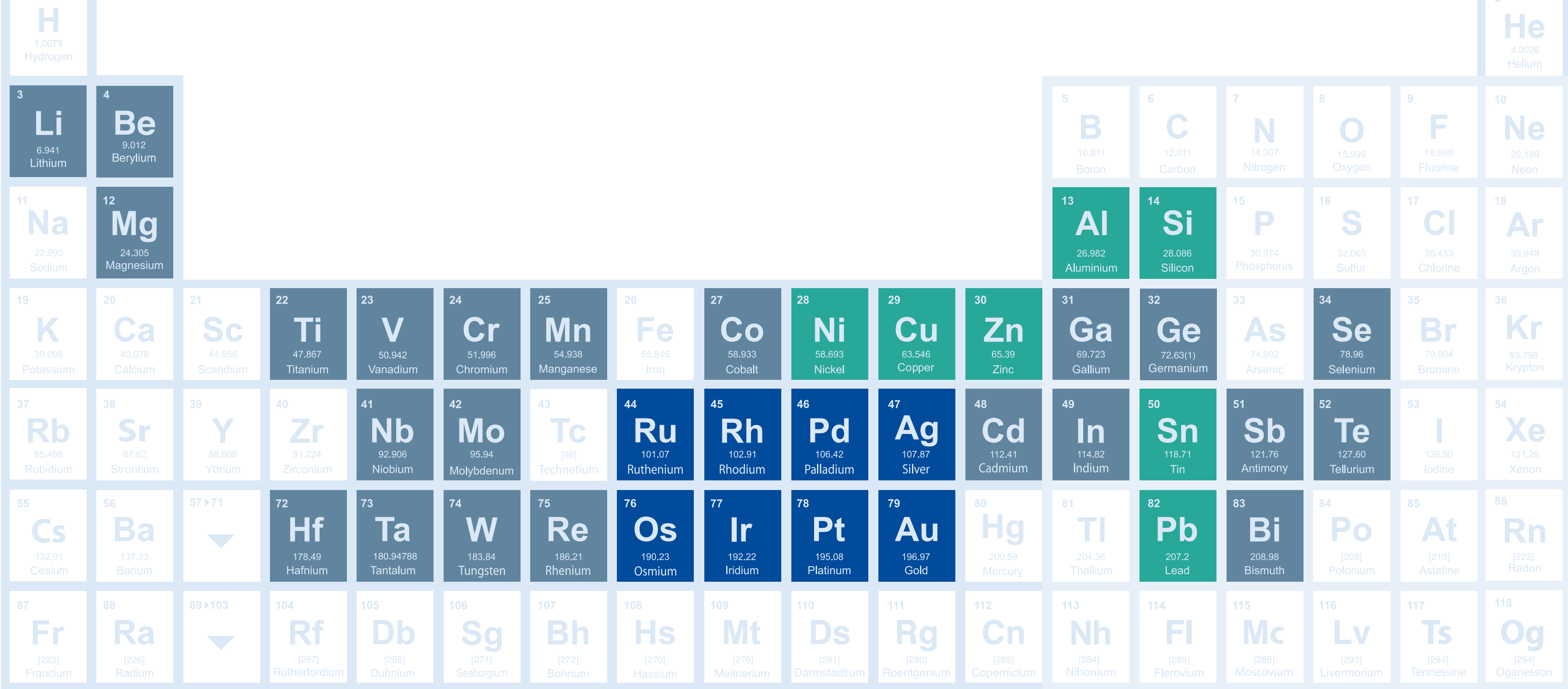
900+ facilities across Europe

Source: Eurometaux

*aggregated global share for Europe's base metals capacity (aluminium, copper, lead, nickel, zinc)

[13] Eurometaux, [14] European Aluminium, European Copper Institute, International Zinc Study Group, International Lead Association, Nickel Institute, **Around 7% including EFTA

Non-ferrous metals produced and/or recycled in Europe



Base Metals:

The backbone for Europe's economic infrastructure and products, these metals are used in large and increasing quantities. Base metals act as "carriers" for a range of other metals.

