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Transition Pathway for the European Metals Sectors

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TRANSITION PATHWAY FOR THE EUROPEAN METALS SECTORS

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This document reflects the results of a co-creation process with stakeholders active in the metals ecosystem. The recommended actions do not necessarily represent the position or endorsement of all stakeholder groups nor the position of individual Member States or the European Commission. This document is without prejudice to any future initiatives. The actions presented in this document described ambitions and desired objectives for the transition.

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EXECUTIVE SUMMARY

In its updated 2021 industrial strategy[1], the Commission proposed a series of transition pathways to be developed jointly with EU Member States, industry and other stakeholders. These pathways identify the actions needed to achieve the twin green and digital transition, while giving a better understanding of the challenges, scale, benefits and conditions required. This transition will also strengthen the resilience of the metals sectors, an industry heavily affected by several headwinds e.g., low demand in the European metals value chains, high energy prices in the EU, third country trade distortions, spill-over effects of global metals excess capacity on the EU market, high regulatory burden, and difficult access to primary and secondary raw materials, exacerbated by the Russian war of aggression against Ukraine. This Transition Pathway for metals should also contribute to achieving the goals of the Critical Raw Materials Act[2]. In February 2025, the Commission adopted the Clean Industrial Deal[3], a plan for the EU competitiveness and decarbonisation, and the Affordable Energy Action Plan[4] aiming to address some of the most acute challenges faced by the metals sectors. The Steel and Metals Action Plan announced in the Clean Industrial Deal will complement the horizontal measures by focusing on the specific needs of the steel and metals industries.

In the summer of 2023, the Commission launched the 'co-creation' process for the transition pathway for the European metals[5] industry. The process involved EU Member States, the ferrous and non-ferrous metals industries, social partners, NGOs and academia. In September 2023, a sub-group of the High-Level Group on Energy-intensive Industries was created to help with this 'co-creation'.

This 'Transition pathway for metals sectors' report identifies a series of actions proposed by different stakeholders to ensure a successful twin transition for the metals sectors. This executive summary summarises those findings and provide timely input into the Steel and Metals Action Plan and other relevant Commission initiatives.

SUSTAINABLE COMPETITIVENESS

Energy policy: Energy cost is certainly a major factor determining today's competitiveness and the future transition to low-carbon production processes, as well as the sustainability of the EU's ferrous and non-ferrous sectors. The current geopolitical context and recent developments have led to very high energy costs in the EU. Although wholesale electricity prices have fallen substantially from 2022 levels, they remain higher than in the past, and the European metals sectors face increasing divergence in energy prices compared to their global counterparts, to the detriment of competitiveness for European companies. This demands particular attention by policymakers, including measures to ensure that the increased renewable energy capacity leads to more competitive energy prices, as highlighted notably in the Draghi report[6]. While power purchase agreements (PPAs) can offer protection from price volatility, metals and other energy-intensive industries face several barriers to access them. Renewable and fossil-free hydrogen will be essential for the future production of primary steel,

[1] COM(2021) 350 final, *Updating the 2020 New Industrial Strategy: building a stronger Single Market for Europe's recovery* https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM:2021:350:FIN.

[2] https://single-market-economy.ec.europa.eu/publications/european-critical-raw-materials-act_en.

[3] https://commission.europa.eu/topics/eu-competitiveness/clean-industrial-deal_en

[4] https://energy.ec.europa.eu/strategy/affordable-energy_en

[5] Here, the term 'metals' also includes important uses of metals' inorganic compounds, including (for example) battery materials, photovoltaics and semiconductors.

[6] "The future of European competitiveness: Report by Mario Draghi". See link.

as well as for the decarbonisation of downstream processes in the ferrous and non-ferrous sectors. A well-functioning hydrogen market requires swift implementation of the recently adopted EU gas and hydrogen regulatory framework[7]. However, attention should be also paid to the implementation of the delegated act on a methodology for renewable fuels of non-biological origin[8] and its ability to deliver on the EU's domestic production target for renewable hydrogen. Due to the initial scarcity of renewable hydrogen, it could be considered to allocate to end users with the highest CO_2 emissions abatement potential per tonne consumed. In addition, stakeholders have identified that more legal certainty in the hydrogen-related regulatory framework would be needed to spur investments and production of renewable and fossil-free hydrogen.

Climate change policy: Fragmented approaches at global level on carbon pricing might lead to a carbon leakage risk for European metals producers, which are bound by the European emissions trading system (EU ETS). This risk has been addressed notably by making free allowances available under the ETS under certain conditions and through indirect ETS costs compensation schemes under the ETS State aid guidelines. To fulfil the EU's climate targets and fulfil its obligations under the Paris Agreement, the EU ETS was revised and the greenhouse gas (GHG) reduction target increased accordingly. In this context, metals producers are now facing the challenge to implement, in some cases already by 2030, unprecedented decarbonisation projects. while third countries' producers are not subject to comparable targets and in several cases are still investing in traditional carbon intensive technologies.

To maintain a competitive European metals industry, the right enabling conditions must be put in place. Iron, steel and aluminium are among the sectors covered by the Carbon Border Adjustment Mechanism (CBAM). As of 2026, this mechanism will start gradually replacing ETS free allowances as a carbon leakage protection instrument. Detailed rules need to be prepared to ensure the new system reduces risks such as circumvention, resource shuffling and freeriding. Metals sectors are very electro-intensive and are recognised as being at risk of carbon leakage due to their exposure to indirect carbon costs passed on by electricity generators through electricity prices. Fifteen Member States compensated to a various extent those indirect electricity costs partially dampening leakage risk. Until the EU power grid is fully decarbonised, it is crucial to keep effectively mitigating this risk, particularly as the sectors increase the electrification of their production processes

Trade policy: The EU has lost a significant share of the global market for base metals production in the last decade and suffers from limited industrial capacity across value chains and especially in the refining part for critical metals like lithium, cobalt and rare earth elements. Even though the EU uses trade defence measures widely in the metals sectors, with steel and aluminium in particular, the industry remains threatened by significant spill-over effects of global excess capacities on the EU market and by global distortions from China and other countries that artificially support their domestic industries or circumvent EU trade defence measures and sanctions. As a consequence, the EU's manufacturing base is now impeded by artificially depressed global prices, rising imports, rising costs and both tariff and non-tariff restrictions, including on raw materials. In addition, the ability to tackle the growing issues of decarbonisation and excess capacities at the global level is hampered by some countries blocking progress within the multilateral framework. European economic security policies should support strategic EU objectives laid down in the framework of rapidly evolving EU industrial and environmental policies. The existing and, as relevant, new trade policy instruments need to be effectively deployed to tackle distortions from imports and guarantee access to export markets.

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[7] https://energy.ec.europa.eu/topics/energy-systems-integration/hydrogen_en#a-hydrogen-policy-framework

[8] COMMISSION DELEGATED REGULATION (EU) 2023/1184, link

Lead markets for green products: The metals sectors' transition will result in low- and near-zero carbon products. In many cases these can be more expensive than the traditional carbon-intensive products, making it potentially very difficult for domestic companies to compete on the world market. It is thus necessary to create the business case and to support the purchase of such products by downstream users of metals, while guaranteeing a level playing field for operators supplying the same market. The Ecodesign for Sustainable Product Regulation (ESPR)[9] aims at improving the sustainability of products placed on the EU market, including imports. Specific rules under the Regulation (to be enacted via delegated acts) will need to acknowledge the specificities of metals and promote the purchasing of low- and near-zero carbon products. Short-term regulatory measures could stimulate the development of lead markets and trigger large-scale deployment of decarbonisation technologies in the basic materials sectors.

The table below summarises actions proposed by stakeholders on sustainable competitiveness (for detailed recommendations see the 'Sustainable competitiveness' building block, pages 39-49):

	Actions – Energy policy	Actors	Timeframe
1.	Explore measures to deliver more affordable electricity prices in the short term;I	EU	Short-term
2.	Assess demand for and improve the availability and access to Power Purchase Agreements (PPAs) for energy-intensive industries;	EU/MS/ Industry	Short-term
3.	Continue regulatory implementation and harmonisation to streamline and accelerate permit-granting procedures for renewable projects, particularly in go-to areas identified after sound spatial planning able to balance agriculture, environmental and community resources;	EU/MS	Short-term
4.	Assess and measure the decarbonised electricity needs of the EU metals industry and the associated infrastructure requirements, taking into account the implementation of efficiency and circularity measures to reduce electricity needs	Industry	Short-term
5.	Increase process demand flexibility and local energy storage – where possible and cost-effective – to mitigate grid congestion and increase the use of local variable renewable energy sources, thereby benefitting from lower network fees and energy prices;	Industry	Long-term
	Actions – Climate change policy	**Actors**	**Timeframe**
1.	Assess the carbon leakage risk of CBAM goods produced in the EU and exported to third countries (which do not have ETS/ similar carbon pricing) and, where appropriate, present a legislative proposal to address such risk, compatible with WTO rules;	EU	Short-term
2.	Deliver an effective governance and enforcement of the Carbon Border Adjustment Mechanism, against all circumvention practices, including resource shuffling;	EU	Short-term
3.	Assess the need to include more downstream products in the CBAM to avoid circumvention;	EU	Short-term
4.	Take note of the call by stakeholders on the need to preserve the indirect carbon costs compensation and consider how	EU/MS	Short-term

[9] Regulation (EU) 2024/1781, Ecodesign for Sustainable Products Regulation, link

	measures to compensate indirect costs could be further harmonised;		
5.	Take note of the call to assess how ETS revenues can further support decarbonisation of direct and indirect emissions in hard-to-abate industrial sectors;	EU/MS	Short-term

	Actions – Trade policy	Actors	Timeframe
1.	Consider measures to strengthen the EU's trade and competition toolbox to address the distortive effects of subsidies, unilateral trade measures, circumvention, unfair trade practices and structural overcapacities in the global metals market, while facilitating diversification of supplies;	EU	Short-term
2.	Deploy efforts to effectively tackle the two existential challenges facing the steel and aluminium industries worldwide: (i) spill-over effect of excess capacity on the EU market and (ii) carbon intensity based on EU/US policy coordination;	EU	Medium-term
3.	Ambitiously enforce existing rules including those on trade defence, the Enforcement Regulation, the Foreign Direct Investment Screening Mechanism, the Foreign Subsidies Regulation and the Anti-Coercion Instrument (and soon the Forced Labour Ban Regulation).	EU/MS	Short-term

	Actions – Lead markets for green products	Actors	Timeframe
1.	Acknowledge specificities of metals; metals as permanent materials, high recyclability in the ESPR;	EU	Short-term
2.	Use existing rules to promote green public procurement (e.g. vehicles and construction products);	MS	Short-term
3.	Consider international standards / certification schemes for "green products" to address the "green premium" challenge.	EU/MS/ Industry	Short-term
4.	Promote a holistic approach to assessing CO2 reduction potential along value chains;	EU/MS	Short-term
5	Assess how to support and incentivise to markets and customers, encouraging the purchase of low-carbon products;	EU/MS	Short-term

REGULATION AND PUBLIC GOVERNANCE

Legislation under the European Green Deal has led to many new and/or updated regulatory requirements for Europe's metals industry, including an increased regulatory focus on reducing chemical risk. Several themes require discussion, including legal incoherence, complexity, regulatory burden and permitting process of new projects. Metals and inorganics are considered as 'substances' in the context of the EU chemicals framework and are regulated as such. Many metals and metal compounds are hazardous and some of them are classified. In spite of this, most metals and alloys have a long history of safe use due to limited bioavailability. The Commission could continuously evaluate and improve EU laws, focusing on changes to laws that will have the greatest impact. Existing and future legislation can address some of the major barriers that currently prevent the twin transition from proceeding.

Simpler, more effective and transparent legislation: The current regulatory system is highly complex, with many interlinkages between elements of the Green Deal and other key EU policy areas. Attention must be given to the implementation phase and to supporting companies in their efforts to comply with multiple new or updated regulatory requirements.

Coherent legislation: The metals sectors strive for coherence between new legislative changes and for a high level of agreed targets and objectives across different policy areas.

Areas of particular importance in this respect include: (i) energy and climate change policies, and their impact on the competitiveness and resilience of EU industry; (ii) Critical Raw Materials policies, and in particular the Critical Raw Materials Act; (iii) chemicals policy; (iv) waste legislation; (v) the Water Framework Directive; (vi) social and employment policies; and (vii) circularity objectives.

Managing the regulatory burden on EU companies: Many useful and valuable policy tools already exist and have been in use for many years. These can be further simplified without losing scientific quality, or adjusted and better implemented and enforced. Due consideration will need to be given to the proportionality of new measures with respect to benefits sought, including environmental and social benefits. Likewise, potential and related compliance costs should be duly assessed and taken into consideration among different policy proposals.

Speeding up the permitting process: Permitting for both exploration and full-scale mining operations remains a prerogative of Member States. In this context, it is now necessary to ensure that Member States are able and willing to fast-track projects' permits at the appropriate speed and with the requisite due diligence, while preserving a high level of human health and environmental protection and ensuring the social acceptance of such projects. There are many other scenarios within the industrial transition where faster permits are needed. These include: (i) new, low-carbon production processes (including at pilot/demonstration scale and industrial scale); (ii) expanding capacity of existing plants through new production lines; (iii) new metals recycling plants; (iv) new installations for production and storage of green hydrogen; and (v) further deployment and upgrade of electricity grids.

The table below summarises actions proposed by stakeholders on regulation and public governance (for detailed recommendations see the 'Regulation and Public Governance' building block, pages 53-57):

	Actions - Simpler, more effective and transparent legislation	Actors	Timeframe
1.	Reduce administrative burdens and simplify implementation: less red tape and reporting, more trust, better enforcement, faster permitting;	EU	Short-term
2.	Assess current legislation on metals value chains and identify areas where complexity and inconsistencies negatively affect companies in a disproportionate way, aiming to fix incongruencies and clarify complex points	EU/ Industry	Short-term
3.	Ensure that pieces of legislation addressing industry do not work in silos but in an integrated approach;	EU	Short-/ Medium-/ Long-term
4.	Implement industry's roadmaps towards achieving the climate neutrality objective, with the support of EU and national authorities.	Industry/ EU/MS	Short-term
	Actions - Coherent legislation	Actors	Timeframe
1.	Take note of the stakeholder proposal to consider complementing the hazard-based approach with a risk assessment and control for chemicals management;	EU	Short-term
2.	Continue involving all stakeholders in discussions on the overall regulatory framework, and on the upcoming Chemicals industry package, to help identify lack of coherence and/or missing links between policies, ensuring a balance in representation between industry, trade unions and civil society;	EU/MS/ Industry	Short-/ Medium-/ Long-term

3.	When developing regulatory actions, whenever possible, consider also collaboration and coordination in value chains.	EU/MS	Short-/ Medium-/ Long-term
	Actions – Managing regulatory burden	Actors	Timeframe
1.	Explore opportunities to improve and/or better implement existing EU regulatory tools before introducing new ones;	EU/MS	Medium-term
2.	Strive for proportionality with respect to costs and benefits of regulatory actions;	EU/MS/ Industry	Long-term
3.	Make better use of digital tools to minimise the administrative burden on EU companies and encourage public authorities to increase staff numbers to fast track administrative processes;	EU/MS	Long-term
4.	Avoid unnecessary duplication of work and excessive reporting, while ensuring that all mandatory information is reported in a clear and transparent manner.	EU	Short-term
	Actions - Speeding up the permitting process	Actors	Timeframe
1.	Implement the Critical Raw Materials Act's new rules to accelerate permitting for Strategic Projects;	EU/MS	Short-term
2.	Address permitting bottlenecks in the context of encouraging and facilitating investments in new facilities – mines, processing plants, recycling plants;	MS	Short-term
3.	Ensure that permitting procedures deliver sound environmental and social assessments and that the public concerned is meaningfully involved to ensure the highest public acceptance, including the right to challenge the project's deployment decision.	MS	Long-term
4.	Make better use of digital tools to quicken permitting procedures, as well as encourage public authorities to use additional staff	EU/MS	Medium-term

SUPPORT TO RESEARCH & INNOVATION, PRODUCTION TECHNIQUES AND TECHNOLOGICAL SOLUTIONS

The transition of the European steel industry relies on the roll-out of new and existing technologies, techniques and production processes. Non-ferrous sectors will abate most of their emissions through the ongoing decarbonisation of the electricity grid, while new technologies will be required at a later stage to abate residual emissions. Ensuring sufficient funding to research, development and innovation (R&D&I) at all Technology Readiness Levels (TRLs) is fundamental in order to sustain the metals industries' transition process. It is also important to focus on scaling up demo and pilot projects to accelerate the future deployment of specific innovative technologies. Particular attention will need to be paid to aligning EU funding programmes with the R&I needs of the mining and metals industries. The current situation of R&D&I for the ERA Roadmap low-carbon technologies[10] in metals sectors is not ideal as the EU ranks in third position among the main seven world regions.

The table below summarises actions proposed by stakeholders on support to R&I, production techniques and technological solutions (for detailed recommendations see the 'Support to R&I, production techniques and technological solutions' building block, pages 59-60):

[10]https://research-and-innovation.ec.europa.eu/research-area/industrial-research-and-innovation/era-industrial-technology-roadmaps_en

	Actions - Support to R&I, production techniques and technological solutions	Actors	Timeframe
1.	Publish and implement metals industry technology roadmaps for decarbonisation and increased circularity;	Industry	Short-term
2.	Take note of the call by the stakeholders to adjust the safe and sustainable by design framework to be 'safer and more sustainable by design' and more easily applicable to metals so that the full life cycle of chemicals and materials is adequately covered;	EU	Short-term
3.	Co-implement the Strategic Research and Innovation Plan[11], Strategic Materials Agenda[12] and Strategic Research and Innovation Agenda[13] of the European Technology Platform on Sustainable Mineral Resources to guide future R&I priorities;	EU/MS/ Industry	Medium-term
4.	Support the development, commercialisation, deployment and uptake (including through 'market pull' and pre-commercial procurement) of new techniques and technological solutions.	EU/MS/ Industry	Medium-term

INVESTMENTS AND FUNDING

The net-zero transition requires substantial investments in low- and near-zero carbon technologies across all industries. Both public and private investments are necessary to support this transition. Given the long asset life and long-term investment timeframe in the sector, a stable and supportive policy environment is cited as key to incentivising investments with predictability and certainty. High capital costs are likely to be combined with significantly higher operating costs for low- and near-zero carbon production processes and renewable and fossil-free energy. Public intervention can be an efficient way to de-risk investment and is an essential complementary tool when market incentives and regulation are not sufficient to drive investments. Private investors are ready to play their part in the twin transition, recognising that the mining and metals sectors are pivotal to the net-zero transition. For steel and aluminium, the EU Taxonomy lays down a common language that helps the financial sector identify sustainable economic activities and channel investments, by specifying which economic activities can be considered as environmentally sustainable.

