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.
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.

2. Europe’s metals ecosystem - major potential to further reduce its carbon footprint, with the right framework conditions
   - Potential for an 8% overall reduction in greenhouse gas emissions (vs. 1990 levels), once indirect emissions have been eradicated in a decarbonised EU power sector.
   - Potential technological potential for further reducing direct GHS 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 CO2 footprint compared to primary extraction and production.

3. Europe’s metals ecosystem - exposed to significant levels of international competition, because metals are a globally traded commodity
   - 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, making the threat of EU production being replaced by more carbon-intensive non-EU production very real.
   - Europe’s metals ecosystem - facing specific regulatory challenges from the transition of Europe’s power sector
   - 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.

4. Europe’s metals ecosystem - a sector whose 2050 future can be secured with a dedicated industrial strategy
   - Competitively-priced and abundant carbon-free electricity, innovation and investments support, enhanced value chains, and industrial symbiosis, assertive trade and competition policies, and ambitious Circular Economy policies.

5. Europe’s metals ecosystem - a sector whose 2050 future can be secured with a dedicated industrial strategy
   - 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 CO2 footprint compared to primary extraction and production.

Key Findings
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.

Europe is mostly dependent on imports of its primary raw materials, accounting for only 7% 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.

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.

Introducing the Metals Ecosystem

**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 devices and low-carbon technologies. Almost all specialty metals are by-products of base metals production.

Non-ferrous metals produced and/or recycled in Europe

<table>
<thead>
<tr>
<th>Metal</th>
<th>% Share of global production per metal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Al</td>
<td>0.6%</td>
</tr>
<tr>
<td>Cu</td>
<td>4.1%</td>
</tr>
<tr>
<td>Ni</td>
<td>3.0%</td>
</tr>
<tr>
<td>Pb</td>
<td>9.7%</td>
</tr>
<tr>
<td>Zn</td>
<td>5.4%</td>
</tr>
<tr>
<td>Al</td>
<td>4.0% **</td>
</tr>
<tr>
<td>Cu</td>
<td>13.1%</td>
</tr>
<tr>
<td>Ni</td>
<td>9.6%</td>
</tr>
<tr>
<td>Pb</td>
<td>9.4%</td>
</tr>
<tr>
<td>Zn</td>
<td>13.4%</td>
</tr>
</tbody>
</table>

**Source:** Eurometaux

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

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

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

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

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

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

**METALS IN A CLIMATE NEUTRAL EUROPE - A 2050 BLUEPRINT**

**EXECUTIVE SUMMARY**
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.

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 European metals and materials 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.

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.

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.

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

<table>
<thead>
<tr>
<th>Metal</th>
<th>China (%)</th>
<th>EU (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminium</td>
<td>54</td>
<td>46</td>
</tr>
<tr>
<td>Copper</td>
<td>35</td>
<td>52</td>
</tr>
<tr>
<td>Lead</td>
<td>42</td>
<td>30</td>
</tr>
<tr>
<td>Nickel</td>
<td>30</td>
<td>46</td>
</tr>
<tr>
<td>Zinc</td>
<td>46</td>
<td>34</td>
</tr>
<tr>
<td>Cobalt</td>
<td>48</td>
<td>52</td>
</tr>
</tbody>
</table>

% share change 2008-2016

Source: Tarsus, 2017

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

<table>
<thead>
<tr>
<th>Technology</th>
<th>Non-Ferrous Metals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wind Power</td>
<td>Al, Si, Sn, Pb, Zn</td>
</tr>
<tr>
<td>Solar Power</td>
<td>Al, Si, Sn, Pb, Zn</td>
</tr>
<tr>
<td>Battery</td>
<td>Al, Si, Sn, Pb, Zn</td>
</tr>
<tr>
<td>Clean Mobility</td>
<td>Al, Si, Sn, Pb, Zn</td>
</tr>
<tr>
<td>Electronics &amp; Grid</td>
<td>Al, Si, Sn, Pb, Zn</td>
</tr>
<tr>
<td>Electronics &amp; Grid</td>
<td>Al, Si, Sn, Pb, Zn</td>
</tr>
<tr>
<td>Electronics &amp; Grid</td>
<td>Al, Si, Sn, Pb, Zn</td>
</tr>
</tbody>
</table>


* European Commission Critical Raw Materials factsheet, 2017

* 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.

**High Reduction in Overall Emissions**

The non-ferrous metals industry has reduced its absolute emissions by 49% since 1990, matched only by the chemicals sector.

**High Levels of Circularity**

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

<table>
<thead>
<tr>
<th>Base Metal</th>
<th>1990</th>
<th>2005</th>
<th>2015</th>
<th>2050 (EU)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminium</td>
<td>17.0</td>
<td>9.0</td>
<td>2.8</td>
<td>-</td>
</tr>
<tr>
<td>Nickel</td>
<td>4.5</td>
<td>2.2</td>
<td>1.6</td>
<td>-</td>
</tr>
<tr>
<td>Copper</td>
<td>18.1</td>
<td>18.1</td>
<td>18.9</td>
<td>-</td>
</tr>
<tr>
<td>Silicon</td>
<td>32.4</td>
<td>15.8</td>
<td>6.6</td>
<td>-</td>
</tr>
<tr>
<td>Zinc</td>
<td>2.4</td>
<td>2.4</td>
<td>2.5</td>
<td>-</td>
</tr>
</tbody>
</table>

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

European primary production of non-ferrous metals has also lower GHG emissions than other areas of the world, especially compared to China where base metal production can be up to 8 times more CO2 intensive (largely due to the high use of coal in the power mix).