Precious metals:

Available for centuries, the rarity of precious metals has traditionally given them a high economic value. Today they are used in various high-technology applications including solar panels, electronics & fuel cells.

Specialty metals:

Used in small volumes, these often rare metals are essential for the production of high-technology devises and low-carbon technologies. Almost all specialty metals are by-products of base metals production.

Rare Earth Metals are used across European industries, but do not yet themselves have a major domestic manufacturing base

Metals - The foundation of low-carbon value chains

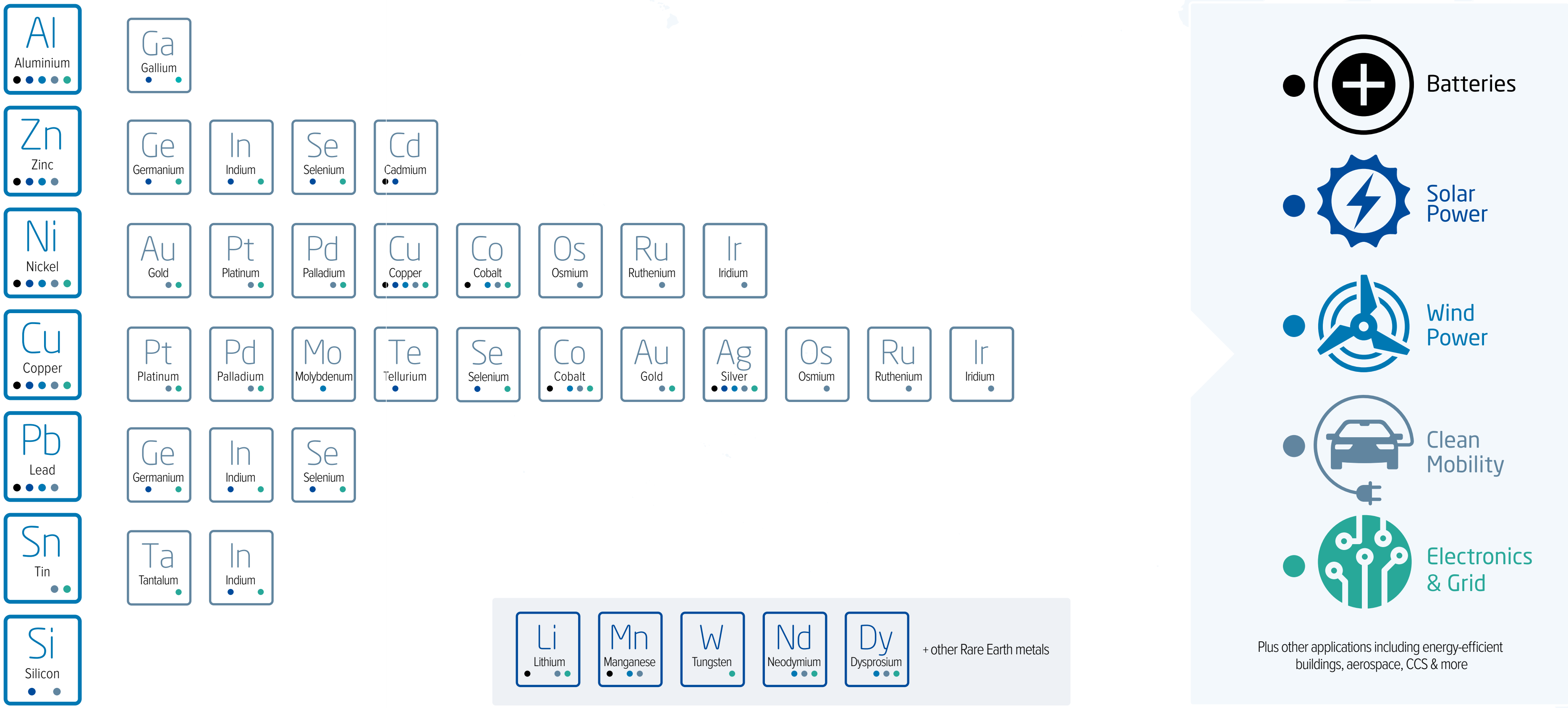
The transition to a climate-neutral Europe can only be achieved with sufficient amounts of non-ferrous metals. For example, the World Bank in 2017 projected that 300% more metals will be demanded by the world's wind turbines by 2050, 200% more metals for solar panels, and 1000% more metals for batteries[15].