The table below summarises actions proposed by stakeholders on investments and funding (for detailed recommendations see the 'Investments and Funding' building block, pages 62-66):

	Actions - Investments and Funding	Actors	Timeframe
1.	Continue funding and consider increase of funding at EU level of related R&I programmes and activities, prolong the Clean Steel Partnership under Horizon Europe, increase, as relevant, funding for commercialisation-focused programmes, support the Co-funded Partnership on Raw Materials, and take into account the needs for funding in the next Multi-annual Financial Framework, including the next Framework Programme for Research and Innovation (FP10) and in other relevant initiatives, and by Member States and regions;	EU/MS	Short-term

[11] https://op.europa.eu/en/publication-detail/-/publication/9f04603f-534b-11ed-92ed-01aa75ed71a1/

[12] https://www.ami2030.eu/wp-content/uploads/2023/04/Ami2030-Dossier-2.pdf

[13] https://www.etpsmr.org/?post_documents=etp-smr-strategic-research-and-innovation-agenda-2023

2.	Consider providing financial support for retrofits and transformation aimed at effective and innovative low and near zero carbon technologies, sustainable solutions and products;	EU/MS/ Industry	Short-term
3.	Reduce the administrative burden (at EU and national level) and improve coordination to facilitate access to effective funding for industry;	EU/MS	Short-term
4.	Encourage simplification and consolidate mechanisms, platforms and schemes to reduce complexity and lower barriers for industrial players to engage in and benefit from EU initiatives;	EU/MS	Medium-term
5.	Improve the alignment of objectives along entire value chains, e.g. put together cross-sector working groups on how material efficiency can be significantly improved;	Industry	Medium-term
6.	Ensure that the EU's sustainable finance agenda recognises Europe's metals production as an essential part of supplying the energy transition and EU climate neutrality goals;	EU/ Industry	Short-term
7.	Develop robust and workable criteria for mining and refining for both 'substantial contribution' and 'do no significant harm', in line with the objectives of the Critical Raw Materials Act and the integrity of the taxonomy;	EU/ Industry	Short-/ Medium-term

ACCESS TO PRIMARY AND SECONDARY RAW MATERIALS

Some metals production must come from virgin metal ores. It is very important that the metals industry has access to **primary raw materials** produced by responsible mining and refining. The EU is very dependent on other regions for primary non-ferrous metals supply, as well as for other critical raw materials such as those used for stainless steel production. The EU has a strong ambition to reduce long-term metal dependency and has set objectives to increase its domestic mining, processing and recycling capacity for strategic raw materials.

The **circular economy** is an approach targeting the closure of materials loops and their return to the market. Resource efficiency is one underlying concept; proper ecodesign of products by manufacturers can contribute significantly to this. While the EU circular economy for metals faces several challenges, their circularity could be greatly boosted by overcoming bottlenecks in collection, sorting and recycling systems for all existing and emerging metals waste streams. For some non-ferrous metals, however, additional action will be needed, in particular to meet the EU's recycling targets and thereby reduce dependencies from third countries. In some cases, such as treating clean energy technologies waste, Europe will need to launch and scale up completely new recycling processes and capacity.

Recycling end-of-life products is an important driver for supply in established metals markets. Recovered extractive waste can also contain valuable amounts of critical raw materials. Alongside the provisions of the Extractive Waste Directive, the Commission has integrated complementary provisions on mining waste into the Critical Raw Materials Act. Metal scrap is fundamental for obtaining **secondary raw materials** to produce non-fossil fuel-based metals. The future availability and accessibility of scrap will be a vital issue for the metals industry in the coming decade, including for its decarbonisation. Increasing leakage of metal scrap and metal-containing waste from the EU (trade flows and illegal activities) represents a loss of economic opportunities and value for the EU waste treatment and metals industries and could hinder their transition. The EU has set as one of its objectives not to export its waste challenges to non-EU countries. The newly announced initiative, Circular Economy Act, will contribute to creating market demand for secondary materials and a single market for waste. In parallel, the

issue of scrap availability has been raised by several stakeholders. During this hearing EVP Séjourné mentioned that scrap could be considered a real raw material in itself.

The table below summarises actions proposed by stakeholders on access to primary and secondary raw materials (for detailed recommendations see the 'Access to primary and secondary raw materials' building block, pages 68-74):

	Actions – Primary raw materials	Actors	Timeframe
1.	Rigorously work towards achieving the Critical Raw Materials Act's 2030 production benchmarks and catalyse action in key areas necessary for achieving them;	EU/MS/ Industry	Short-term
2.	Implement the Critical Raw Materials Act's new rules to accelerate permitting for strategic projects at the Member State level;	EU/MS	Short-term
3.	Continue implementing strategic partnerships with raw materials-rich countries to secure resources for downstream industries where the domestic primary raw material supply will not be sufficient, while acknowledging their right to use resources for their own transition and their aspiration to move up the supply chains.	EU	Long-term
	Actions – Circular economy	Actors	Timeframe
1.	Further develop EU waste collection, the sorting and recycling industry and infrastructure by making it more economically viable in order to secure supply, strategic autonomy and competitiveness, and support the transition;	EU/MS/ Industry	Short-term
2.	Consider developing the pan-EU digital system to electronically exchange data on waste shipments, thereby reducing the administrative burden when obtaining consent to ship waste and improving the monitoring of waste flows (quantities, destinations);	EU/MS	Short-term
3.	Assess the need to include new European waste codes for growing waste streams of significant importance and volume e.g., battery black mass;	EU	Short-term
4	Undertake more thorough waste management in the recycling industry to avoid tramp elements entering metals production through the waste input;	Industry	Short-term
5.	Increase the EU metal recycling sector's access to metal waste by removing barriers to intra-EU waste shipments;	EU/MS	Short-term
6.	Improve eco-designing of products enabling reuse, repair and refurbishment to extend lifetime.	Industry	Short-term

INFRASTRUCTURE

A successful transition of the ferrous and non-ferrous industries can only be possible with the development of the necessary infrastructure at national and cross-border levels.

For actions on energy infrastructure see the section and building block 'Sustainable competitiveness', the table below summarises actions proposed by stakeholders on other infrastructure (for detailed recommendations see building block 'Infrastructure' pages 76-78):

	Actions - Infrastructure	Actors	Timeframe

1.	In line with the Communication on industrial carbon management[14], acknowledge and further support the role of CCU/CCS in sectors with hard-to-abate emissions in the absence of other solutions (actions envisaged in the Communication should be rolled out across various EU policies to ensure regulatory consistency);	EU	Medium-term
2.	Explore the possibilities to accelerate approval procedures for new CCS/CCU infrastructure projects;	EU/MS/ Industry	Medium-term
3.	Deploy safe, high-speed and reliable digital infrastructure;	Industry	Short-term
4.	Deploy technologies to improve mining and metals-manufacturing processes and data gathering, and apply learnings from other industry sectors.	Industry	Medium-term
5.	Continue to use the Innovation Fund to support the deployment and upscaling of direct and indirect electrification, CCS and CCU technologies and infrastructure, for hard-to-abate process emissions, with the aim of capturing, transporting and storing CO2 emissions;	EU	Short-/ Medium-/ Long-term

SKILLS

The transition of the metals industry cannot take place without developing the skills of its workforce, including those of workers in the mining sectors and other parts of the value chains. The 'EIT RawMaterials' Knowledge and Innovation Community, funded under the European Institute of Innovation and Technology (EIT), is addressing the need for education programmes in the field of raw materials. Social dialogue is the right instrument for planning job-to-job transitions, complemented by transition strategies for such transitions, including reskilling and upskilling programmes and workers' job transfer plans. A major barrier for attracting future workers is the negative public perception of the industry, which needs to be addressed.

The table below summarises actions proposed by stakeholders on skills (for detailed recommendations see the (for detailed recommendations see the 'Skills' building block, page 80-81):

	Actions - Skills	Actors	Timeframe
1.	Assess the need to establish a centralized EU observatory for monitoring metals industry skills needs;	EU/MS/ Industry	Medium-term
2.	Expand on-the-job training opportunities, recognizing that workers of the future must engage in lifelong learning;	Industry	Short-term
3.	Address the metals sectors image challenge by highlighting the vital role of metals in modern society and contribution to circular economy;	EU/MS/ Industry	Short-term
4.	Emphasize industry's commitment to health and safety;	Industry	Short-term
5.	Promote metallurgy and stem careers in educational institutions, encourage students to pursue careers in	EU/MS/ Industry	Short-term

[14] COM/2024/62 final, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM%3A2024%3A62%3AFIN

metallurgy and studies in the areas of science, technology, engineering and maths (STEM), particularly in primary and high schools. Existing government and civil-society initiatives to support young people's and women's engagement in STEM subjects should be leveraged;

SOCIAL DIMENSION

The European Green Deal emphasizes importance of addressing the social impact of the twin transition, including supporting those regions, industries, workers, households and consumers that will face the greatest challenges. A major precondition for realising the twin transition of metals sectors is securing the understanding and support of the general population. This includes in communities where initiatives are planned, that would help this ecosystem to become green, digital and resilient. This requires appropriate anticipation of change and socially responsible restructuring where necessary. Social dialogue is vital to the sustainability and success of the metals sectors. At the same time, 'due diligence' is becoming a differentiating factor in customers' choices for metals products; in this context, the EU metals sectors are working hard on improving its environmental, social and governance (ESG) performance. Further efforts to promote diversity and gender equality, to combat the barriers to career progression for women will be necessary to increase the proportion of women in the sector.

The table below summarises actions proposed by stakeholders on social dimension (for detailed recommendations see the (for detailed recommendations see the 'Social dimension' building block, page 83-85):

	Actions - Social dimension	Actors	Timeframe
1.	Consider setting up local just transition working groups in metal regions in EU Member States to prepare for and support the twin transition of the metals sectors' value chains;	MS	Short-term
2.	Take into account voluntary certification schemes that are in place already when developing due-diligence policies;	EU/MS	Short-term
3.	Leverage internationally recognised standards and instruments, aim for due-diligence policies to align with internationally recognised standards (such as the UN Guiding Principles and OECD guidance) to promote coherence and to avoid duplication of work;	EU	Short-term
4.	Utilize old and new technologies (including advanced digital approaches) to provide job opportunities for individuals of all ages, and both for men and women;	Industry	Medium-term
5.	Take steps to address age imbalance and ensure that valuable knowledge is not lost and is appropriately transferred to younger generations of workers.	Industry	Medium-term

IMPLEMENTING THE TRANSITION PATHWAY

The co-creation of the Transition Pathway for the European Metals Sectors must be followed by an efficient co-implementation process. This will be based on the principles of inclusiveness, transparency and openness to all stakeholders in the metals value chain. Stakeholder participation will include Member States, industrial actors, trade unions, civil society, think thanks, academia and research institutes.

Given the complexity of the tasks envisaged for the implementation of the ‘Transition Pathways for the European Metals Sectors’ a Commission expert group is thought to be an appropriate organisation and governance structure.

Stakeholders suggest that specific chapters of the ‘Transition Pathways for Metals’ should be discussed by stakeholders, while also inviting relevant departments of the Commission. Stakeholders also suggest that a high-level political transition dialogue could take place (similar to the approach in the Transition Pathway for Construction) to take stock of the implementation.

Coordination with other European institutions would increase synergies and improve implementation of the pathways.

I. INTRODUCTION

In its updated 2021 industrial strategy, the Commission proposed a series of transition pathways to be developed jointly with EU Member States, industry and other stakeholders. These pathways identify the actions needed to achieve the twin green and digital transition, while giving a better understanding of the challenges, scale, benefits and conditions required. This transition will also strengthen the resilience of an industry heavily affected by the Russian war of aggression against Ukraine and can contribute to achieving the goals of the Critical Raw Materials Act.

In the summer of 2023, the Commission launched the 'co-creation' process for the transition pathway for the European metals industry. The process involves EU Member States, the ferrous and non-ferrous metals industries, social partners, NGOs and academia. In September 2023, a sub-group of the High-Level Group on Energy-intensive Industries was created to help with this 'co-creation'.

The metals sectors are typically considered as two interlinked subsectors – ferrous and non-ferrous.

Ferrous metals are metals that contain iron as the primary element. The ferrous sector is characterised by very high volumes, high recycling rates, relatively few product families (carbon steels, high-alloy steels, stainless steels, cast or forged irons) but thousands of types and grades, and a few very high-volume uses e.g. construction and automotive. The sector is energy intensive – particularly the integrated process (i.e. blast furnace + basic oxygen furnace) for steel production – and both electricity and fossil fuels are used. Traditionally, coal-based carbon is used as a reducing agent to produce iron from ore. However, the sector is in transition to replace this fossil carbon by less CO_2-intensive agents like natural gas and hydrogen. A large portion of steel production (approximately 45%) is already based on the remelting of scrap in electric arc furnaces. This, however, is limited by the availability of ferrous scrap. Many ferrous alloys contain non-ferrous metals as indispensable alloying elements giving the desired properties like strength, ductility and fatigue- or corrosion-resistance (e.g. stainless steels containing chromium, nickel, molybdenum).

Non-ferrous metals are metals or alloys that do not contain iron in appreciable amounts. The sector is diverse, with high volumes for base metals (e.g. aluminium, copper, nickel, zinc, lead) and lower/very low volumes for speciality/technology metals (e.g. cobalt, lithium, rare earth elements - REEs) and precious metals (e.g. silver, gold, platinum group metals). Recycling rates are high for base metals and variable for technology metals, depending on the metal and its main uses. Precious metals have high recycling rates overall, driven by their very high value. There are many non-ferrous product families. Both metals and metal compounds are important and they have many diverse uses. The non-ferrous metals industry is electricity hyper-intensive, with almost fully electrified production processes. Large amounts of electricity are used for primary and secondary production, especially for metals like aluminium, zinc and silicon.

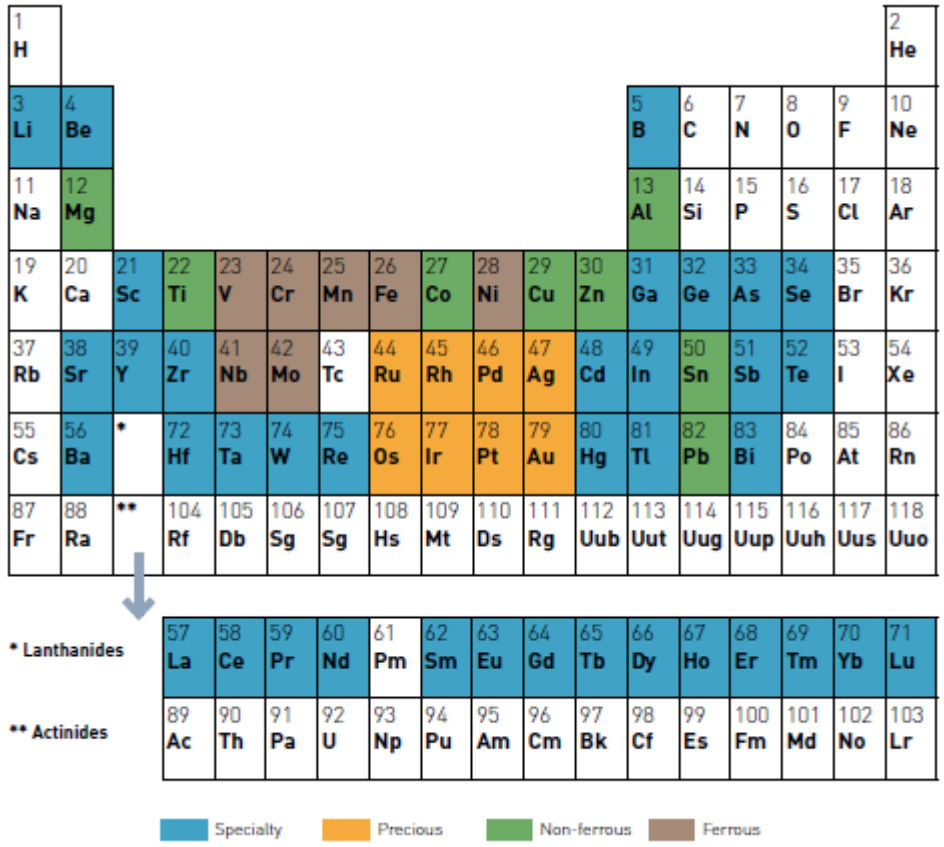

Figure – The major metal groupings addressed in this pathway. *Source: UNEP (2011) Recycling Rates of Metals – A Status Report, A Report of the Working Group on the Global Metal Flows to the International Resource Panel,* Graedel, T.E., Allwood, J., Birat, J.-P., Reck, B.K., Sibley, S.F., Sonnerman, G., Buckert, M., Hagelüken, C.

The metals sectors have a strategic role to play at the heart of decarbonising and digitalising the European economy and in the EU's objective to establish itself as a global cleantech leader.

The metals industry is the largest industrial emitter of carbon dioxide in the EU, representing 8.1% of total EU emissions in the EU in 2022[15]. The EU will not meet its climate targets unless the metals sectors decarbonise. In addition, metals are fundamental components and enablers of the green and digital transition in numerous key downstream industrial ecosystems such as mobility and construction. Metals will be required in growing volumes in order to achieve Europe's manufacturing goals for batteries, wind turbines, solar panels, hydrogen technologies and grid infrastructure. Metals are also important for aerospace, defence, future innovation, digitalisation and artificial intelligence.

Without healthy metals sectors, the EU will never achieve open strategic autonomy with a resilient economy. Instead, it will face economic security concerns[16] caused by over-reliance on a limited number of regions for key feedstocks, technologies and materials. Many metals

[15] Source – Eurostat, includes mining, manufacture of basic metals and metals processing.

[16] State of the Union Address by President von der Leyen (europa.eu) – reference to China's export restrictions on gallium and germanium, which are essential for goods like semiconductors and solar panels.

are now defined as ‘strategic’ and/or ‘critical’ by the Commission[17], due to a combination of their high economic importance and sourcing/supply considerations.

The EU and global metals industry

The 2023 annual production of crude steel in EU (the EU-27 countries, covering over 500 production sites) was 126 million tonnes (average 2010-2022: 154 million tonnes), or 6.7% of global steel production. The steel sector employs 304 000 people directly and is responsible for up to 2.1 million indirect jobs. The sector is worth EUR 251 billion in gross value added to the EU economy every year[18]. For non-ferrous metals, annual EU production, covering over 900 production sites, was 47 million tonnes, around 20% of global production. The non-ferrous sector employs 500 000 people directly and covers 3 million indirect jobs. Its annual turnover is EUR 120 billion[19].

Primary production in the ferrous and non-ferrous metals sectors comes mainly from medium-sized and large companies, many of which are multinational. Small and medium-sized enterprises (SMEs) are much more present in downstream transformation into materials and products and in the secondary recycling value chain.

In the short to medium term, there will be a sharp increase in demand for many metals, driven primarily by the twin transition under the Green Deal. Demand will not only increase in the EU, but globally - meaning that the EU will have to compete to secure access to those materials in the whole value chain. Global steel demand is expected to grow from just under 2 billion tonnes in 2021 to 2.6 billion tonnes in 2050. Global demand for base metals like aluminium and copper is expected to almost double in the same period, while battery metals, rare earth elements and other technology metals face steep increases of up to 500% according to the World Bank[20].