<table>
<thead>
<tr>
<th>Metal</th>
<th>1990</th>
<th>2015</th>
<th>2050 (EU)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminium</td>
<td>52.4</td>
<td>31.2</td>
<td>20.0</td>
</tr>
<tr>
<td>Nickel</td>
<td>9.0</td>
<td>18.9</td>
<td>11.6</td>
</tr>
<tr>
<td>Copper</td>
<td>37.0</td>
<td>31.8</td>
<td>20.5</td>
</tr>
<tr>
<td>Silicon</td>
<td>6.1</td>
<td>5.2</td>
<td>3.4</td>
</tr>
<tr>
<td>Zinc</td>
<td>8.1</td>
<td>6.6</td>
<td>4.2</td>
</tr>
</tbody>
</table>

Sources: EEA & Eurostat

European primary production of non-ferrous metals industry greenhouse gas emissions, 1990-2015 (Mt CO₂e) [x 3.4]

Historical evolution of EU non-ferrous metals industry greenhouse gas emissions, 1990-2015 (Mt CO₂e)

### Energy Consumption

Europe’s 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.

### Recycling

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

### 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.

### Decarbonisation

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.

### GHG Mitigation

There is a theoretical potential for the non-ferrous metals industry to reduce its GHG emissions by more than 80% 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 55%, based on 2015 emissions and projections. This alone would lead to a theoretical 80% total reduction of the sector’s emissions compared with 1990.

For the industry’s remaining emissions, there is a wide-range of technological options with major potential for achieving GHG reductions in line with the climate-neutrality by 2050 (net full-fossil potential). The successful research, development, upscaling and deployment of these technologies require fully integrated industrial strategy, supported 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-cost carbon-free energy sources at affordable prices.

### Circular Economy

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 requirements 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 (2050), due to Europe’s increasing demand for metals and the large amounts of metals found in stocks with long lifetime applications (e.g. buildings).

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

Europe’s metals recycling - high potential for further circularity

Europe’s 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, and boost competitiveness.

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Projected increase in EU aluminium and copper scrap volumes, 2015-2050 (Mt)
List of potential innovation options for lowering non-ferrous metals sector emissions (non-exhaustive)

<table>
<thead>
<tr>
<th>Technology option</th>
<th>Description</th>
<th>Impact</th>
<th>Enabling conditions</th>
<th>Relevance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heat recovery by e.g. buildings sector</td>
<td>Can help reduce emissions in the buildings sector</td>
<td>Can be significant and cost-effective</td>
<td>Requires integration with heat and power generation systems</td>
<td>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</td>
</tr>
<tr>
<td>Market conditions need to be favourable. More variable load on waste and hazardous materials.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Regulatory challenges for a bellwether industry</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Executive Summary**

The non-ferrous metals industry’s frontrunner status means it will be at the forefront of the sector’s regulatory challenges. The non-ferrous metals industry is highly dependent on carbon-free electricity to meet its energy needs, and will need to make significant investments to decarbonize its production processes. The industry is therefore already significantly impacted by indirect carbon costs from the Emissions Trading System (ETS), which has led to a rising ETS price expected in coming years, 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. The non-ferrous metals industry’s frontrunner status means it will be the first in line to face several major regulatory changes in the years ahead. It will need to be well-prepared to take advantage of new opportunities, while also addressing significant challenges.

The metals industry is 5X more sensitive to higher electricity prices than the manufacturing industry overall. **Electricity costs as % of total production cost**

*Source: CEPS, Ecofys, Ecorys*
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 ecosystem 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
   - Developing 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-CO2 solutions
   - Improve public procurement practices across the EU by making better use of the existing Public Procurement Package & by linking public procurement to low-CO2 standards
   - Support innovation through enhanced 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 included in Europe’s Transition to a climate-neutral society
   - 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 systems
   - Take care that chemicals management measures are designed to maintain investment predictability into metal operations, while achieving the primary objective of safe chemicals use
   - Support metals producers to enhance energy efficiency in other sectors, e.g. through the utilisation of low-temperature waste heat in the residential sector

4. An ambitious Circular Economy framework
   - Invest into Europe’s capacity for state-of-the-art recovery of metals from end-of-life and emerging stocks, including through new technologies
   - Avoid leakage of scrap outside of the EU (where 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
   - Enhance product design, through material design and more efficient downstream processes, and improve resource efficiency and recyclability of metals (e.g. for electronics waste)
   - Optimize the collection and sorting infrastructure for scrap and products, in order to improve recycling rates

5. Assertive trade & competition policies
   - Encourage a more forceful and diligent EU utilisation of existing trade defence instruments, and act sooner in cases of various distortions that might erode the competitiveness of the domestic industry
   - Pursue a globally balanced 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-owned enterprises 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

6. 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-CO2 solutions
   - Improve public procurement practices across the EU by making better use of the existing Public Procurement Package & by linking public procurement to low-CO2 standards
   - Support innovation through enhanced 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

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Contact:
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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 for 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