The European Commission has therefore set itself an objective to further develop its raw materials value chains, to meet growing demand for low-carbon technologies - including batteries, clean mobility (hybrid, electric & fuel cells), and renewable energy (wind, solar).

Doing so will require that Europe holds and expands its market share across all stages of the raw materials value chain: extraction, processing, and recycling.

Europe's domestic supply of precious and critical metals is in a large part dependent on an industrial base for producing and recycling the basic metals: aluminium, copper, lead, nickel and zinc. These metals are "carriers" for other essential metals ranging from cobalt to gold.

Supplying Europe's low-carbon technologies through an integrated metals ecosystem



[15] World Bank - The Growing Role of Minerals and Metals for a Low Carbon Future, 2017

A ‘price-taker’ industry operating in a truly global marketplace

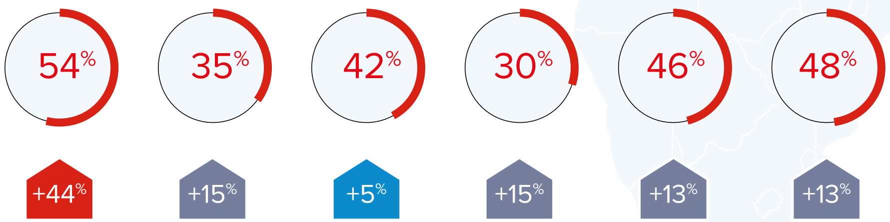
Europe’s metals ecosystem operates in a truly global market. The non-ferrous metals industry is the only basic materials sector that sees consolidated global price setting for most of its products, with the London Metal Exchange (LME) being a crucial pricing instrument. These global price setting dynamics mean that EU producers cannot pass on unilateral regional costs (such as EU regulatory costs) to its customers without losing market share.

Alongside internationally set prices, Europe has a significant import dependency for all metals ores and concentrates, including 100% import reliance for several specialty metals and rare earths[16]. Europe also imports far more primary metal than it exports.

There is strong evidence for major state-aid interventions and support in metals production outside of the EU, in particular in China. As an example, a recent OECD report concluded that 85% of subsidies in the aluminium sector went to 5 Chinese companies. Such actions have resulted in excess capacities in China for aluminium, silicon and several other metals - at the same time as European production has stalled (e.g. over 30% of Europe’s primary aluminium production capacity has been idled since 2008).

This situation results in higher exports of semi-finished and finished products into Europe, as well as depressing global metals prices and the possibility for European metals producers to compete on a level playing field.

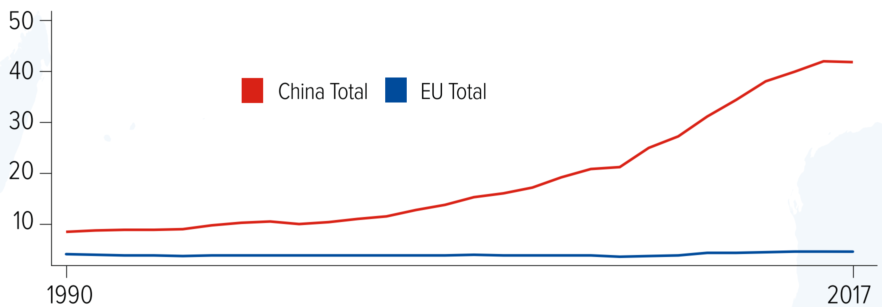
China’s market dominance for non-ferrous metals (% share 2016)



% share change 2008-2016

Source: Taube, 2017

Production of Non-Ferrous Metals, EU vs China (Millions of tonnes)

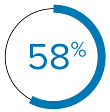


Source: British Geological Survey

[16] European Commission Critical Raw Materials factsheet, [17] OECD - Measuring distortions in international markets: the aluminium value chain, 2019

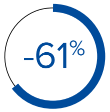
A frontrunner industry towards a 2050 Climate-Neutral Europe

Europe's non-ferrous metals industry is a genuine frontrunner industry in the transition to a climate-neutral society. It has made several important step changes in recent decades, which will form a major part of decarbonisation pathways for other energy-intensive sectors and industry overall.