[17] Critical Raw Materials Act (europa.eu).

[18] Learn about steel (eurofer.eu).

[19] Key Industry Data (eurometaux.eu).

[20] Arrobas,Daniele La Porta; Hund,Kirsten Lori; Mccormick,Michael Stephen; Ningthoujam,Jagabanta; Drexhage,John Richard. *The Growing Role of Minerals and Metals for a Low Carbon Future* (English), Washington, D.C., World Bank Group. http://documents.worldbank.org/curated/en/207371500386458722/The-Growing-Role-of-Minerals-and-Metals-for-a-Low-Carbon-Future

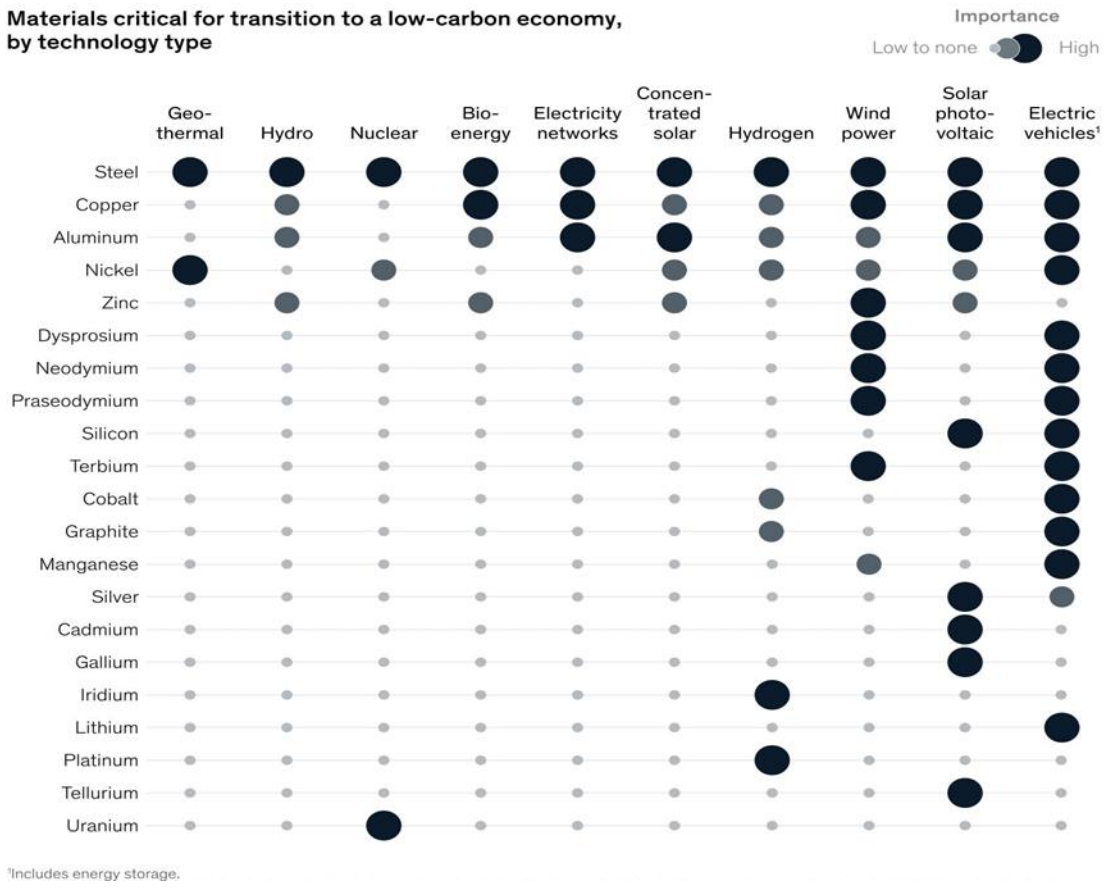

Figure – Materials critical for transition to a low-carbon economy, by technology type. McKinsey & Company, *Source: Critical raw materials for strategic technologies and sectors in the EU, a foresight study*, European Commission, 9 March 2020*; The role of critical minerals in clean energy transitions*, IEA, May 2021; McKinsey analysis

Today, Europe has an established production base for steel, base metals (aluminium, copper, nickel, zinc, lead), precious metals, silicon and ferroalloys. The Critical Raw Materials Act has set 2030 goals for building up new EU mining, processing and recycling capacity for battery materials (lithium, graphite, cobalt, etc.), rare earth elements and other critical raw materials. Under these targets, 10% of needs would be supplied from domestic mining and 40% from domestic processing. At the same time, the sector is threatened by the ongoing energy crisis, which in 2023 had taken 50% of the EU's aluminium and zinc capacity, and 40% of silicon capacity, offline.

Other countries are already gearing up to grow their local metals supply chains or have already done so. The US Inflation Reduction Act has made large subsidies available for new critical metals investment projects, or for the decarbonisation of existing steel and metals production. China has long viewed its metals sectors as strategic, achieving a dominant global position for most metals after sustained governmental support[21]. Other countries, from Canada to South Korea and Australia, have also launched national strategies.

The metals sectors in the EU have an opportunity and a willingness to grow and create new jobs, depending on their ability to stay competitive and attract investments. The sectors also

[21] https://www.reuters.com/technology/china-launch-new-40-bln-state-fund-boost-chip-industry-sources-say-2023-09-05/

recognise that competing with other sectors for skilled workers will require a change in its public perception and image in society.

The metals sectors are working hard on improving its environmental, social and governance (ESG) performance. This includes responsible sourcing and due diligence to address global supply chain concerns ranging from child labour to environmental pollution. Strengthening sustainable and responsible sourcing of minerals and metals throughout global value chains can play an important role in ensuring that the materials needed for Europe's twin transition are sourced responsibly and ethically, reducing the social and environmental risks in certain areas of global metals and minerals supply.

Further information on metals, their use and the role of further electrification is available in the Annex 1.

The metals supply chain

In simple terms, the metals supply chain can be considered as four different 'life cycle' stages.

1. Raw materials production, through – (i) mining, extraction and separation/concentration of ores, production of primary (new) metal and alloys via various mineralogical and metallurgical processes; and (ii) production of secondary (recycled) metal and alloys via various metallurgical processes.
2. Product design and manufacture – design and manufacture of products using primary and/or secondary metals and alloys. Product design should maximise disassembling opportunities and maximise the amount of materials that can be recovered or reused.
3. Use – products are used to deliver services e.g. decarbonisation, power transmission, durability.
4. End-of-life/recycling/reusing – recovery and sorting of metallic materials from discarded products that are no longer in use, to produce metal/metal compound streams suitable for reuse, including dedicated streams for alloys. When possible, the reuse of discarded products should be considered for similar uses (e.g. steel products in buildings).

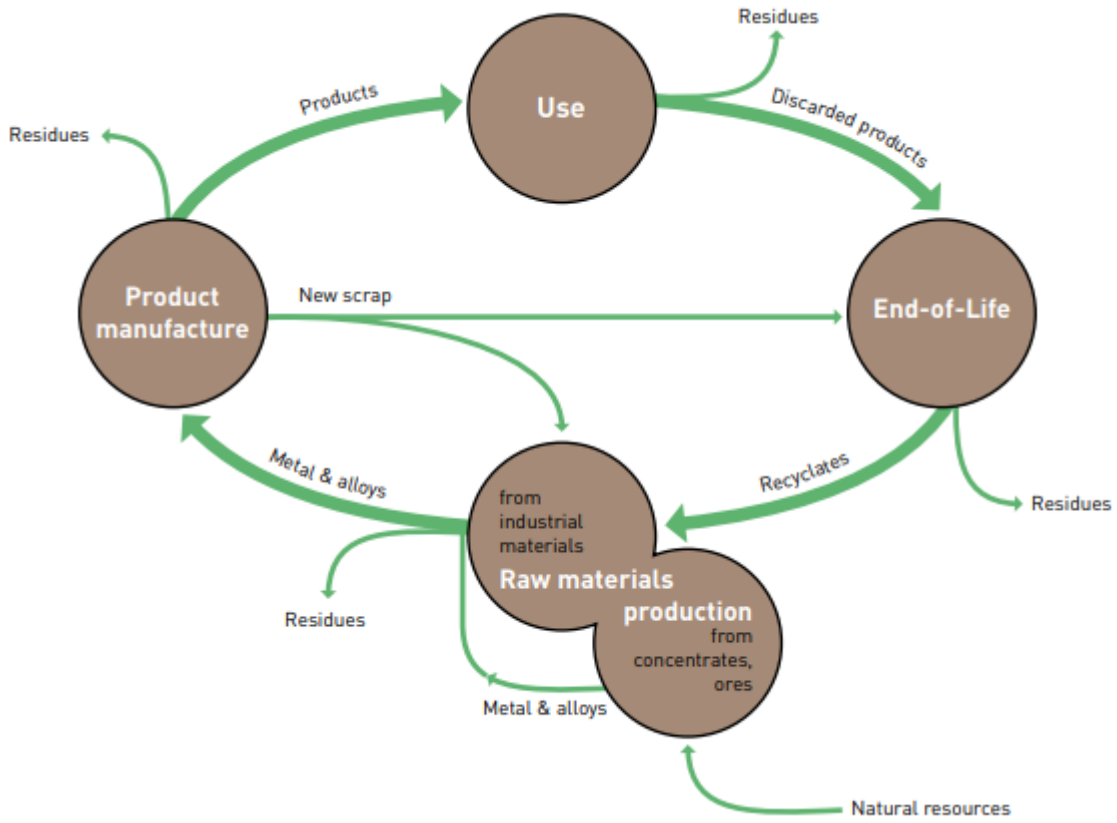

Figure - The life cycle of a metal, consisting of four stages. Recyclates are those materials capable of re-entering use after reprocessing. *Source: UNEP (2011) Recycling Rates of Metals – A Status Report, A Report of the Working Group on the Global Metal Flows to the International Resource Panel,* Graedel, T.E., Allwood, J., Birat, J.-P., Reck, B.K., Sibley, S.F., Sonnerman, G., Buckert, M., Hagelüken, C.

Importantly, interdependencies between metals exist in all life cycle stages – metals are almost always mined/produced/used/recycled in combination with other metals. For example, metals rarely occur in nature on their own and are typically mined from ore bodies together with other metals, giving a 'main' metal product and one or more 'by-product' metals which can have significant economic value. In use, metals are often in alloy form, combined with other metals in materials and products. This has implications for recycling at end of life as it is very complex and sometimes impossible to recover the metal as such when embedded with another metal matrix. In such cases the recovery occurs in the alloy form (scraps). The use or non-use of one metal typically has consequences for several others e.g. lead is also used in processes to recycle several other metals.

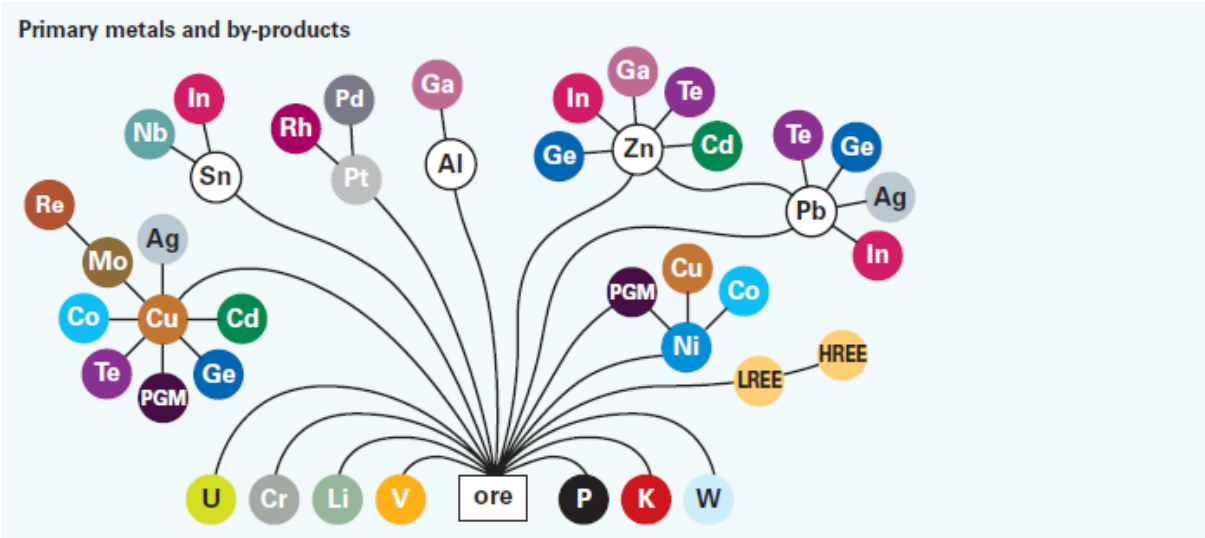

Figure – Schematic representation of the routes from ore to elements, indicating primary versus those produced as co- or by-products. *Source: Zepf V. et al., BP (2014): Materials critical to the energy industry. An introduction. 2nd edition.*

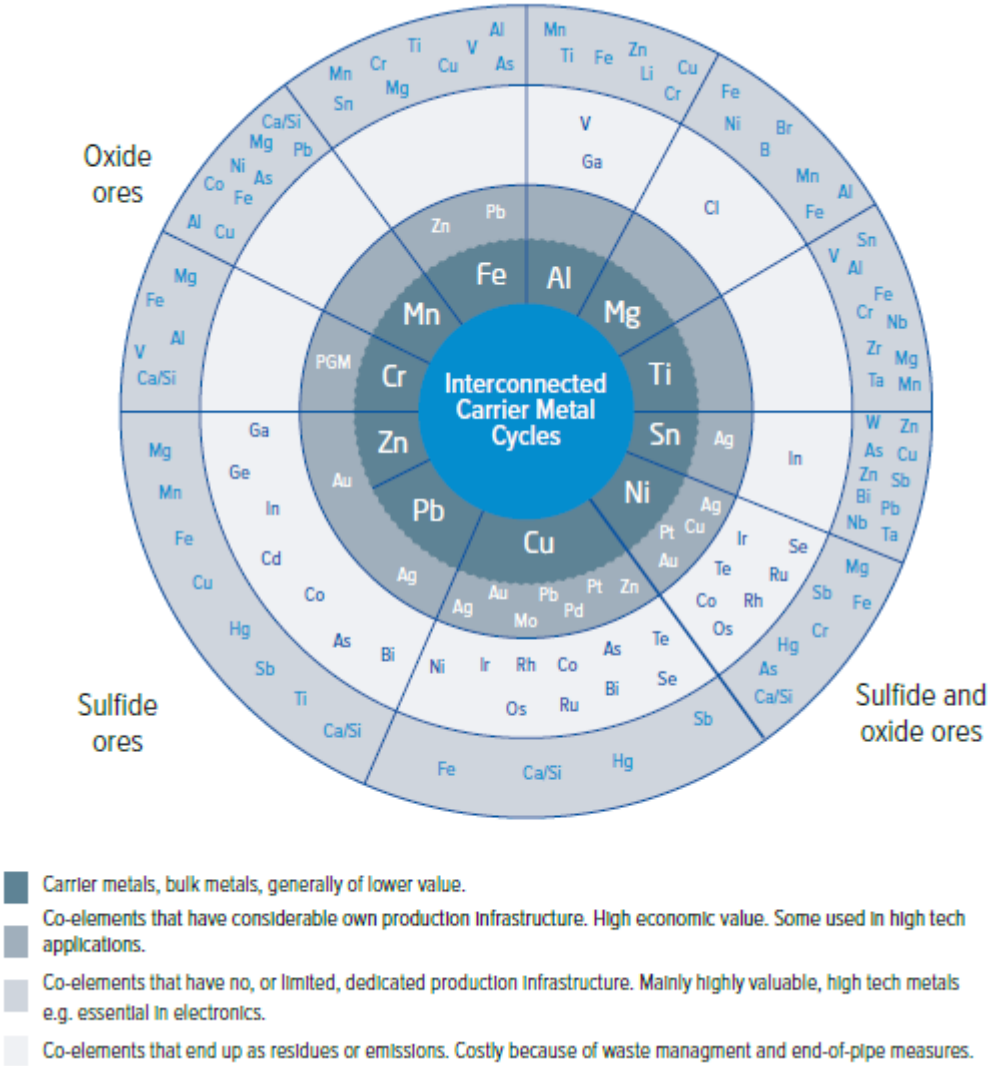

Figure - The UNEP 'metals wheel' showing metals sector interlinkages. *Source: UNEP (2013) Metal Recycling: Opportunities, Limits, Infrastructure, A Report of the Working Group on the Global Metal Flows to the International Resource Panel,* Reuter, M. A., Hudson, C., van Schaik, A., Heiskanen, K., Meskers, C., Hagelüken, C.

Most of the metals mined to date are still in use today in pure or alloyed form, in the anthropogenic material stock (above ground stock) – this is the stock of metals in society resulting from human activity[22]. This stock is a large and valuable resource and represents a huge investment by mankind in terms of cost and energy[23]. The stock and flows concept for metals is helpful in understanding how metals should be produced, used, reused, reduced and recycled in the EU in the long term. Many uses of metals are, by design, of very long duration (e.g. several decades), in long lifetime products. In the EU context, the anthropogenic stock takes several forms, some of which are impacted by import/export flows across EU borders.

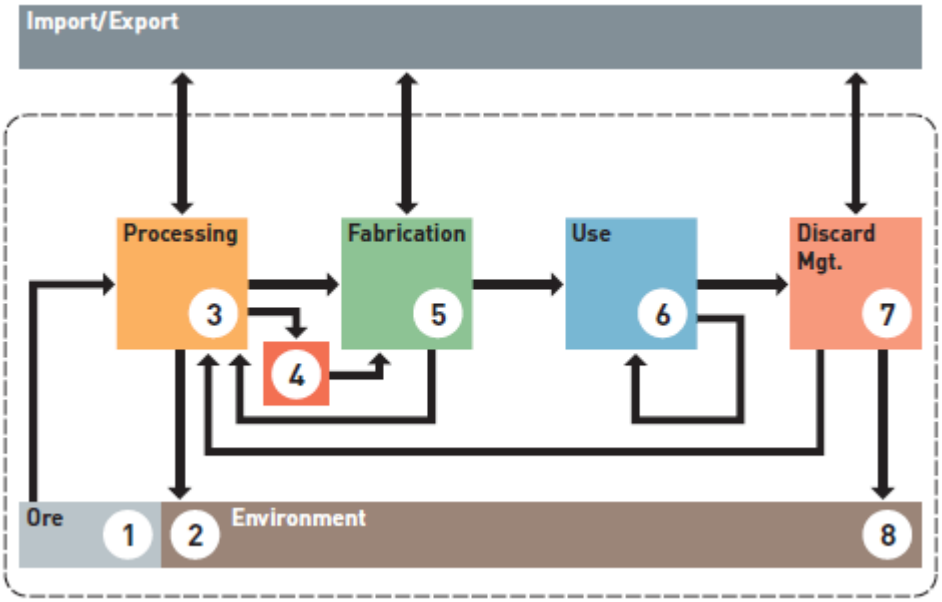

Figure – The generic life cycle of a metal, with stock locations indicated: 1. virgin ore bodies; 2. mine waste; 3. processor stockpiles; 4. government stockpiles; 5. manufacturer stockpiles; 6. in-use stock; 7. recycler stockpiles; 8. landfill. *UNEP (2010) Metal Stocks in Society – Scientific Synthesis.*

Despite the size, availability and recyclability of the metals stocks, mining and primary production will still be needed for the foreseeable future for several reasons. First, in a scenario where metals demand is flat or increasing and where there is a long 'lag' between metals entering use and then becoming available for recycling (due to longevity of use), demand for new metal can never be fully met by recycling even when collection rates for metals at 'end of life' are very high (e.g. >90%). Even though by 2050 end-of-life scrap's share in total steel and aluminium production will have increased significantly, it will only account for around 44%[24] of global steel production and about 55% of global aluminium production[25]. This is a challenge not only for steel and aluminium but for all metals. Another good example of this is platinum

[22] https://www.eea.europa.eu/en/circularity/thematic-metrics/materialsandwaste/anthropogenic-material-stock-growth

[23] Interrelation of resource stock, material stock and product cycles. Source: *Eco-Efficiency and Materials: Foundation Paper*, Five Winds International for International Council on Metals and the Environment, April 2001.

[24] https://www.weforum.org/stories/2023/01/davos23-steel-scrap-decarbonization/?utm_source=chatgpt.com

[25] Mission Possible Partnership, 'Making Net-Zero 1.5°C-Aligned Aluminium Possible', https://international-aluminium.org/resource/mpp-and-iai-release-ambitious-decarbonisation-aluminium-sector/.

group metals (PGMs) in automotive catalysts. Here, recovery rates for PGMs are very high[26] due to the metals' value, and there is a 30-year gap between first use and metal becoming available for recycling. Second, there is room for improvement in the design of materials and products for recycling, and in the collection and sorting of metals at end of life. There are many good reasons for investing in all these technologies – not only where recovery rates are low e.g. for rare earth metals in magnets. Improvements will take time to realise and there are always likely to be some losses from the metals stock in the production, use and recycling of products and materials. Consequently, careful and responsible mining and primary production will be needed to feed the metals stocks until the amount of material becoming available for recycling is at least as great as the annual demand for new metal (which in practice will be long after 2050)[27].

The metals industry's 2050 transition

Climate neutrality: The metals industry is the largest industrial emitter of carbon dioxide in the EU. Carbon intensity has been reduced significantly in recent decades, with continual efficiency improvements, more recycling and greater electrification, but the metals industry continues to face challenges in curbing scope 1 + 2 + 3 emissions. The sector has also invested in continual improvement of production performance to prevent, control and reduce pollution of the environment; the aim being to achieve a relative decoupling of resource efficiency. The 2030 and 2050 legally binding EU climate targets and the EU's zero-pollution ambition represent the next important steps for the metals industry's emission-reduction efforts, as part of the climate and environmental component of the Green Deal. The EU climate legislation – especially the EU emissions trading system as revised in the context of the Fit for 55 package – will dramatically accelerate structural change in the sector.

There is a theoretical (but realistic) potential for the non-ferrous metals subsector to reduce its greenhouse gas emissions by more than 90% compared to 1990 levels[28]. The most important mitigation will come from decarbonising 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 in the non-ferrous metals subsector's emissions compared with 1990 levels. For the non-ferrous metals subsector's remaining emissions, there are a wide range of technological options with major potential for achieving greenhouse gas reductions in line with the target of climate neutrality by 2050.

In Europe, steel is produced through two production routes. The primary route consists of first extracting iron from iron ores (compounds of iron and oxygen) in blast furnaces and then processing this iron into steel in converters (basic oxygen furnaces). The secondary route consists of melting steel scrap in an electric arc furnace, using electricity. This makes the secondary route less energy intensive and thus less CO_2 intensive than the primary route, which requires fossil energy carriers (coal, natural gas) to be used as energy source or reducing agent, whilst for the secondary route, most of the CO_2 emissions stem from the electricity used. Hence, for the secondary route, decarbonising the EU power grid is an important means of reducing CO_2 emissions. For stainless steel already produced in electric arc furnaces using scrap, the relative impact of scope 3 emissions, such as the contribution of some ferroalloys (FeNi and FeCr) is gaining importance. Maximising the input of stainless

[26] Johnson Matthey platinum group metal (PGM) virtual conference 2023 – 'Platinum group metals: critical to the future of sustainable technologies?' Session 1 – The global impact of changes in PGM supply and demand, 18 July 2023.

[27] KU Leuven, 'Metals for Clean Energy', https://www.eurometaux.eu/media/jmxf2qm0/metals-for-clean-energy.pdf.

[28] *Metals for a Climate Neutral Europe: a 2050 Blueprint*, Wyns, T., Khandekar, G., The Institute for European Studies (IES) at the Vrije Universiteit Brussel (VUB), October 2019.

scrap and lower carbon footprint raw materials like ferroalloys is sought to reduce scope 3 emissions. It is also important to deploy dedicated reuse and recycling streams.

For incremental or deep reduction of CO_2 emissions in the EU steel sector[29], three technological pathways are being pursued. The **first pathway** (incremental emissions reduction), known as 'smart carbon usage', consists in reducing the use of fossil carbon and thus reducing CO_2 emissions. This is achieved via:

- process integration, which looks at changes to existing ironmaking/steelmaking processes based on fossil energy carriers (through shortening of processes, reuse of process heat, etc.); or
- carbon capture and storage, which will play an important role in further reducing residual CO_2 emissions.

The **second pathway** (deep emissions reduction), known as 'carbon direct avoidance', consists in avoiding the use of fossil carbon. This is achieved via direct use of low-CO_2 electricity (such as in the electric arc furnace route or downstream processes) or hydrogen instead of fossil carbon, especially as the main reduction agent or energy provider (such as in 'Direct reduced iron (DRI) reactors).

The **third pathway** is the circular economy. This consists of circular economy approaches aimed at: (i) enhancing the design of products that use steel to ease their disassembly and limit contamination (particularly copper contamination); (ii) steel recycling and the reuse of steel by-products (such as certain slag); (iii) direct reuse of steel products when feasible; and (iv) further increasing energy and resource efficiencies .

Zero pollution: The metals sectors in Europe supports the implementation of EU legislation towards zero pollution complying with among others - the Industrial Emissions Directive[30] (deploying best available techniques), air/soil/water quality standards, the REACH[31] and CLP Regulation[32] (classification, labelling and packaging of substances and mixtures) Regulations, Extractive Waste Directive[33] and downstream legislation such as the RoHS[34] (restriction of hazardous substances in electronics) Directive and the Batteries Regulation[35].

Many metals and metal compounds are hazardous and most of them are classified under the CLP Regulation, which contributes to ensure safer use through efficient risk management. Most of the metals are used in alloy form, in which the metal is embedded in a matrix form, which significantly reduces releases into the surrounding environment (e.g. presence of nickel in stainless steel pipes used for drinking water). Applying a purely hazard-based approach is relevant only for classification. To ensure that chemicals management of metals is not in conflict with other objectives – climate, circularity, critical raw materials (the '4Cs' model) – the correct consideration of exposure and risk is important so that some hazardous substances are still available to meet these objectives and prevent regrettable substitution.

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[29] Material Economics, Steeling Demand: Mobilising buyers to bring net-zero steel to market before 2030. See: https://materialeconomics.com/node/10

[30] Directive (EU) 2024/1785, OJ L, 2024/1785, 15.7.2024

[31] Regulation (EC) No 1907/2006, OJ L 396, 30.12.2006, p. 1–849

[32] Regulation (EC) No 1272/2008, OJ L 353, 31.12.2008, p. 1–1355

[33] Directive 2006/21/EC, OJ L 102, 11.4.2006, p. 15–34

[34] Directive 2011/65/EU, OJ L 174, 1.7.2011, p. 88–110

[35] Regulation (EU) 2023/1542, OJ L 191, 28.7.2023, p. 1–117

Circularity: Metals are inherently circular – they are infinitely recyclable without loss of properties. This is a key feature that sets them apart from other classes of material (organics/plastics/wood/paper). Recycled metal 'scrap' typically requires much less energy to melt than metal from virgin raw materials; scrap metals are a valuable resource which should be managed carefully. The availability of scrap and measures to keep scrap in the EU are key issues, as are investing in developing new recycling processes and optimising existing ones for low-volume critical metals which do not have high recycling rates today. Scrap is the perfect 'almost zero carbon' feedstock for metals and should be viewed as a strategic material. Beyond the pure quantity of recycled metals, it is as important to look at opportunities to reduce quality losses. Many things can be done to reduce these losses, including better design for disassembly, improving collection and sorting, and reducing copper contamination (in the case of steel). The increasing demand for raw materials can also be mitigated by improving the durability of user end products and industrial appliances, by making them modular and proactively countering planned obsolescence.

Digitalisation: This has the power to change the way the metals sectors innovate, source, produce, collaborate across ecosystems and develop new business models. It opens up many new opportunities. This 'fourth industrial revolution' brings a new concept of industry (also called 'Industry 4.0'). This concept is based on advanced digitalisation of production processes and the combination of internet-oriented technologies, enabling smart sensors, machines and IT systems to be connected across the value chain. Implementing these 'cyber-physical' systems can bring a series of benefits, such as productivity increases through the automation of production and decision-making processes, less waste, better equipment utilisation and resource use, and lower costs. However, Industry 4.0 is not only about adopting new technologies. It will also demand organisational changes, specialised knowledge, skills and expertise, and common data sharing standards.

Metals can be better tracked through the supply chain using advanced techniques to deliver benefits in overall sustainability. Digital product passports provide opportunities for greater circularity of metals. Technologies are available to help improve traceability and provenance through the supply chain. This will increase transparency about how metals are produced and sourced and increase trust among stakeholders.

Regional level

Given the metal industry's current territorial concentration, structural change might expose certain European regions to unprecedented social and economic challenges. In addition to cohesion policy, the EU's Just Transition Mechanism and the territorial just transition plans will need to help these regions anticipate and manage the ongoing change. The EU's next multiannual financial framework will need to reflect on how to help these regions to prevent or mitigate the economic changes that will result from the twin transition.

The global context

The EU metals industry is highly integrated in many complex international value chains that are sensitive to sudden developments in geopolitical context. There has been extensive study of trade flows / import dependencies for non-ferrous metals. This is because many metals are not only essential for the twin transition but are also on the critical raw materials list[36].

[36] https://single-market-economy.ec.europa.eu/sectors/raw-materials/areas-specific-interest/critical-raw-materials_en

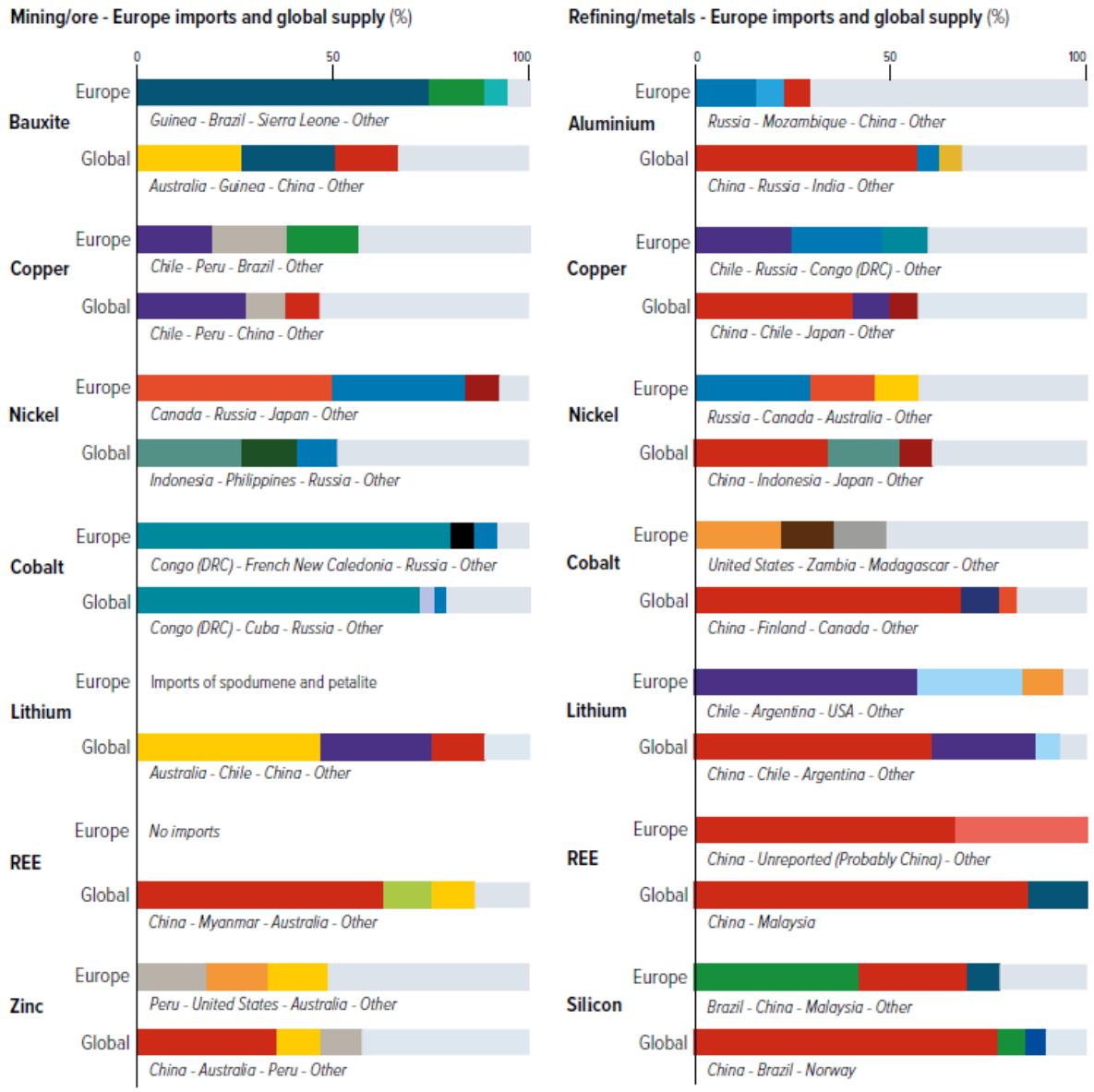


Figure – European imports and global supply for several non-ferrous metals, differentiated between mining/ore and refining/metals.
Note: these numbers do not capture the impact of war in Ukraine and changes in trade flows.
Source: *Metals for Clean Energy: Pathways to solving Europe's raw materials challenge*, KU Leuven, April 2022

Recent headwinds experienced by EU companies include the COVID pandemic, Russia's war of aggression against Ukraine impacting energy markets, and the implementation of the US Inflation Reduction Act, which is already resulting in increased international competition and a shift of certain activities outside the EU. It is challenging for EU producers to compete in their own market against imports and globally due to higher costs (energy, labour, a demanding carbon regulation, environmental regulation, foreign subsidies) and the inability to pass costs on to downstream users without significant loss of market share. Energy costs are particularly important in metals production, with electricity for example comprising 40% of production costs for non-ferrous metals like aluminium, zinc and silicon. The sector is vulnerable to electricity price increases, so that access to electricity at globally competitive prices is vital.

Metals pricing is typically global and transparent e.g. the London Metal Exchange, iron ore price index. This means that high costs cannot be passed on (i.e. non-ferrous metals are price-takers). These challenges have resulted in the sectors' recent shrinkage (the share of EU-27

crude steel production fell from 10.9% in 2011 to 6.7% of global production in 2023[37]), with primary production being taken offline (sometimes permanently) due to import pressures and increased costs. A similar trend can be seen for aluminium, where the regional shrinking of global market share is combined with the global growth of the sector (China, etc.).

There is strong evidence of major State aid intervention and support in metals production outside the EU, in particular in China. A 2018 OECD report[38] concluded that 85% of subsidies in the aluminium sector went to 5 Chinese companies. Such actions have resulted in excess capacities in China for steel, aluminium, silicon and several other metals[39] – while European production has stalled (e.g. over 30% of Europe's primary aluminium production capacity was idle between 2008 and 2021, with an additional cut in 2022 as an effect of the energy crisis). For silicon, the world's current refined silicon output amounts to approximately 3 000 kt, with Chinese overcapacity of 4 000 kt on top of that. This situation results in higher exports of semi-finished and finished products into Europe and depressed global metals prices, which means that European metals producers are unable to compete on a level playing field.

Moreover, at the time when European companies are investing in new, less CO_2-intensive production processes, global excess capacity is growing, driven by mostly carbon-intensive production, further threatening the long-term viability of the EU metals sectors. According to current OECD calculations, a total of around 157 million tonnes of crude steel capacities are currently under construction or in the planning stage between 2024 and 2026. Just under 60% of this capacity expansion will come from CO_2-intensive coal powered blast furnaces, mainly in Asia.

Europe's metals import profile will also need to shift in the next decade to meet its energy transition requirement. Active choices will be required, including sustainability, resilience and security considerations. For example, China is the dominant global refiner of lithium, cobalt, silicon and rare earth elements, and so is positioned to supply more of Europe's growing needs unless the latter diversifies further. Indonesia will provide most of the world's planned nickel capacity expansion by 2030, largely through China-owned operations. Both regions predominantly produce their metals with coal-fired power and a high carbon footprint (although individual producers vary). In addition, this production is sometimes associated with human and social rights concerns, e.g. forced labour in the case of silicon production.

[37] EUROFER, Worldsteel

[38] OECD (2019-01-07), 'Measuring distortions in international markets: the aluminium value chain', *OECD Trade Policy Papers*, No 218, OECD Publishing, Paris. http://dx.doi.org/10.1787/c82911ab-en

[39] SWD(2024)91, on Significant distortions in the economy of the People's Republic of China, link

II. BUILDING BLOCKS

The aim of this chapter is to highlight the actions and developments proposed by stakeholders to accelerate the EU metals industry's green and digital transition while also making the industry resilient. It follows the structure of the blueprint developed by the Industrial Forum Task Force 2[40] on transition pathways, and is based on a building block approach, where each building block covers a key aspect of the twin transition and the desired move to greater resilience[41]. In addition to the seven building blocks defined by the Industrial Forum, stakeholders agreed to also include a building block on "access to primary and secondary raw materials". For each topic listed under the respective building blocks, a list of actions and recommendations has been identified by stakeholders, together with an indicative timeframe for implementation: short-term, medium-term and long-term. Short-term indicates activities that should start as soon as possible; Medium-term indicates activities that should start by 2030; while Long-term activities should be launched and completed by 2050. Each action also mentions the main actor responsible for its implementation, according to the stakeholders participating to the co-development process. 'EU/MS' means that the responsible actor should be either the EU – e.g. via an EU level legislation – or the Member States with a legislative initiative at national level[42]. 'Industry' designates an action that should be coordinated and implemented by industrial actors.