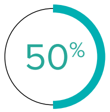
HIGH LEVELS OF ELECTRIFICATION

The non-ferrous metals industry is the most electrified of all energy-intensive industries, with a 58% share of electricity use in its overall energy consumption.[18]



HIGH REDUCTION IN OVERALL EMISSIONS

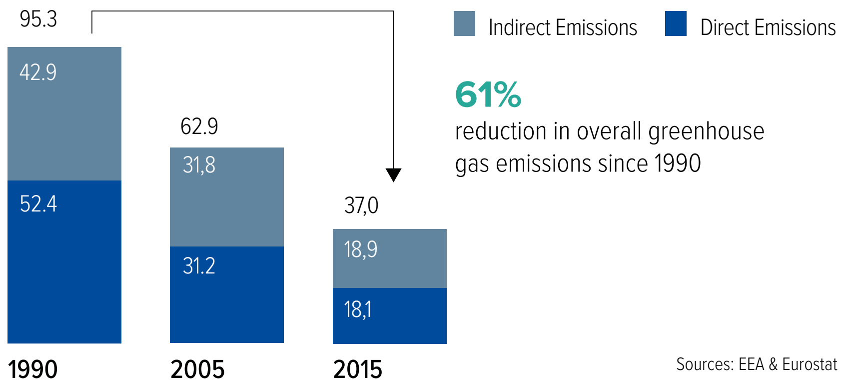
The non-ferrous metals industry has reduced its absolute emissions by 61% since 1990, matched only by the chemicals sector.[19]



HIGH LEVELS OF CIRCULARITY

The non-ferrous metals industry has already achieved high levels of circularity for base metals, with over 50% of Europe's domestic supply now coming from recycled sources.[20]

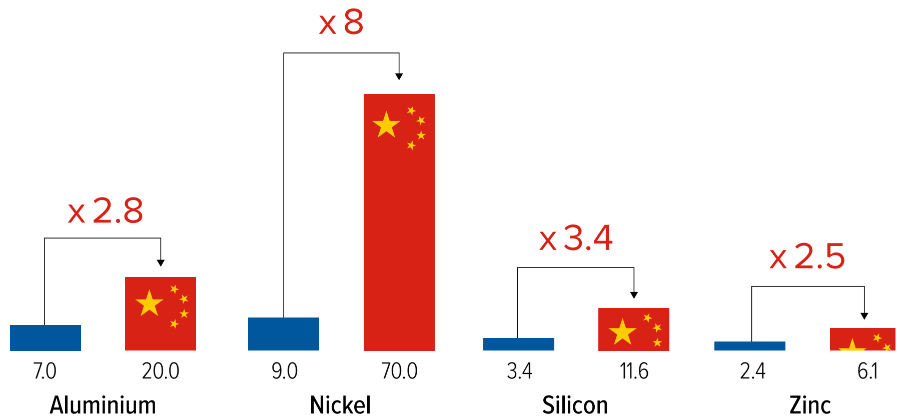
Historical evolution of EU non-ferrous metals industry greenhouse gas emissions, 1990-2015 [21] (Mt CO_2e)



Sources: EEA & Eurostat

European primary production of non-ferrous metals also has lower GHG emissions than other areas of the world, especially compared to China where base metals production can be up to 8 times more CO_2 intensive (largely due to the high use of coal in the power mix)

Carbon footprint of primary metals production, EU vs China (tCO_2)



Sources: European Aluminium, The Nickel Institute, AlloyConsult, Congcong Qi, et al., 2017

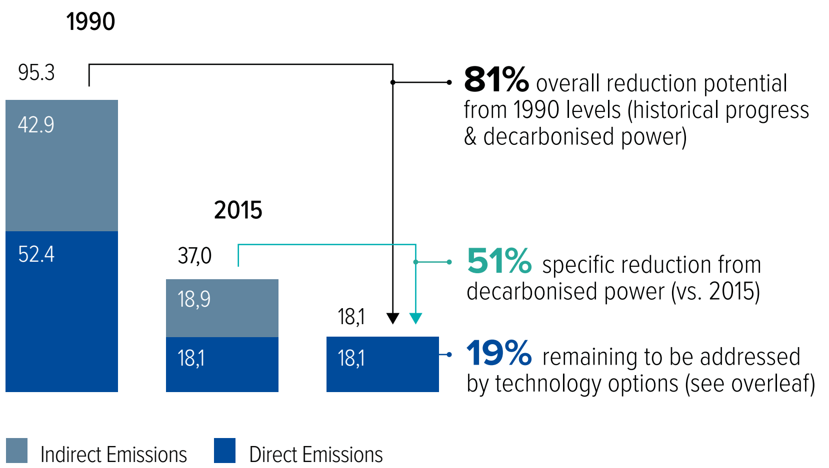
[18] Eurostat, 2018, [19] EEA, Eurostat (complemented by commodity association data) [20] Eurometaux, UN COMTRADE, [21] Emissions profile for EU production of aluminium, copper, lead, nickel, zinc, and Silicon/Ferro-alloys

EU primary metals production – high potential for further GHG mitigation

There is a theoretical potential for the non-ferrous metals industry to reduce its GHG emissions by more than 90% compared to 1990 levels. The most important mitigation will come from the decarbonisation of the EU power sector which according to EU data could reduce the remaining emissions from EU non-ferrous metals production by 51%, based on 2015 emissions and production figures. This alone would lead to a theoretical 81% total reduction of the sector's emissions compared with 1990 levels.

For the industry's remaining emissions, there are a wide-range of technological options with major potential for achieving GHG reductions in line with climate-neutrality by 2050 (see full table overleaf). The successful research, development, upscaling and deployment of these technologies needs a fully integrated industrial strategy, underpinned by a strong governance framework. This will require addressing the R&D and financing challenges, fostering the creation of markets for climate neutral, circular products, and securing access to abundant, low-carbon energy and non-energy sources at affordable prices.

Potential evolution of EU non-ferrous metals industry greenhouse gas emissions from a decarbonised power system (Mt CO_2e)



Sources: EEA & Eurostat

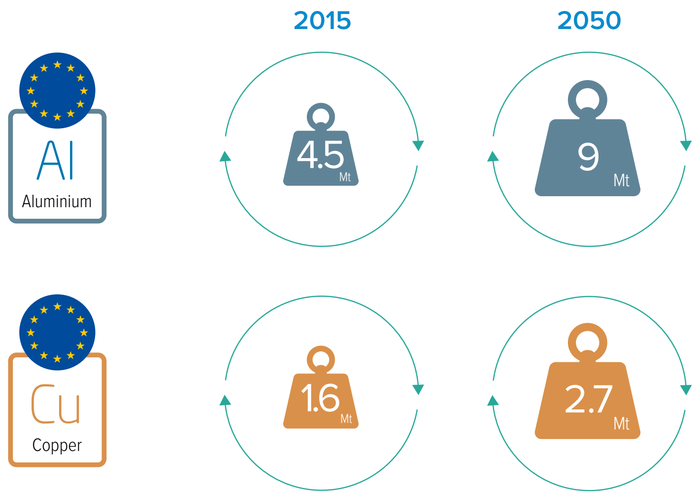
Europe's metals recycling - high potential for further circularity

European recycling volumes for metals are projected to increase significantly due to higher quantities of metals becoming available from Europe's in-use stock. An ambitious EU Circular Economy agenda will help to maximise recycling volumes, improve yields, & boost competitiveness.

Higher recycling volumes will lower the metals industry's overall carbon footprint on a lifecycle basis, as recycling processes require less energy than extraction and primary production operations (although recycling of some metals from complex waste fractions could incur higher energy requirement due to low metal concentrations and/or small volumes).

Europe's additional recycled metals are not projected to replace its existing demand for primary metal in the timeframe considered by this report (until 2050), due to Europe's increasing demand for metals and the large amounts of metals found in stock with long-lifetime applications (e.g. buildings).