[40] The blueprint matrix including the different building blocks for all ecosystems on transition pathways was developed by the Industrial Forum (Task Force 2 – Support to the development of transition pathways).

[41] The task force identified seven building blocks: sustainable competitiveness; investments and funding; research & innovation (R&I) techniques and technological solutions; regulation and public governance; infrastructure; skills; and the social dimension.

[42] As stated in the disclaimer and legal notice, results of the stakeholder co-creation process presented in this report do not necessarily represent the position of all stakeholder groups nor the position of individual Member States or the Commission.

1. SUSTAINABLE COMPETITIVENESS

This section comprises topics on energy (electricity and infrastructure, hydrogen and infrastructure), carbon pricing, trade and the creation of markets for 'green' products.

The EU metals industry faces unprecedented challenges. The Report by Mario Draghi[43] provides a comprehensive overview of challenges that energy-intensive industries, such as metals industry, are facing at the moment. A thriving metals industry is crucial for the EU's strategic autonomy and resilience. However, over the past decade, the EU has shifted from being a net exporter of metals to a major net importer. This is a concern both for the metals industry and for the thousands of people in the EU who work in these sectors.

On 26th of February 2025, the Commission adopted the Clean Industrial Deal, a plan for EU competitiveness and decarbonisation that outlines concrete actions to turn decarbonisation into a driver of growth for European industries. The Deal presents measures to boost every stage of production, with a focus on energy-intensive industries such as steel, metals, and chemicals, that urgently need support to decarbonise, switch to clean energy, and tackle high costs, unfair global competition, and complex regulations and the clean-tech sector. On the same day the Commission adopted the Affordable Energy Action Plan aiming to speed up the roll-out of clean energy, complete the internal energy market with physical interconnections and use energy more efficiently and cut dependence on imported fossil fuels.

Ensuring a level playing field is key to remaining competitive with producers outside the EU who are not exposed to equivalent energy prices, carbon costs and social and environmental standards. The prices of energy and feedstock have risen significantly. The transition to net-zero metals production will require huge investments and major increases in operational costs, in particular for energy, further diminishing the competitiveness of the industry. It also requires access to very large quantities of decarbonised and globally competitive electricity and renewable and low-carbon hydrogen. In the case of steel, hydrogen can be a more cost-effective alternative to direct electrification or serve as a reducing agent in steelmaking.

Measures to promote circular economy including collecting, sorting and recycling, which are crucial for the metals industry, will positively influence the competitiveness of the European metals industry. This is further elaborated in building block 5, 'Access to primary and secondary raw materials'.

The metals industry is one of the most globalised industrial sectors in the EU and is therefore highly dependent on open and fair trade, in particular of raw materials mined and produced outside the EU. The EU is facing a new global reality and must ensure that it remains competitive during the industry's massive transformation to climate neutrality. As a result, it is essential to develop disruptive thinking and innovative measures to attract investments and support the business case for producing low- and near-zero carbon products in the EU and strengthen its resilience.

Energy

Energy, next to access to primary and secondary raw materials, is a key input in metals production and therefore an essential factor in the sectors' competitiveness. For some non-ferrous metals, the cost of electricity can represent up to 40% of operating costs, while being

[43] "The future of European competitiveness: Report by Mario Draghi". See link.

priced on global trading platforms such as the London Metals Exchange. As a consequence, producers of metals traded on such types of international exchanges cannot pass the higher costs of the electricity they use on to their customers.

Access to sufficient decarbonised energy sources, such as electricity and renewable and low-carbon hydrogen, at globally competitive prices are therefore key pre-conditions for a successful green transition and for the industry's competitiveness to be maintained in the global arena. The State of the Energy Union Report 2023[44] indicate that the short- to medium-term outlook for the metals industry in terms of affordable electricity supply are of serious concern. The sector has flagged the need for the EU to deploy new decarbonised power generation capacity (including back-up) as swiftly as possible in order to re-establish EU power-market liquidity and ensure a globally competitive decarbonised electricity supply. Next to this, it is essential that energy infrastructure projects are completed on time to enable transporting fossil-free energy and decarbonised electricity securely and cost-effectively. Otherwise, even the most cutting-edge technologically advanced decarbonisation projects would risk being stranded.

At the same time, there is a significant cost-efficient potential for incremental energy savings in EU industry. Tapping this can help deliver more with less and bring much wanted resilience by reducing dependence on imported energy sources. However, this is not the case for steelmaking in a short to medium-term, as energy transition is expected to double the energy consumption by 2030.

The importance of wholesale electricity markets in delivering globally competitive energy prices

The metals industry sources its electricity both via hedging contracts and spot-markets In both situations, wholesale electricity markets play a key role in indicating how cost-competitive the electricity is with spill-over influence on Power Purchase Agreements (PPAs). Wholesale market prices constitute a large share of the costs of procuring energy for the metals industry (followed by network costs and renewables levies where applicable). As a result, wholesale market prices have an immediate impact on the industry's competitiveness.

Natural gas prices have been gradually decreasing[45] thanks to coordinated efforts by the EU and its Member States in reducing consumption and increasing storage availability for winter periods. Wholesale electricity markets have also witnessed a fall in prices, slightly improving the outlook for EU electricity consumers, but not as low as the levels witnessed historically, before the 2021 crisis. However, these developments need to be treated with caution given the new predominance of volatile LNG as a supply source in Europe. This predominance brings with it an inherent vulnerability to external shocks, such as geopolitical tensions, and to the price-setter role of Asian economies in global LNG markets.

The State of the Energy Union Report 2023 confirms that wholesale electricity prices have decreased substantially since 2022. However, these remain higher than in the past, resulting in widening gaps between EU manufacturers and cleantech sectors and their global counterparts to the detriment of competitiveness for EU companies.

While the cost of producing renewable energy has fallen and some Member States already apply measures aiming to reduce energy costs to energy-intensive industries, the costs of consuming decarbonised energy remain relatively high, due to the structural coupling of fossil-

[44] https://ec.europa.eu/commission/presscorner/detail/en/ip_23_5188

[45] ACER Gas Markets Monitoring Report 2024 – Key Findings

fuel prices and electricity prices in electricity wholesale markets, negatively impacting the competitiveness of industrial consumers. As a result, the ferrous sector stresses the need for a thorough assessment of the wholesale electricity markets. This should include evaluating the feasibility of passing onto consumers the benefit of the increasing share of low-cost fossil-free electricity and achieving globally competitive electricity prices, including finding solutions to reduce the shaping and firming costs of PPA's, by evaluating the alternative market design options (e.g., the Price Shock Absorber and the Segmented Pay-as-Clear Model).

One of the solutions put forward by stakeholders is based on a concept of pooling renewable energy supply and demand, incentivising the provision of green electricity to industrial consumers according to the additional capacity added via PPAs, with the aim of reducing the shaping and firming costs. Additionally, stakeholders welcome the possibility of accessing fossil-free electricity through PPAs as provided for in the recently revised electricity markets regulatory framework (Article 19a(4) and Article 19b) of the Electricity Market Design Regulation[46]. However, to be effective, the measures must be implemented quickly and be tailored to the sector's urgent need to decarbonise.

An enabling long-term contracting framework for energy-intensive industries as the way forward to mitigate energy costs and improve decarbonisation efforts

In principle, power purchase agreements (PPAs) and hedging contracts offer concrete solutions for industrial consumers to both access a stable supply of fossil-free electricity at cost-competitive prices and have their risk of exposure to wholesale market prices mitigated. Such procurement tools also have tangible benefits for the decarbonisation of the entire European electricity system. Unlocking their deployment at a large scale across the EU is therefore a key priority for the Commission and, thanks to the recently agreed reform of the electricity markets regulatory framework (the 'EMD reform'), for Member States.

The increased availability of long-term contracts, as PPAs and hedging contracts, could for its part improve the metals industry's energy costs and decarbonisation outlook. However, except for the case of a few primary aluminium smelters, these contracts have historically been confined to non-industry energy-intensive sectors, such as Information and Communication Technologies. The opportunity to also sign these contracts in manufacturing sectors, such as steel and non-ferrous metals, is gaining momentum across Europe, but they are far from covering a substantial share of their final electricity consumption and bear high upfront financial costs (i.e. guarantees against payment default risks).

Some of the barriers reported by stakeholders are as follows.

- Excessively high wholesale market prices that directly affect the affordability of PPAs[47].
- A lack of dedicated financial instruments to improve the credit worthiness of energy-intensive industries.
- Shaping and firming costs that make renewable energy sources (RES) PPAs expensive. Shaping and firming costs are the costs of matching the intermittent generation profile of RES to the flat, base-load consumption pattern of electro-intensive industries. They can represent a substantial premium to a normal baseload contract purchased on the open market and significantly impede electro-intensive industries from accessing renewable electricity. However, stakeholders flag that the flexibility of their production processes is quite limited[48], and therefore it prevents them from

[46] Regulation (EU) 2024/1747, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=OJ:L_202401747.

[47] Some data are available at https://pexapark.com/.

[48] Except zinc smelters, which have a flexible consumption profile and can offer demand response services for appropriate remuneration.

adjusting their consumption to the intermittent supply profile of the PPA (more details in the dedicated section below). Nevertheless, some installations, including steel and primary aluminium[49], could, with additional investments and appropriate remuneration, become more demand responsive and adapt to the changing nature of the electricity system in which intermittent sources dominate. The volume and price risks associated with PPA supply therefore remain extremely hard to manage for industries continuously consuming energy[50].

- PPAs have to compete with government-backed RES support schemes that can offer simpler and stronger credit solutions. This sometimes results in project developers favouring them over PPAs with industry; the EMD reform (under Article 19a(1) and (4)) provides a stronger obligation for Member States to facilitate access to PPAs through a diversified set of actions and link these with CfD-funded renewable electricity projects.
- There is a lack of liquidity on the RES PPAs market. This could be addressed by ensuring sufficient volumes of power are offered to the PPAs market and implementing EMD legal requirements.
- Infrastructure bottlenecks and a slow pace of RES deployment.
- Regulatory costs created by EU reporting and clearing regulations, such as REMIT and EMIR.
- Limited cross-border interconnection capacity for exchanges.
- Lack of appropriate national regulatory frameworks or even awareness to foster the use of PPAs.
- The overall uncertainty of the EU energy market leads to higher prices.
- The lack of compensation for ETS indirect carbon costs in some Member States, which can undermine long-term visibility on final costs of electricity.

In this context, the Commission's EMD reform introduces several innovative solutions to unlock PPAs and to improve market participants' hedging options.

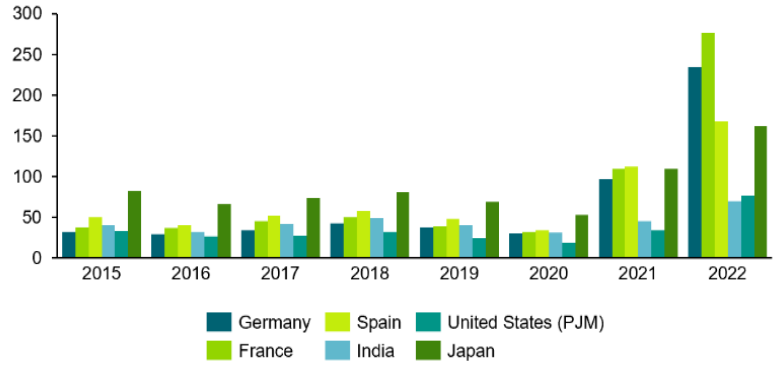
On PPAs, Member States now have stronger obligations to facilitate consumers' access to long-term PPAs by assessing and removing existing barriers for customers and by including de-risking solutions for potential offtakers. Most importantly, the metals sectors generally welcomes the new provisions on PPAs and CfDs set out in Article 19a(4) and Article 19b. These rules enable the sale of fossil-free electricity covered by a public CfDs to selected customers through a PPA as a way to ensure industry can access cost-competitive decarbonised electricity.

In this context, it is crucial for national governments to swiftly and effectively implement the new regulatory framework for PPAs and CfDs in the EMD reform for the sector to achieve its decarbonisation targets and for its competitiveness.

[49] Certain primary aluminium smelters can participate in occasional load curtailments throughout the year. However, for this to be viable the compensation from the grid operator must be adapted to each plant, exceed the profit associated with the metal otherwise produced, and offset the additional operating costs while the potlines re-gain peak efficiency. The electrolysis process requires stability to work most efficiently.

[50] Navigant, Low Carbon Energy Transition – Implications for the steel industry, 2024.

Average day ahead market electricity prices in major steel producing countries, EUR/MWh



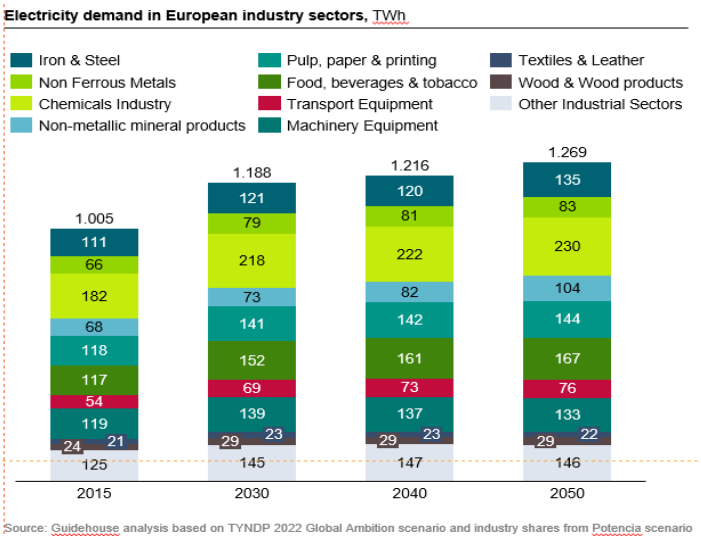
Source: Guidehouse analysis based on IEX (2023), Area Prices; Bundesnetzagentur (2023), SMARD.de; JEPX (2023) "Trading results of day-ahead market"; ANRE (2023) "Electric Power Market Statistics", Monitoring Analytics (2023), State of the market report for PJM.

The largest steel producing country China is not included in the graph as there is no transparent market data publicly available. However, data from the European Commission suggests, that also Chinese electricity prices did not increase as sharply as in Europe.

Speedy and cost-effective roll-out of new decarbonised or low-carbon generation capacity to meet industrial demand

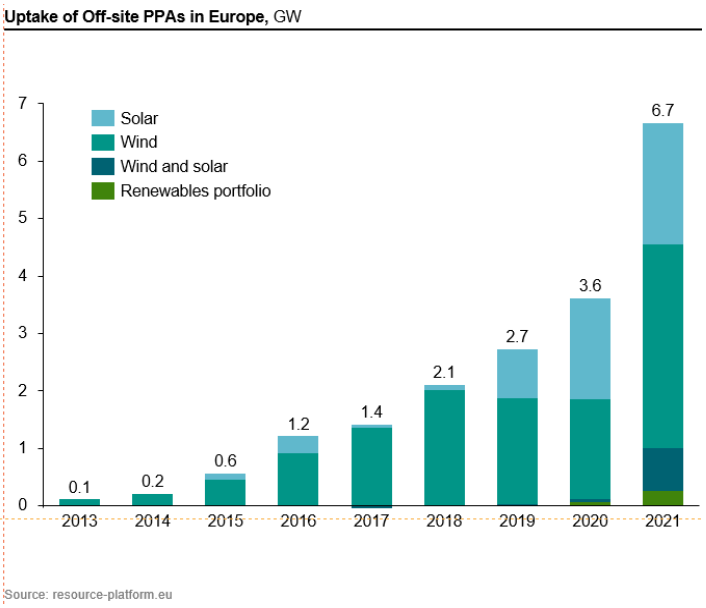
Looking towards 2030, the European metals industry is set to compete for its power consumption and electrification with a wide variety of sectors accessing fossil-free generation (e.g. transport, buildings, heating and cooling). Achieving EU renewable energy objectives and deployment of capacity in the current decade will require vast financial resources and the roll-out of investments at an unprecedented pace. Industrial stakeholders have expressed the concern that industrial consumers, such as the metals industry, would have to bear the costs of the entire transition. This would add to the loss of international competitiveness the sector is facing due to persistently high energy prices.

Electricity demand in European industry sectors, TWh



Source: Guidehouse analysis based on TYNDP 2022 Global Ambition scenario and industry shares from Potencia scenario

Given these circumstances, Member States are called on to implement the revised energy regulatory framework, in particular the revised Renewable Energy Directive (2023/2413) (RED III) as best as possible to create a conducive environment for the clean transition of the metals industry. This framework will strike a balance between attracting investments in new generation capacity while minimising overall costs, including network costs, for consumers. Therefore, a harmonious approach to removing existing and potential barriers to the roll-out of new decarbonised capacity, grid modernisation and interconnections is of paramount importance, while making sure industrial competitiveness is not affected and measures are taken to foster reduced system costs for EU industry. Risks to the security of supply for industries and increased congestion are also particularly detrimental to the transition pathway.

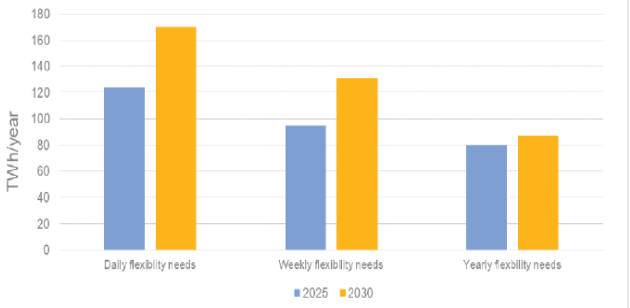


Making the industrial electricity demand of the metals sectors more flexible

With the share of variable and intermittent power generation in the EU increasingly penetrating electricity systems, the need to strengthen the EU's resilience and security of supply has become clear and crucial. Expanding and modernising electricity grids, deploying dispatchable (back-up) generation capacity and making demand more flexible (where technically and economically possible) are expected to play an essential role.

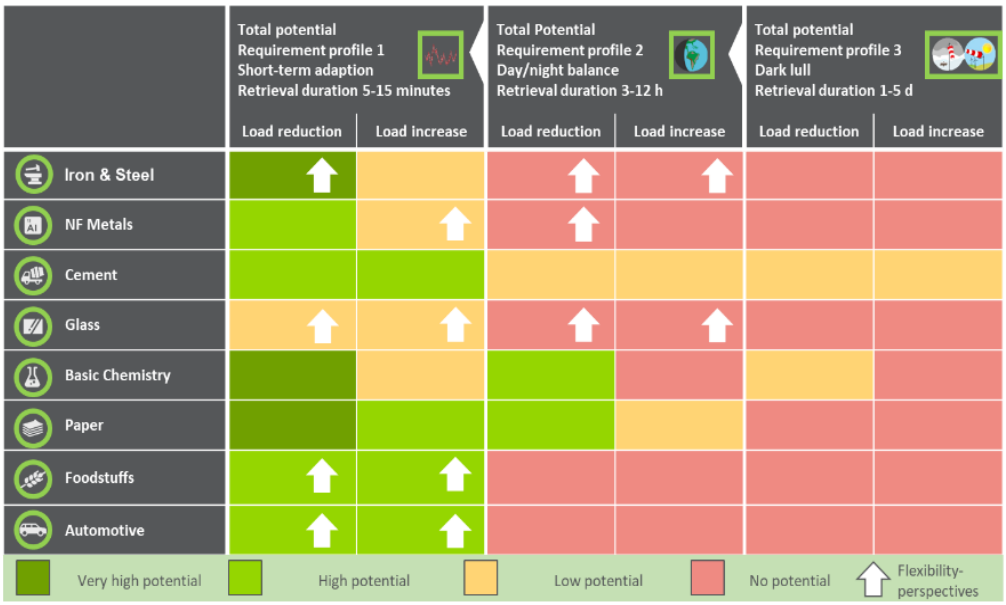
Making electricity demand flexible has gained a lot of attention in the revised electricity markets regulatory framework. The Commission has identified great potential to increase the contributions of flexible demand to the functioning of electricity systems. However, the investment required is substantial and will require coordinated efforts from all technological solutions and contributions from industrial sectors as well.