Projected increase in EU aluminium and copper scrap volumes, 2015-2050 (Mt)



Sources: European Aluminium & OECD

List of potential innovation options for lowering non-ferrous metals sector emissions (non-exhaustive)

Technology options	Description - impact	Enabling conditions	Relevance
Decarbonisation EU power	Large impact for non-ferrous metals industry. Can bring total (direct + indirect) emissions down by 81% ref. 1990.	This evolution will happen outside of non-ferrous metals industry. Transition to low-carbon electricity will have to go with affordable and secure electricity. Non-ferrous metals can help by higher levels of demand response/ancillary grid services.	All metals +++
Energy efficiency	Important energy savings are possible mostly related to digitisation and automated process management and efficiency in furnaces.	Not all energy savings technologies are compatible with new breakthrough technologies. Favourable investment climate required for continuous investments.	All metals +++
Anode technology aluminium	Innovation in electrolysis process can bring further efficiency gains of up to 20%. Inert anode technology can eliminate direct emissions while reducing energy use.	Major R&D effort needed, including support for pilot and demonstration. Investments can be capital intensive but likely with lower operational costs.	Al +++
Further Electrification	Further electrification of pyrometallurgical processes and/or shift to hydrometallurgical processes in some smelting processes. Electrification (heat) in downstream processes.	High temperature electrification might not yet be mature or too expensive compared to natural gas-based heating. Shift to hydrometallurgical processes can be limited and will most likely be applied in secondary and waste streams	Cu, Zn, Pb, Ni Al (& downstream all metals) +++
Fuel shift - bio-based	Fuel shift from fuels/coal to gas has occurred in non-ferrous metals industry where possible. Further shifts to natural gas and bio-feed are possible. Can be relevant for recovery of metals from smelting slag or leaching residues	Fuel shift must be economically viable and bio-based fuels must meet required quality.	Cu, Ni, Pb, Zn (ISF), Ferro-alloys, Si +++
Non-carbon reducing agents/ hydrogen	Can be relevant for some pyro smelting processes (e.g. copper). Limited application of H2 in ferro-alloys. Can be relevant for recovery of metals from smelting slag or leaching residues	Will depend on economic development of H2 production by other sectors and available infrastructure. Smelters already requiring a lot of O2 might have better business case for use of H2 via electrolysis, which has O2 as a by-product.	Cu, Zn (ISF), Pb, Si ++
CC(U)S	Due to relative low level of GHG emissions compared to e.g. steel, chemicals and cement not priority for non-ferrous metals but can be linked to other sectors when technology is ready. Can become important for silicon and alloys production.	Will depend on capture, transport and storage technology and infrastructure developed by other larger industries.	Ferro-alloys, Si, Zn (ISF), Cu ++
Higher metals recovery (residues, slag and scrap)	New technologies (mostly hydrometallurgical but also new pyro) can enable recovery of high amount of metals (incl. precious and rare) from waste and secondary streams. Important potential for improvements. Greenhouse gas impact can be limited (over-all) but important environmental and economic co-benefits possible.	Further R&D support needed including scaling up to pilot and demonstration stage. Can be regulatory conflict with regulations on waste and hazardous materials.	Cu, Zn, Ferro-alloys, Ni, Pb Alunina +++
Sector coupling: demand response and waste heat	Important potential by non-ferrous metals for increased demand response services. Waste heat recovery by e.g. buildings sector can help reduce emissions there	Market conditions need to be favourable. More variable load profiles cannot be punished with higher grid tariffs.	Al, Cu, Zn, Ni, Pb, Si, Ferro-alloys +++

+++ Important technology options often with significant mitigation potential
++ Options with possible significant mitigation potential but can be difficult for the non-ferrous metals industry to apply on its own, e.g. requiring cooperation with other larger industries

Regulatory challenges for a bellwether industry

Europe's metals ecosystem - the "canary in the coal mine" for energy-intensive industries?

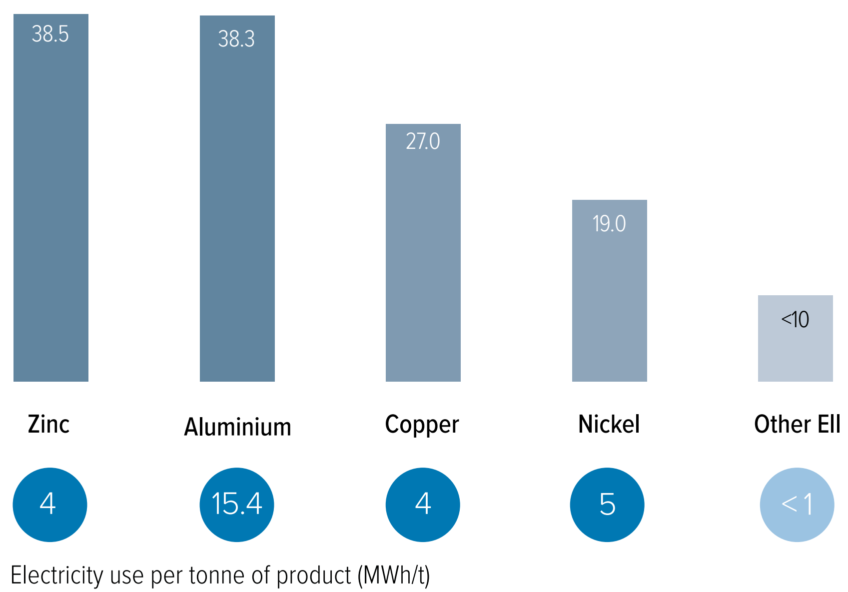
The non-ferrous metals industry's frontrunner status means it will be the first in line to face several major regulatory challenges from Europe's climate transition. How it copes will be an early indicator of the adequacy of EU industrial policies to support energy-intensive industries through the transition.

In particular, the non-ferrous metals industry's electro-intensity makes it particularly susceptible to the potential impacts of a decarbonising power system, i.e. higher electricity prices and lower grid stability. The industry's use of electricity (per tonne of product & as a percentage of total production costs) is currently higher than any other energy-intensive sector.

The industry is therefore already significantly impacted by indirect carbon costs from the Emissions Trading System (ETS), passed on by power producers to metals producers. With a rising ETS price expected in coming years, the impact of indirect carbon costs is expected to rise significantly, impacting the competitiveness of metals producers. An adequate system to limit the impact of indirect carbon costs on the most electro-intensive industries is needed, as well as other regulatory costs.

Other Energy-Intensive Industries are considering the potential to electrify their carbon-intensive processes to meet Europe's 2050 targets. It's imperative that the EU acts to ensure that carbon-free electricity is available at affordable prices for all the sectors that need it.

Electricity costs as % of total production cost



The **metals industry is 5X** more sensitive to higher electricity **prices** than the manufacturing industry overall[22]

Source : CEPS, Ecofys, Ecorys, JRC

[22] With the exception of chlorine, with 3 MWh/t and 43% of production costs

Industrial policy solutions - the canary that survives the coal mine

Europe can help its metals industry to fulfil its decarbonisation potential through an EU industrial strategy and European Green Deal that rewards climate achievements while protecting and nurturing the industry, its eco-system and its essential value chains.

In a best-case scenario for 2050, Europe will succeed in growing and developing its metals ecosystem alongside the implementation of its climate-neutral strategy. This will ensure its strategic value chains are supplied in large parts by metals that have been produced in Europe with a minimum carbon footprint.