Figure 10: expected evolution of flexibility needs in the EU



Source: ACER (Final assessment of the EU wholesale Electricity market design, April 2022)

The metals industry is already a large contributor to flexibility via voluntary action and as a provider of ancillary services. Therefore, it is in a position to continue its efforts as the system's renewable electrification progresses. However, industrial flexibility (i.e. demand-side response) can only happen within the sector's specific technical and economic constraints that are limiting the overall potential compared to other more flexible technologies. Technical constraints refer to the maximum potential for changing the electrical load considering safety and plant-related restrictions and dependence on a plant's downstream processes. Economic constraints refer to the opportunity and investment costs for shifting or reducing consumption. Opportunity costs refer to the cost of foregoing commodity production (aluminium or steel) to accommodate either the change of time of consumption or a reduction in response to the flexibility needs of grids. Investment costs refer to the fixed costs of the industrial assets that imply full-load operation to be recovered. Changes in consumption patterns or quantities can have a direct impact on the investments and on plants' revenues (caused by reduced production volumes, loss of customers, etc.).



Source: Eurofer, Low Carbon Energy Transition report prepared by Navigant

Within these constraints, the steel sector reports the possibility to modify their consumption only in the short term with a time window of 5-15 minutes. Zinc smelters have more flexibility, capable of modulating production by more than 50% very quickly. In contrast, primary aluminium producers have more limited flexibility and are only able to partially reduce consumption for maximum of 2 hours (only partially to lower temperature for a limited time, then ramping up to the required temperature to avoid metal solidification and damage to the installation).

Overall, with the right voluntary and adequately compensated framework conditions in place that are tailored to consider the specific characteristics of every metal sector, industrial demand side response (DSR) could be a constructive opportunity for the sector to contribute further to the decarbonisation and resilience of the electricity system. Stakeholders highlight that policies around DSR must be reconciled with the current challenges facing consumers and energy-intensive industries, in particular the ongoing decarbonisation efforts, the need to access fossil-free electricity cost-affordably and securely, and the sector-specific constraints in providing additional flexibility services.

Key recommendations by stakeholders

Facilitate access to sufficient and globally cost-competitive decarbonised electricity:

- evaluate the impact of energy prices and costs on the competitiveness of energy-intensive industries vis-à-vis international competitiveness;
- take note of the proposal of stakeholders to assess the wholesale electricity market's potential to provide globally competitive power prices for European electro-intensive industries and delivering the transition to climate neutrality;
- explore alternative solutions and business models (for industry) aimed at optimising energy-intensive industries' access to cost-competitive fossil-free energy, as also set in the Communication on 2040 climate target, and optimising the use of energy and materials;
- take note of the proposal of stakeholders to measure and analyse the price gap for the European metals industry vis-à-vis their international counterparts, including a competitiveness check for those that are price-takers on global markets;
- consider how measures to compensate ETS indirect costs could be further harmonised;
- recognise the importance of existing State aid measures (reduction of RES and cogeneration levies, compensation of indirect emissions costs) and the recently expired Temporary Crisis and Transition Framework measures in Chapters 2.1 and 2.4 as higher energy prices still remain;
- ensure continuity in the implementation of the State aid framework aiming to prevent carbon leakage, while preserving the integrity of the single market;
- ensure a cost-competitive and pragmatic approach in policies to stimulate industrial energy demand response;
- explore solutions to improve the availability and access to PPAs for energy-intensive industries.

The non-exhaustive list of solutions to ensure access to cost-competitive decarbonised electricity:

- easy-to-access guarantee schemes backed by Member States and commercial banks or the European Investment Bank to tackle the cost of risk associated with the credit worthiness of energy-intensive industries;
- speedy deployment by national governments of decarbonised electricity projects, streamline permitting, including through increased capacity in permitting authorities, increased use of digital tools and the early involvement of all stakeholders (pre-permitting procedures);
- eliminate electricity infrastructure bottlenecks;
- identify and facilitate solutions for tackling the shaping costs entailed by baseload industrial consumers when consuming intermittent RES electricity;
- increase process demand flexibility and local energy storage – where possible and cost-effective – to mitigate grid congestion, and increase the use of local variable renewable energy sources thereby resulting in lower network fees and energy prices;
- some of the solutions that could rapidly increase the uptake of PPA contracts in the sector include the creation of an EU-wide public funding window (such as the option being investigated under the European Investment Bank Advisory Hub), recognition of PPAs as cash flows instead of financial derivatives to maximise the impact on a company's earnings before interest, taxes, depreciation, and amortisation (EBITDA), and ensuring that publicly financed fossil-free generation projects will reserve part of their capacity for industrial offtakers of PPA from energy-intensive manufacturing sectors, building on Article 19(5) of the EMD reform.

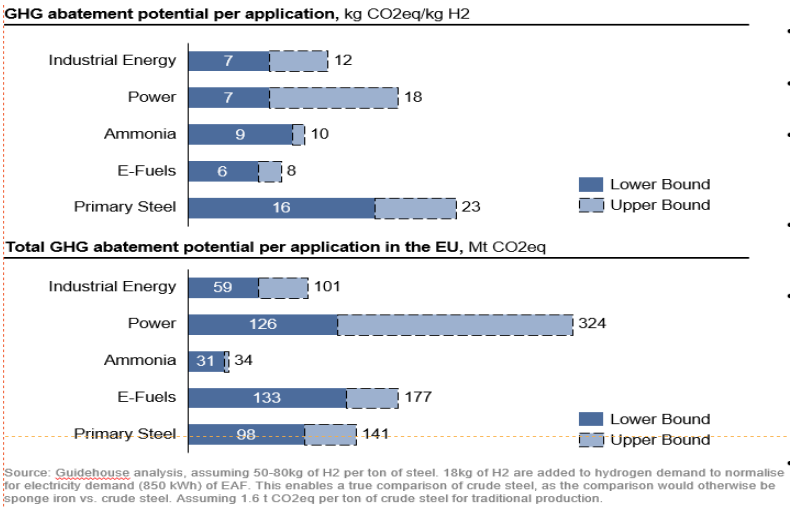
Create a proper financing framework for investments in new decarbonised generation capacity:

- assess and measure the decarbonised electricity needs of the EU metals industry and the associated infrastructure requirements, taking into account the implementation of efficiency and circularity measures to reduce electricity needs;
- monitor and consider solutions to minimise the cost impact of investments in grid expansion and modernisation, capacity mechanisms and investments in new fossil-free generation projects on industry competitiveness;
- ensure implementation of new provisions of the revised Renewable Energy Directive and the Net-Zero Industry Act (NZIA) rules on streamlining permit-granting processes for renewable generation projects;
- ensure that the use of CfDs does not drain the PPAs market or the forward market, thus precluding electro-intensive industries from benefiting from new generation investments and access to price hedging products.

Hydrogen and infrastructure

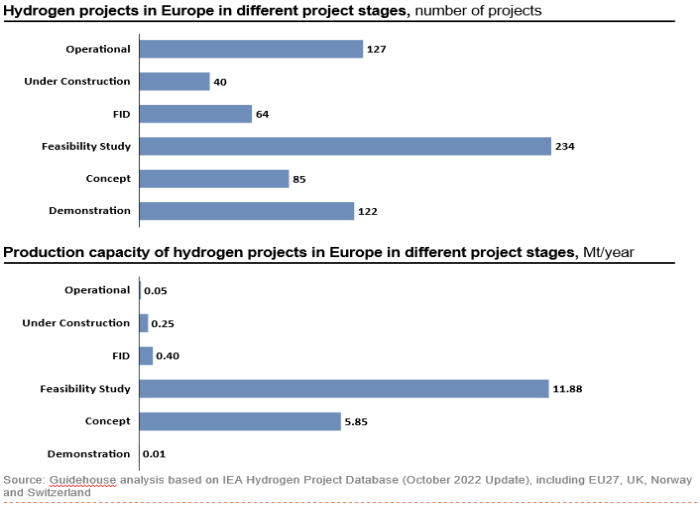
Hydrogen-based metallurgy belongs to the set of breakthrough technologies that can deliver an almost complete CO_2 abatement once sufficient low-carbon electricity is available. This technology will gradually substitute fossil inputs and fuels for the chemical reduction of raw materials (such as iron ore in the steelmaking process) and as a CO_2-free energy in stationary production processes (such as in hot rolling steel mills). Its successful integration depends on its availability, both in sufficient quantities and at cost-competitive prices, which is directly linked to the availability and cost of sufficient amounts of low-carbon electricity.

The use of hydrogen in energy-intensive industries (such as the steel sector) has significant potential for GHG emissions abatement. This places hydrogen as a crucial fossil-free energy carrier for the decarbonisation of the EU metals industry through its use for energy and non-energy purposes.

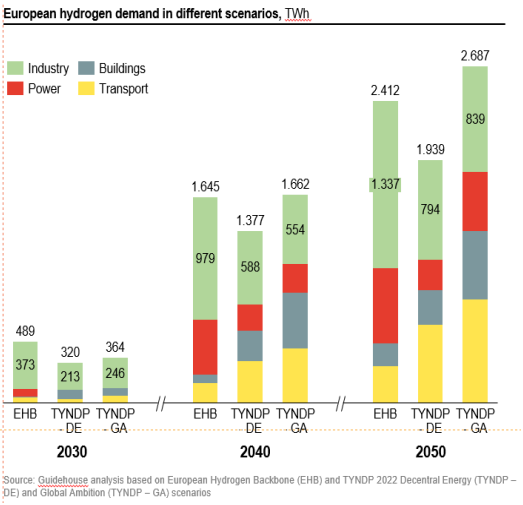


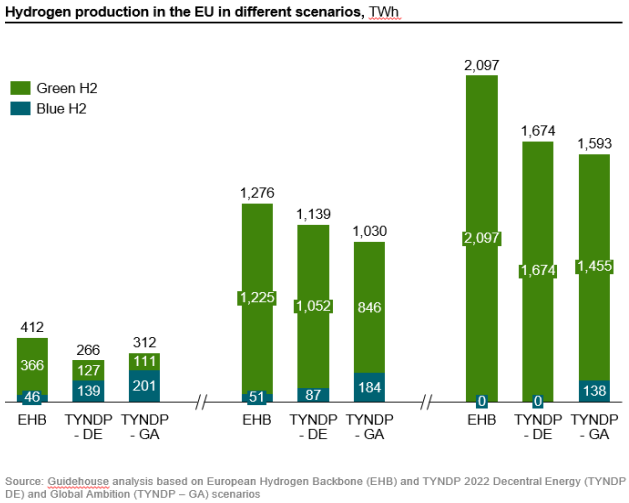
Source: Guidehouse analysis, assuming 50-80kg of H2 per ton of steel. 18kg of H2 are added to hydrogen demand to normalise for electricity demand (850 kWh) of EAF. This enables a true comparison of crude steel, as the comparison would otherwise be sponge iron vs. crude steel. Assuming 1.6 t CO2eq per ton of crude steel for traditional production.

The European hydrogen economy is nascent and mostly dominated by fossil-based hydrogen. There are less than 50 000 tonnes of renewable hydrogen produced in Europe.



Industrial demand for low-carbon hydrogen is forecast to be the leading driver of the initial stages of market development and could therefore be accelerated by policymakers during the ramp-up phase (see figures below). The first kind of large electrolysers used in industry and the innovative hydrogen-based industrial processes within the metals sectors will kick off economies of scale in electrolyser and application manufacturing that will facilitate the roll-out of these cleantech technologies across industry and other sectors of the EU economy. In this regard, a sufficient take-up of green hydrogen by industrial users by 2030 is necessary,





enabling industrial hydrogen end users to access sufficient and affordable volumes in a timely manner that enables cost-effective decarbonisation. The Renewable Energy Directive (RED) sets targets for industrial uses of renewable fuels of non-biological origin (RFNBO), aiming for at least 42% by 2030 and 60% by 2035.

The forecasts shown above illustrate the strategic role industrial demand for hydrogen plays in the creation of a European hydrogen market. Policies and initiatives should use this potential to achieve EU feedstock and energy targets. As a result, stakeholders call for endorsing a pragmatic approach to national policymaking that integrates economic, circular and climate considerations. This approach should guide the organisation of the nascent low-carbon hydrogen market and the development of infrastructure, targeting sectors where hydrogen has

the potential to deliver the greatest CO_2 abatement. This approach should also take into account the low-hanging benefits of circular and direct electrification options.

Many industrial applications using hydrogen in the metallurgical sector require a round-the-clock supply; therefore, renewable hydrogen can only be used if there is sufficient storage capacity. The need to accelerate the development of the European hydrogen backbone is essential in this regard. The Commission is also setting out the regulatory framework for low-carbon hydrogen via a delegated act later this year, and this could help ensure sufficient supplies of low-carbon hydrogen are made available to the sectors dependent on it for their decarbonisation pathways. Thus, increasing the availability of low-carbon electricity supplies will enable greater running hours for electrolysers, which would support industries requiring a continuous supply of hydrogen. Renewable hydrogen storage will be essential as it would provide, where feasible, increased flexibility in industrial operations to match the fluctuations in renewable energy production. Metals industry could also play a role in production of hydrogen in their own production sites, where this is feasible.

The fast development and execution of hydrogen infrastructure projects at both national and cross-border levels is critical for hydrogen supply. Several industrial sites are located in areas unsuitable for hydrogen production due to, for example, insufficient renewable energy resources for on-site generation. For these sites, pipeline transport facilities are the sole alternative for receiving hydrogen. Developing pipeline connections for these strategic customers is therefore crucial.

Key recommendations by stakeholders

Prioritisation of hydrogen use for industrial sectors as the nascent hydrogen economy's guiding principle:

- Consider applying the prioritisation of hydrogen access and use in sectors where its use as a feedstock and energy source has the highest CO_2 emissions abatement potential per tonne consumed as a principle for the organisation of the hydrogen market.
- Consider the adoption of a European wide ranking system among hydrogen demand sectors on the basis of criteria, including CO_2 emissions abatement potential, degree of exposure to international competitiveness, energy-intensity and existence of viable and available hydrogen alternatives, including direct electrification.

Support industry in adapting to a decarbonised energy system:

- Increase the availability of low-carbon electricity supplies to enable greater running hours for electrolysers, which also increases their cost efficiency and durability.
- Develop hydrogen storage via the rapid deployment of the European hydrogen backbone.

Timely and smart planning and development of hydrogen infrastructure for the supply of hydrogen to industry:

- Promote an end-user approach to infrastructure planning and development at cross-border and national levels within the EU hydrogen regulatory framework.
- Consider to include information on hydrogen demand and timeframes from sectors with the highest CO_2 emissions abatement potential per tonne of consumed hydrogen as criteria for network planning in the hydrogen regulatory framework.
- Ensure timely and effective implementation of the hydrogen regulatory framework rules on infrastructure planning and development.

Carbon pricing: EU emissions trading system (ETS) and the Carbon Border Adjustment Mechanism (CBAM)

Carbon pricing is one of the main instruments chosen by the EU to incentivise cost-effective emissions reductions, and it may provide investment signals to create markets for low- and near-zero carbon products. However, most of Europe's trading partners' carbon prices are often significantly lower, and their climate policies are less ambitious or non-existent. The EU should therefore do more to encourage and support other jurisdictions to introduce or improve their own carbon-pricing mechanisms, so as to reduce, through for instance progress in international fora such as COP 29, the gap between Europe and other countries' climate ambition and legislation. As a result, it is essential that EU climate legislation delivers on the agreed climate targets while effectively addressing the risk of carbon leakage in certain sectors.

The EU ETS, as set out in the ETS Directive[51] and further amended, is the main EU climate policy instrument for emission reductions in industrial sectors. Following the recent revision of the Directive, ETS sectors are required to reduce their emissions by 62% by 2030 compared to 2005. This is a major development since it implies that the ETS cap will be roughly halved by the end of this decade. To contribute to these ambitious targets, industrial sectors, including metals, need to implement unprecedented decarbonisation projects, the success of which relies on the existence of the right enabling conditions.

Until 2025, the carbon leakage risk linked to direct carbon costs is addressed by free allocation. As of 2026 for certain sectors, free allocation will be gradually replaced by CBAM, for which the legal basis is Regulation[52]. The instrument ensures the carbon price of imports is equivalent to the carbon price of domestic production and covers the following sectors: cement, iron and steel (including ferroalloys), aluminium, fertilisers, electricity and hydrogen. The transitional period, which started in October 2023 and will run until the end of 2025, requires the party responsible for declaring imports (which could be the importer or the indirect customs representative) to report the emissions embedded in imported CBAM goods every quarter, without paying a financial adjustment. Importers will begin paying the CBAM financial adjustment in 2026. For metals, CBAM will initially apply only to direct embedded emissions (not indirect embedded emissions from electricity production), and compensation for indirect carbon costs through State Aid will not be phased out. However, the Commission will report on a possible extension of the CBAM scope to cover indirect emissions in this sector, as required by the CBAM Regulation.

Since the CBAM is an unprecedented measure covering many goods used in complex metals value chains, it is essential that all elements impacting its design and functioning deliver an efficient mechanism aiming to provide efficient governance and effective enforcement. The industrial stakeholders note the need for effective ~~, with strict~~ anti-circumvention rules targeting all practices that undermine the integrity of the instrument, including resource shuffling, i.e. the rechannelling of trade flows to focus cleaner production for the EU market while diverting carbon-intensive goods to non-EU countries. At the same time, default values should not allow for freeriding circumvention practices by non-EU producers exporting goods with a higher carbon footprint. Furthermore, as the CBAM covers only specific segments of complex metals value chains, it will be important to address the carbon leakage risk throughout the entire value chain and avoid that this risk is not mitigated in downstream sectors. In this respect, extending CBAM's scope to downstream goods should be considered.