A scenario to be avoided is that Europe's metals production is increasingly replaced by imports with a higher carbon footprint, to the detriment of its climate goals

The EU can enable its metals ecosystem's transition to climate neutrality through a 5 pillar industrial strategy which encourages innovation and addresses global imbalances:

1. Competitively-priced carbon-free electricity

- Develop an integrated strategy for the development of a full range of low-carbon and carbon neutral energy carriers and related energy infrastructure and energy storage in Europe
- Provide a market-based and market responsive framework that delivers cost-efficient electricity meeting industrial needs
- Guarantee stable and predictable compensation for indirect EU ETS costs & renewable energy support schemes
- Introduce a positive regulatory framework for power purchase agreements and long-term power contracts (including cross-border PPAs)
- Adequately value industry's current and future role in balancing the profile of electricity markets

2. Innovation & investments support

- Optimise the governance and coherence of Europe's innovation architecture, including robust and regular monitoring and flexibility for reorientating financing when necessary
- Use fiscal and financial instruments to assist in guiding industrial investments towards low-CO_2 solutions
- Improve public procurement practices across the EU by making better use of the existing Public Procurement Package & by linking public procurement to low-CO_2 standards.
- Support brownfield conversion through regulatory flexibility and access to the EU ETS modernisation fund
- Ensure that the new sustainable finance taxonomy considers the large investment challenges for energy-intensive industries and the role of metals in enabling downstream green investments

3. Nurturing value chains & industrial symbiosis

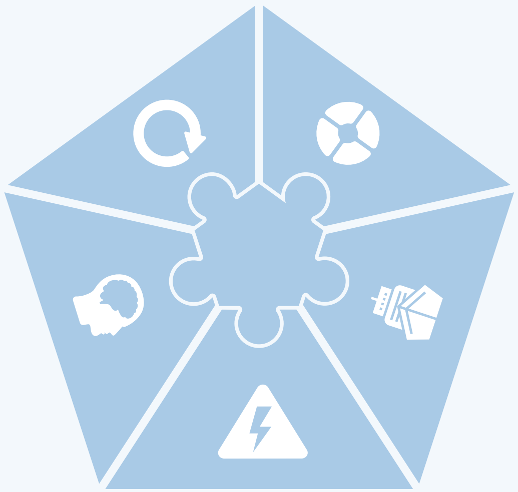
- Extend the strategic approach under the action plan for batteries to other value chains which are critical for Europe's transition to a climate-neutral economy
- Encourage a higher level of domestic production of all metals as part of an integrated industrial strategy for green value chains, including high sustainability standards.
- Further facilitate industrial symbiosis and sector coupling for the metals industry, including the development of regional clusters
- Take care that chemicals management measures are designed to maintain investment predictability into metals operations, while achieving the primary objective of safe chemicals use.
- Support metals producers to enhance energy efficiency in other sectors, e.g. through the valorisation of low temperature waste heat in the residentials sector

5. Assertive trade & competition policies

- Encourage a more forceful and diligent EU utilisation of existing trade defence instruments, and act sooner in cases of a serious and immediate threat of injury to domestic industry
- Pursue a globally focussed competition policy, as well as addressing the distortive effects of foreign companies on the EU internal market, including state ownership and financing
- Pursue necessary reforms of the World Trade Organisation, in order to tackle the growing issues of state subsidisation and excess capacities
- Use free trade agreements and bilateral dialogues to improve cooperation with countries that are key suppliers of primary raw materials to Europe
- Strengthen EU standards, use public procurement, and harmonise customs clearance practices at harbours

4. An ambitious Circular Economy framework

- Invest into Europe's capacity for state-of-the-art recovery of metals from existing and emerging stock, including through new technologies
- Avoid leakage of scrap outside of the EU when there are not sufficient guarantees that metals recovery will happen at the necessary standards
- Support development of climate friendly technologies and techniques that enhance the recovery of metals and alloys from secondary raw material streams.
- Improve product design, through requiring easier and more efficient disassembly, traceability and recyclability of metals (e.g. for electronics waste)
- Optimise the collection and sorting infrastructure for metals scrap and products, in order to improve recycling rates



INSTITUTE FOR
EUROPEAN
STUDIES

StephensonDesign.eu

Contact:

Tomas Wyns
Senior Researcher, IES-VUB
Tomas.wyns@vub.be

The authors extend their sincere gratitude to all the experts and stakeholders who have participated in the process of creating this report and have shared their expert input. The views expressed in this publication are those of the authors alone.

A digital copy of the report *Metals in a Climate Neutral Europe - A 2050 Blueprint* (published October 2019) is available via either the QR code above or the following link: **bit.ly/metals2050**