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[51] 2003/87/EC, OJ L 275, 25.10.2003, p. 32–46

[52] Regulation (EU) 2023/956, OJ L 130, 16.5.2023, p. 52–104

While the current design of the CBAM attempts to address the carbon leakage risk only on the EU market, the phase-out of free allocation exposes EU companies to carbon costs that could also impact their competitiveness on global markets. Exports by current CBAM sectors amount to more than EUR 60 billion. In addition to the direct impact on these sales, one should also consider that capital-intensive sectors like metals face high-fixed costs that require high-capacity utilisation rates; therefore, even relatively small losses of market share may jeopardise the competitiveness of entire production plants. To mitigate partially such risks, the ETS Directive anticipates support to decarbonisation investments, in particular in CBAM sectors, by the Innovation Fund and also allows Member States to use auction revenues to support these sectors. Effective carbon leakage protection is needed to provide the metals industry with the certainty needed to implement decarbonisation investments. Under the existing legislation, several Commission reports on carbon leakage risks are expected in the coming years.

In addition to the direct carbon costs of the EU ETS, the EU metals industry also faces the power sector's indirect carbon costs passed on in electricity prices. Due to the design of the EU electricity market, these costs do not reflect and are not linked to the actual emissions embedded in the electricity consumed. Instead, they are based on the emissions of the marginal power plant setting the price in the relevant geographic zones of the European power market. Sectors that tend to be trade- and electro-intensive are eligible for indirect CO_2 cost compensation that can be granted by Member States.

The ETS Directive allows for financial support for sectors or subsectors that are exposed to a genuine risk of carbon leakage. This risk comes from significant indirect costs that are actually incurred from greenhouse gas emission costs passed on in electricity prices. This financial support must be in line with State aid rules, and, in particular, must not cause undue distortions of competition in the single market. Moreover, free allocation can also cover parts of indirect emissions for certain products following the latest update of the Free Allocation rules[53]. As the transition of the metals industry to climate neutrality will involve further direct and indirect electrification of production processes, it is essential to effectively address the indirect carbon leakage risks.

The Net-Zero Industry Act provides for the application of resilience and sustainability criteria in public procurement and public auctions of specific net-zero technologies, such as renewable energy technologies, and their main specific components. Due to the fact that many of these components are made of steel and non-ferrous metals, it is advisable to assess the contribution of the Net-Zero Industry Act for either promoting the resilience of the metals sectors, where there is a high dependency on imports from a third country, or for promoting demand for low-carbon components in public procurement of public auctions, in view of further promoting the application of such non-price criteria.

Key recommendations by stakeholders include:

- assess the risk of carbon leakage for exports in a forward-looking manner and consider the need to complement the carbon leakage framework with a solution for exports that is compatible with WTO rules;
- deliver an effective governance and enforcement of the CBAM during its implementation against all circumvention practices, including resource shuffling;

[53] https://eur-lex.europa.eu/eli/reg_del/2024/873/oj

- assess the need to include more downstream products in the CBAM as soon as possible to avoid circumvention via importing downstream products not yet in the system's scope;
- consider preserving the indirect carbon costs compensation until a viable solution to include indirect emissions under the CBAM scope or other measures to mitigate impact of the indirect carbon costs is found;
- ensure quick and decisive political and regulatory action through the CBAM or other additional actions to reduce greenhouse gas emissions while mitigating the risk of carbon leakage;
- take note of the call to assess the need to adjust the EU ETS rules to recognise and ensure proper accounting of captured CO_2 used in products permanently and non-permanently in the 2026 review (Article 30 of the ETS Directive) in order to speed up developing the CCU as explained in building block 6, 'Infrastructure';
- consider laying down post-2030 EU ETS rules to address residual industrial emissions when the ETS cap approaches depletion;
- consider monitoring the specific situation of 20% of industrial sites with the highest emission intensities under a given product benchmark since for those sites, from 2026 onwards, receiving free allowances will be conditional on setting up and implementing climate-neutrality plans;
- take note of the call to explore how ETS revenues can further support decarbonisation of direct and indirect emissions in hard-to-abate industrial sectors;
- consider the possibility to develop new ETS product benchmarks to better reflect the circularity potential of metals and their strategic role in strengthening the EU's resilience, as recognised under the Critical Raw Materials Act and the Net-Zero Industry Act as crucial components to net-zero technologies.

Trade

The steel industry has lost more than 50 million tonnes of sales in the EU and export markets since 2017[54]. Those imports have often been produced under less strict environmental and social standards. Additionally, the EU steel industry has lost 26 million tonnes of steel production capacity and 25% of its workforce (around 100 000 jobs) since the financial and economic crisis in 2008.

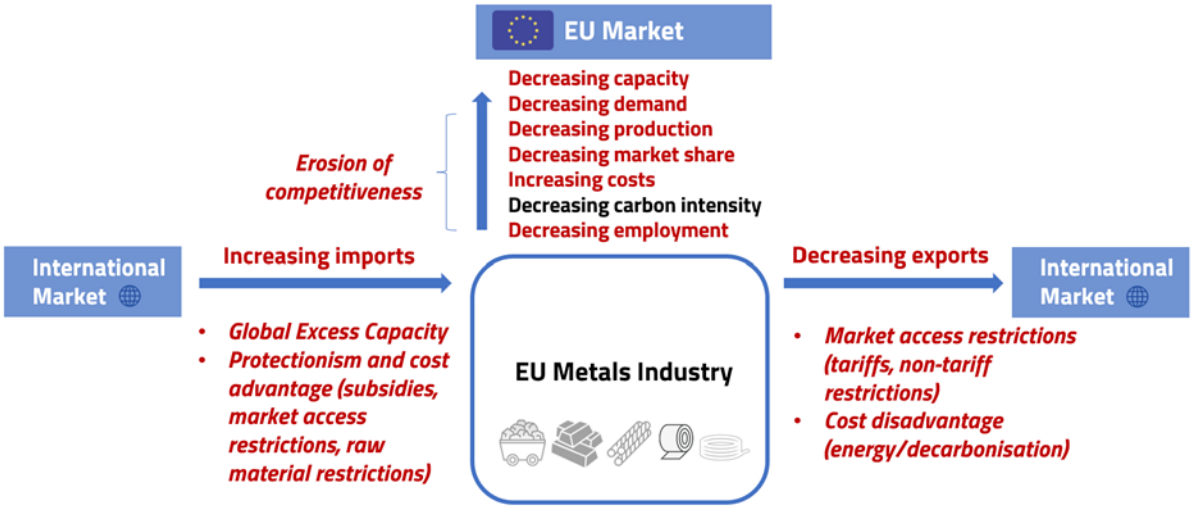
The EU non-ferrous sector has seen a gradual loss of market share to China and other regions[55], witnessing a decline in production of metals like rare earth elements, magnesium and gallium in the last three decades. Since 2015, the EU has lost over one third of its capacity for producing aluminium. In the EU ferroalloys and silicon sector, low-priced imports have gained a significant share of the EU market causing EU producers to scale back production and the closure of approximately 63% of furnaces as of September 2023. This has resulted in an inevitable and unprecedented 43% loss in employment in the sector. Without any action, this trend will likely accelerate, further undermining the EU's industrial base.

Global trade is facing a multitude of challenges, which affect the business environment of the metals sectors. The industry is threatened by global excess capacities, global distortions from China and other countries that artificially support their domestic industries or circumvent EU trade defence measures and sanctions. As a consequence, the EU's manufacturing base is

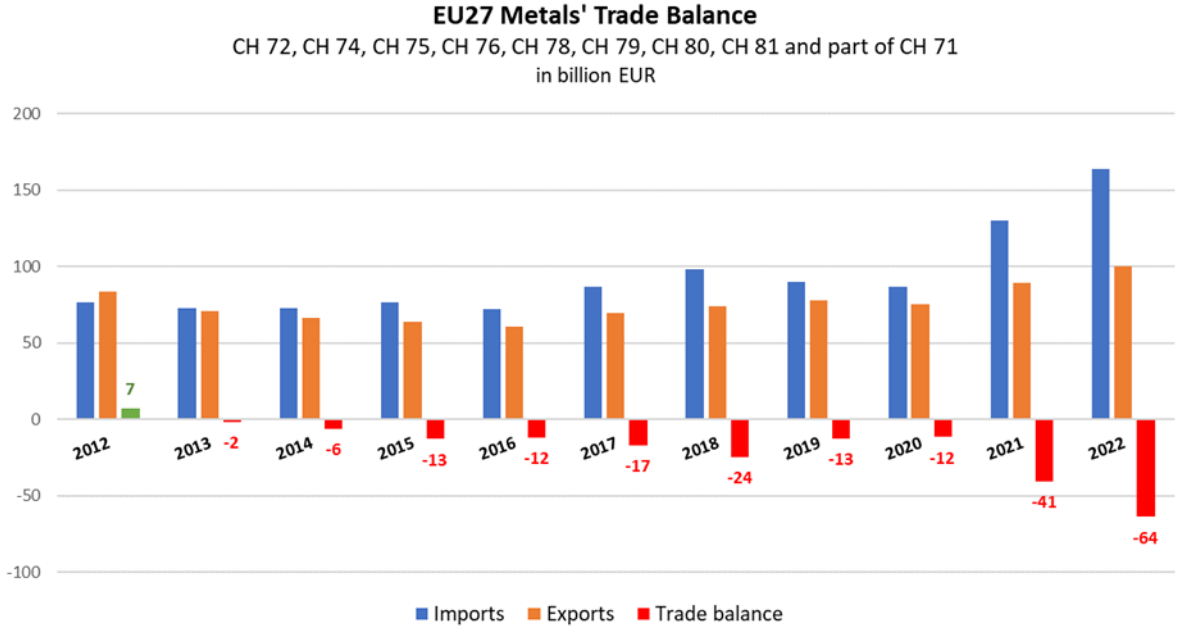
[54] Source : EUFOFER

[55] Source : Eurometaux

now hindered by artificially depressed global prices, rising low-priced imports, rising costs and both tariff and non-tariff restrictions by other countries, including on raw materials. In addition, the ability to tackle the growing issues of decarbonisation and excess capacities at global level is hampered by some countries blocking progress within a multilateral trade framework.



Together with a limited industrial capacity for critical metals like lithium, cobalt and rare earth elements, Europe has lost a significant share of the global market in the last decade for those base metals where it has an industrial base (e.g. steel, aluminium, ferroalloys, copper, nickel, lead, zinc, silicon). Over the last 10 years, the EU metals industry has lost more than EUR 200 billion of sales in the EU and export markets.



Source: COMEXT

The future of the EU metals industry hinges on the following key priorities of EU trade policy that aim to level the playing field with global competitors:

- an open strategic autonomy fostering a resilient and sustainable EU economy;

- ensuring fair competition and a level playing field for EU companies to preserve production and know-how within the EU;
- reforming the WTO to address the challenges faced by the multilateral trading system (overcapacities, capacity and raw materials distortions and decarbonisation);
- strengthening trade and investment relationships with strategic, reliable and like-minded countries to diversify supply sources while ensuring due diligence (e.g. free trade agreements, strategic partnerships on raw materials);
- maximising the contribution of trade policy to address key global challenges such as climate change and sustainable development, including compliance with core International Labour Organization conventions;
- fostering responsible business conduct for transparent, responsible and sustainable supply chains.

The mutually beneficial long-term partnerships with key countries, in particular emerging markets and developing countries, need to be strengthened in order to ensure stable supply chains, access to critical technologies and materials bolstering the resilience of European industries. International R&I cooperation further amplifies these objectives, enabling the EU to pool resources, share risks and accelerate breakthroughs in clean technology while in parallel creating standards that can be applied globally. Further in this direction, EC has adhered to the Climate Club, an international cooperation platform started in 2023 with an initial focus on the emission-intensive sectors steel and cement with the aim to scale up lead markets and to make decarbonised industrial production the default business case.

EU trade policy should support strategic objectives set in the frame of rapidly evolving EU industrial and environmental policies (focusing on strategic and enabling industries, maximising integrated value chains within the EU, and ambitious sustainability and climate change objectives).

Basic sectors like metals are facing massive global excess capacities, largely fuelled by government subsidisation and other distorting support measures. Therefore, EU policies should continue to ensure that integrated production, manufacturing value chains and technological innovation can further develop in the EU, securing well-paid, decent jobs and avoiding societal distress. The focus should be on using existing tools and, where necessary, deploying new tools that effectively tackle distortions from unfair trade practices and support access to export markets.

Key recommendations by stakeholders include:

1. consider measures to strengthen the EU's trade and competition toolbox to address the distortive effects of subsidies, unilateral trade measures, circumvention, unfair trade practices, and structural overcapacities in the global metals market, while facilitating diversification of supplies;
2. tackle the two existential challenges facing the steel and aluminium industries worldwide: non-market excess capacity and carbon intensity based on EU/US policy coordination;
3. ambitiously enforce existing rules where conditions for their respective use are met, including those combating unfair trade practices (trade defence, the Foreign Subsidies Regulation), those preserving EU rights under bilateral trade agreements and in the WTO (the Enforcement Regulation) and other trade and security-related instruments (the Investment Screening Mechanisms, the Anti-Coercion Instrument and soon the Forced Labour Ban Regulation);
4. take note of the call to push for an ambitious reform of the WTO to effectively tackle issues of state subsidisation, global overcapacities and trade distortions, including by improving the Dispute Settlement mechanism;

5. use bilateral free trade agreements and strategic partnerships on critical raw materials to help secure a sustainable and diversified raw materials supply, while effectively enforcing rules of origin and promoting high sustainability standards worldwide; establish stronger trade relations with the EU's key international partners that comply with relevant environmental and social standards;
6. take note of the call to apply harmonised EU due-diligence programmes to the full product value chain, building on existing industry schemes and international standards, to ensure the use of sustainably produced and responsibly sourced metals and minerals;
7. comply with the forthcoming EU Forced Labour Regulation as the basic metals supply chain includes high-risk sectors, such as the extraction and processing of raw materials.

Creation of markets for green products / levelling the playing field

The metals sectors transition will result in low- and near-zero carbon products that in many cases can be more costly to produce than traditional carbon-intensive products. It is therefore necessary that there is an incentive for downstream users of metals to purchase these low-carbon products. At the same time, it is necessary to guarantee a level playing field for those operators supplying the same market.

EU producers are subject to rigorous certification and technical requirements regarding sustainability criteria and social and labour standards, while this is not the case for most non-EU producers. Likewise, measures to redress unfair trade practices are in place to maintain a level playing field and avoid further harming the industries concerned, which are often affected by permanent aggressive pricing policies. Considering the geopolitical trend and the need for a resilient and strong EU, EU trade measures as well as environmental and social standards and regulations applied to non-EU operators to access the EU market are fundamental and should be effectively enforced, in cooperation with the respective non-EU country.

In developing the delegated rules of the Ecodesign for Sustainable Product Regulation[56] (ESPR), the specific nature of metals should be acknowledged and purchasing low- and near-zero carbon products should be encouraged.

Therefore, there should be markets willing to acknowledge the higher environmental benefit of a product and customers willing to pay the higher production costs of low- and near-zero carbon products. A single sector cannot solve this issue alone. This requires more consistent value-chain thinking. Therefore, short-term regulatory measures are recommended to stimulate the development of lead markets for low- and near-zero carbon 'green' products that trigger the large-scale deployment of decarbonisation technologies in the basic materials sector. Some of the relevant initiatives in this regard include the Energy Performance of Buildings Directive[57] requiring carbon footprint labelling of new buildings starting in 2030 and the Construction Products Regulation[58] adding climate information to building products.

Key recommendations by stakeholders include:

[56] https://eur-lex.europa.eu/eli/reg/2024/1781/oj.

[57]Directive EU/2010/31, OJ L 153, 18.6.2010, p. 13–35,https://energy.ec.europa.eu/topics/energy-efficiency/energy-efficient-buildings/energy-performance-buildings-directive_en

[58] Proposal for regulation COM(2022) 144, https://single-market-economy.ec.europa.eu/sectors/construction/construction-products-regulation-cpr_en

- consider measures to guarantee a level playing field for all EU and non-EU operators supplying the same market by ensuring fair competition and compliance with relevant environmental and social standards;
- take note of the call to develop a dedicated strategy on low- and near-zero carbon products, built on evidence-based methodologies for life-cycle carbon accounting;
- consider actively supporting markets willing to acknowledge the higher environmental benefit of a product and customers willing to pay the higher production costs of low- and near-zero carbon products;
- take note of the call to propose VAT exemptions or other market incentives for products made with low- and near-zero carbon products materials;
- consider the need to adopt more coherent value-chain thinking across different industrial sectors and a more holistic approach in assessing the potential for CO_2 reduction along those value chains;
- consider international standards / certification schemes for ‘green products’ that may enable higher production costs to be passed on by manufacturers to downstream customers;
- take note of the call for the public procurement to play a major role in kick-starting nascent markets for low- and near-zero carbon products.

2. REGULATION AND PUBLIC GOVERNANCE

The current regulatory landscape has been built and implemented over time, resulting in a complex framework. While there are links between the different regulations covering the life cycle stages of metals, there are also some overlaps and duplication that may impact successful implementation and create unnecessary burden.

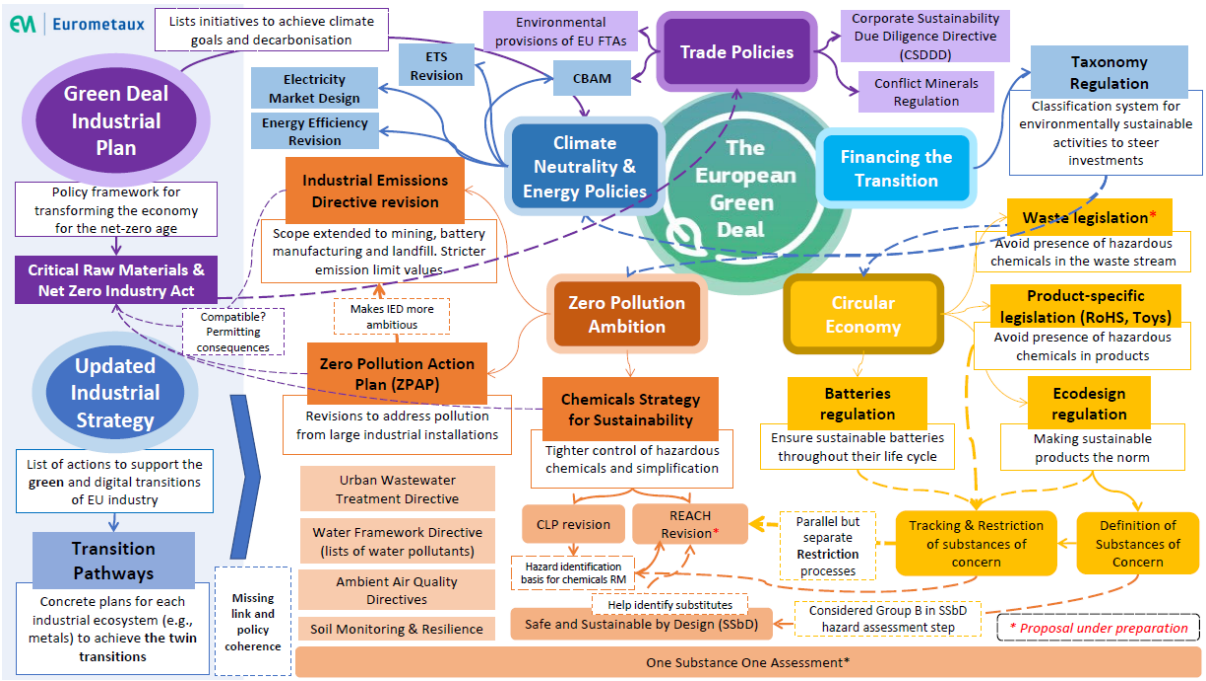


Figure – 'Spaghetti diagram' showing complex interlinkages between aspects of the Green Deal and other EU policy areas
Source: Eurometaux

Regulatory elements regarding energy policy, the ETS and the CBAM and raw materials

Although the 'spaghetti diagram' above clearly shows the complex interlinkages between different policy areas, it does not cover or expand on all energy-related initiatives such as the Renewable Energy Directive (RED) and the Gas Package. Energy costs are certainly one of the major factors that determines today's competitiveness, the future transition to low- and near-zero carbon production processes and the sustainability of the EU's ferrous and non-ferrous sectors. The current geopolitical context and recent developments have led to very high energy costs in the EU, particularly compared to non-EU metal producers. This requires particular attention and action by policymakers, including measures to improve the affordability of energy for industry in the short term and further assessments and potential regulatory changes to deliver international competitive energy prices in the medium and long term.

Carbon pricing is the instrument chosen by the EU to determine emissions reductions and provide investment signals to create markets for low- and near-zero carbon products. The ETS is the main EU climate policy instrument for emission reductions in industrial sectors. The metals industry is subject to this ETS and related carbon leakage protection measures. Steel, aluminium and some ferroalloys are in scope of the new CBAM Regulation.

The 'Sustainable competitiveness' building block discusses more in-depth regulatory aspects related to energy (electricity and infrastructure, hydrogen and infrastructure), carbon pricing, trade and creation of markets for 'green' products. The 'Access to primary and secondary raw

materials' building block deals with the regulatory issues relating to raw material feedstock, including secondary sources – metal scrap, waste and by-products.

On top of these regulatory elements, there are several other EU policies key to metals production in Europe, including EU environmental rules on chemicals, industrial emissions, water, soil and waste. Regulators, industry and social partners are working to ensure that risks from metals production to the environment, the workforce and the wider population are minimised and well-controlled in a way that also supports the industry's viability to supply key value chains enabled by metals.

The new Critical Raw Materials Act (CRMA)[59] and Net-Zero Industry Act (NZIA)[60] clearly show that the legislative aim is to strengthen and promote the development of the metals and compounds value chain sectors in the EU. From the perspective of the metals sectors, the following themes require discussion:

- The **lack of coherence** between some regulatory pillars and objectives and between EU legislation and national legislation ('vertical' coherence); the lack of legislative harmonisation across entire economic/industrial sectors[61] or across entire value chains ('horizontal' coherence) – which can result in **objectives that are contradictory or difficult/impossible to achieve together.**
- The overall **complexity** of the legal framework and in some cases, **poor efficiency**, and a **lack of predictability and clarity** on the outcomes of the regulatory system. These elements can have a significant negative impact on investments required to deliver the twin transition.
- Ensuring that the **regulatory burden** remains manageable and **that costs are proportionate to the benefits** (including environmental benefits) for new and revised measures (for example, stricter rules on chemicals risk management); **maintaining a level playing field within the EU and globally** (for example, for EU-based companies subject to unilateral carbon costs compared to competitors outside the region); **effective implementation and enforcement** of existing legislation before introducing new measures.

The **slow speed of 'permitting'** new projects – exploration activities, new mines, new mineral and metal production and processing plants, new recycling facilities, new low- and near-zero carbon processes, including pilot scale and demonstration facilities, etc. Delays in permitting can **turn an economically viable project into a failure** and can be a further deterrent to metals sectors investors.

The relevance of chemicals policy to metals

Metals and inorganics can be considered as 'chemical substances' in the context of the EU regulatory framework and are managed as such. In 2019, the European Green Deal introduced a 'A Zero Pollution ambition for a toxic-free environment' (ZPA). This is based on three pillars: the Chemicals Strategy for Sustainability[62] (CSS) issued in 2020, the Zero Pollution Action

[59] OJ L, 2024/1252, 3.5.2024, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=OJ:L_202401252

[60] OJ L, 2024/1735, 28.6.2024, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=OJ:L_202401735

[61] Sectoral adaptations are sometimes required.

[62] Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. 'Chemicals Strategy for Sustainability – Towards a Toxic-Free Environment'. European Commission, 2020.

Plan[63] (ZPAP) published in 2021, and the review of EU measures to address pollution from large industrial installations (Industrial Emissions Review (IED), 2022). The three initiatives run in parallel and have increased the regulatory focus on minimising risks from hazardous chemicals.

Metals industry argues that since metals are naturally occurring and hence have a 'background' concentration in the environment, and some are essential for life, a pragmatic approach to the meaning of 'net' zero is therefore required in this context, which recognises the specific characteristics of metals and how biologically essential they are to plans, animals and human life on Earth.

In general, the toxicity (hazard) of metals is related to the availability of the metal ion and its interaction with target sites in the human body and the environmental compartments. This bioavailability is dependent on physico-chemical aspects and environmental conditions but is typically changed when metals are incorporated in matrix materials such as alloys, frits, pigments and slag. Stakeholders highlighted that the whole life cycle of potentially hazardous metals need to be considered, including the exposure and risk for all potential scenarios. They argue that the most efficient way to manage the risks associated with this type of toxicity, which unfortunately is also time- and resource-intensive, is to control and minimise the concentrations of released metal ions (**exposure-based approach**) and consider their bioavailability after that. Stakeholders consider that a purely hazard-based approach, i.e. focusing on the composition of the metal-containing materials (expressed, for example, as a mass fraction), without considering the availability and natural background of these metal ions is an attempt to simplify the assessment that may result in decisions that can be not only over-protective but also under-protective and can conflict with the effectiveness of the EU's overall science-based decision-making process.

The ZPA aims to reshape the EU chemicals framework by proposing several legislative and non-legislative measures, including the revision of several pieces of legislation (from industrial emissions, to air, water, soil and chemicals legislation, such as REACH and CLP). The ZPA also proposed introducing new concepts such as combined toxicity, 'substances of concern', 'most harmful chemicals' and 'essential use[64], and the 'one substance, one assessment[65] approach to streamline the use of data and assessments. The ZPA is a once in a two-decade window of opportunity to get things right.

Simpler, more effective and transparent legislation

A regulatory initiative is successful if it is duly implemented and enforced, meeting its objectives and proving practical for stakeholders to implement. Key conditions for success, therefore, are that the regulation is known and understood by stakeholders, including social partners, and that all those involved are engaged in the development process (regarding both compliance and enforcement). This should result in a regulatory landscape that is as simple as possible, based on a holistic approach that covers all life cycle stages.

It is crucial to focus on the implementation phase and to help companies comply with their many new or updated regulatory requirements. There is also a need to give greater predictability and clarity to stakeholders, incentivising their constructive collaboration.

[63] Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. 'A Pathway to a Healthy Planet for Healthy People'. – EU Action Plan: Towards Zero Pollution for Air, Water and Soil'. European Commission, 2021.

[64] https://environment.ec.europa.eu/strategy/zero-pollution-action-plan_en.

[65] https://ec.europa.eu/commission/presscorner/detail/en/ip_23_6413.

In April 2023 – April 2024, a Mutual Learning Exercise on industrial decarbonisation[66] under the European Research Area (ERA)[67] Action 12 on Accelerating the twin transition through Europe's key industrial ecosystems was implemented, with the engagement of 10 Member States and 2 Associated Countries, on national roadmapping, practices for stakeholder involvement, design of support instruments, links to framework conditions at national level. Moreover, another Mutual Learning Exercise on the whole-of-government approach with a green transition component under ERA Action 12 identified core practices in green transition roadmapping to improve public governance, such as: (i) Goal-oriented strategic plans with a clear timeline, reaching specific goals; (ii) Major players are identified in the innovation system and alignment of activities in industry are supported, helpful in reducing uncertainty and providing direction; Needs and priorities are identified; regular updates and monitoring of progress against milestones and targets is used.

Recommendations by stakeholders are:

- take note of the proposals to assess current legislation that pertains to metals value chains and identify areas where complexity and incongruencies negatively affect companies in a disproportionate way, aiming to fix incongruencies and clarify complex points;
- consider evaluating the effectiveness of implemented legislation/revisions/regulatory actions against their environmental, social and industrial development goals, while respecting the environment and health protection of workers and local communities;
- take note of the call to aim for proportionate and science-based legislative initiatives and clear responsibilities (e.g. for the relevant EU agencies), including capacity building where relevant;
- ensure that different pieces of legislation addressing the industry do not work in isolation from one another but in an integrated way;
- consider tapping into the benefits of social dialogue at EU level for ensuring societal acceptance by discussing future regulations and initiatives, such as those related to clean energy production and diversification of energy supplies, within the framework of the sectoral social dialogue committees for extractive industries, steel and metalworking industries;
- take note of the call to improve and make better use of the available tools to achieve better regulation; make systematic use of science-based impact assessments and develop new guidance and technical methods that ensure a robust scientific approach across EU regulations that have an impact on the metals sectors; and finalise development of the concept of 'one substance, one assessment'.

Coherent legislation

The metals sectors strives for coherence between new legislative changes and for a high level of agreed targets and objectives across different policy areas. Areas of particular importance in this respect include: (i) energy and climate change policies, and their impact on the competitiveness and resilience of EU industry (link to building block 1, 'Sustainable competitiveness'); (ii) the Critical Raw Materials Act and the consequences of chemicals policy (e.g. REACH Regulation); (iii) waste legislation; (iv) chemicals policy; (v) the Water Framework Directive; (vi) social and employment policies; and (vii) circularity objectives (link to building block 5, 'Access to primary and secondary raw materials'). A lack of coherence between these

[66] https://projects.research-and-innovation.ec.europa.eu/en/statistics/policy-support-facility/psf-challenge/mutual-learning-exercise-industrial-decarbonisation

[67] https://research-and-innovation.ec.europa.eu/strategy/strategy-research-and-innovation/our-digital-future/european-research-area_en

important policy areas for metals can result in high-level EU objectives that are contradictory or difficult, if not impossible, to achieve together.

However, the need for coherence is broader. Mining, processing and recycling projects must all meet local environmental regulations (air and water emissions, safe chemicals and waste management). In Europe, the sector complies with the EU's globally leading standards, but there are also areas where specific legislative incoherencies add to the practical difficulties of opening new projects. The industry supports governments designing robust regulatory frameworks with high protection, while also leaving room for flexibility to adapt policies to the realities of metals and minerals production.

The non-deterioration principle enshrined in the Water Framework Directive and interpreted in the EU's Weser ruling

The recent fitness check of the Water Framework Directive[68] concluded that it is largely fit for purpose. It is sufficiently prescriptive with regard to the pressures to be addressed and flexible enough to adapt to emerging challenges not mentioned in the Directive, such as climate change, water scarcity and pollutants of emerging concern. However, implementation of the non-deterioration principle, an integral part of the Water Framework Directive, has been interpreted since 2015 by the EU Weser case[69]. This has had far-reaching consequences for all types of activities, be it water services, urban wastewater treatment, agriculture, industry, etc.

For the metals industry, this means that any increase in a single metal that may deteriorate the status of a surface waterbody will make it more difficult to obtain a permit for new projects, carry out environmental improvements or, most importantly, invest in new green/fossil-free production processes (deep industrial transformation). This is the case even if the overall quality of the surface waterbody remains satisfactory or does not deteriorate.

One example of contradictory objectives concerning metals is the push for: (i) greater circularity; and (ii) minimising and substituting as far as possible substances of concern[70] (SoCs) in recycled material streams e.g. metal scrap. These two objectives are difficult to achieve together in the short term. Only sustainable product design, the clean-up of material streams and many other measures could change the situation going forward. Many metals, alloys and metal compounds meet the definition of SoCs due to their inherent hazards. However, they are currently produced in controlled environments, and their risks are widely managed in the EU through careful use and recycling practices that aim to minimise as far as possible harmful exposure to human health and the environment.

Recommendations by stakeholders include:

- take note of the stakeholder proposal to consider complementing the hazard-based approach with a risk assessment and control for chemicals management;
- invite the new Commission to assess, identify and deliver legislative proposals aimed at eliminating incongruencies, reducing complexity and red tape, while not impeding environmental, social, health and public participation standards;

[68] OJ L 327, 22.12.2000 , p. 1–73, https://commission.europa.eu/publications/fitness-check-water-framework-directive-and-floods-directive_en

[69] Case (C-461/13), https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A62013CJ0461

[70] Defined (non-legally binding) in the Chemicals Strategy for Sustainability as 'substances having a chronic effect for human health or the environment (Candidate list in REACH and Annex VI to the CLP Regulation) but also those which hamper recycling for safe and high quality secondary raw materials.' A second (legally binding) definition will result from the European Sustainable Products Regulation.

- continue involving all stakeholders in discussions on the overall regulatory framework to help identify lack of coherence and/or missing links between policies;
- improve collaboration between/within EU institutions, industry, social partners and civil society to improve coordination of regulatory work and avoid contradictory proposals, following a whole-of-society and whole-of-government approaches;
- work towards a better recognition of a value-chain perspective and overall life cycle approaches when developing regulatory actions, such as when addressing the substitution of chemical substances;
- use an integrated approach to sustainability. Secure a high level of protection of workers, consumers and environment, while promoting and maintaining a viable European industry.

Managing the regulatory burden on EU companies

Many useful and valuable policy tools already exist and have been in use for many years (legislation on chemicals/products, workplace, industrial emissions, water, waste, recycling, etc.). These can be further simplified without losing scientific quality or adjusted and better implemented and enforced based on the extensive experience gained in the past 10-15 years. There is value in reducing the regulatory burden and increasing predictability for EU companies as it would lead to improved competitiveness.

Due consideration will need to be given to the proportionality of new measures with respect to benefits sought, including environmental and social benefits. Likewise, potential and related compliance costs should be duly assessed and taken into consideration among different policy proposals. For example, in implementing the revised Industrial Emissions Directive[71] (IED 2.0), the integrated approach to pollution prevention and control should be safeguarded and cross-media effects always evaluated when more stringent emission values are considered. Any new technology envisaged, under the Industrial Emission Directive or other legislation, should undergo thorough scrutiny and cost-effectiveness analysis beyond theoretical feasibility, while also considering the environmental benefits and social benefits (e.g. public health). High compliance costs can have a significant and adverse impact on the competitiveness of EU companies compared to counterparts in other regions that are not subject to equivalent measures and regulatory frameworks. These costs can also hinder companies' efforts to innovate towards greater resource efficiency and circularity but can also discourage investors from committing to new activities.

Lowering the EU's high environmental, social and health standards is not a viable solution. Therefore, non-EU companies willing to access the single market should be held to the same standards to ensure a level playing field.

EU regulations can also apply to those outside the EU, and efficient enforcement is required to keep a level playing field so that companies inside the EU are not unfairly disadvantaged. Examples include developing a harmonised EU framework for due diligence and ensuring its application to third-country companies operating within the EU, enforcing chemicals legislation applied to imported products and enforcing the Waste Shipment Regulation[72].

Recommendations suggested by stakeholders include:

[71] Directive (EU) 2024/1785, OJ L, 2024/1785, 15.7.2024

[72] OJ L, 2024/1157, 30.4.2024, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32024R1157

- take note of stakeholder proposal to explore opportunities to improve and/or better implement existing EU regulatory tools before introducing new ones;
- strive for proportionality with respect to costs and benefits;
- consider improving enforcement of legislation – particularly with respect to those outside the EU who compete with companies inside the EU (overlap with recommendations in building block 1 on 'Sustainable competitiveness');
- make better use of digital tools to minimise the administrative burden on EU companies and encourage public authorities to increase staff numbers;
- explore synergies between reporting obligations coming from different legislative texts to make reporting requirements smarter and more efficient, avoid unnecessary duplication of work and excessive reporting, while ensuring that all mandatory information is reported in a clear and transparent manner; there must be consistency with other major EU reporting rules (e.g. The Corporate Sustainability Reporting Directive and The Corporate Sustainability Due Diligence Directive);
- consider starting an 'environmental and social standards diplomacy', aiming to work together with like-minded countries to promote common high environmental and social standards.

Speeding up the permitting process

Mining projects typically take 15-18 years to come online in Europe[73]. The EU Critical Raw Materials Act sets maximum deadlines of 15-27 months[74] for strategic projects, which aim to help reduce this bottleneck. However, the are no rules on what will happen to a mining project if the 27-month deadline passes. Furthermore, permitting procedures are complex, often fragmented and face risks of derailment at any stage. In particular, permits are issued at local level, and in some Member States there is not much administrative capacity and experience in dealing with permitting procedures as there have been no new mining projects commissioned in recent decades. Without additional administrative capacity, there is a risk that very few of the EU's active projects today will be online by 2030.

There are many other areas where faster permits are needed. These include: (i) new, low-carbon production processes (including at pilot/demonstration scale and industrial scale); (ii) expanding capacity of existing plants through new production lines; (iii) new metals recycling plants; (iv) new installations for production and storage of green hydrogen; and (v) further deployment of electricity grids. The framework governing carbon capture and storage facilities is also highly fragmented (link with building block 6, 'Infrastructure'). The Net-Zero Industry Act provides a framework intended to accelerate permitting procedures in industrial sectors; its implementation will determine whether its approach is effective in this respect.

In 2024 the Commission launched European Innovation Centre for Industrial Transformation and Emissions (INCITE)[75] that has the role to assess the maturity of innovative technologies linked to decarbonisation, resource efficiency, circular economy and depollution, looking at both environmental and economic aspects. Techniques considered ready for use are incorporated in the Sevilla Process, the mechanism that has supported public authorities in granting industrial operating permits in the EU for the last 25 years. INCITE is covering all the industrial sectors under the Industrial Emissions Directive (IED) with an initial focus on energy-intensive industries. One of the objectives of INCITE's work is to ease the administrative burden for Member States related to permitting of installations or, from the industry

[73]https://www.spglobal.com/marketintelligence/en/news-insights/research/average-lead-time-almost-18-years-for-mines-started-in-2020-23.

[74] The total duration of the permit granting process should not exceed 27 months for extraction projects and 15 months for processing and recycling projects.

[75] https://innovation-centre-for-industrial-transformation.ec.europa.eu/

perspective, to support frontrunners by unlocking flexible permitting conditions as part of the IED implementation.

Delays in permitting can turn an economically viable project into a postponement or failure and can be a further deterrent to metals sectors investors. Link to building block 4, 'Investments and funding'.

Recommendations by stakeholders include:

- implement the new rules under the Critical Raw Materials Act to accelerate permitting for strategic projects (link to building block 5, 'Access to primary and secondary raw materials');
- take note of the call to set up a timely and streamlined mineral exploration licencing and licence renewal process to make it more attractive for inward investment into EU mineral exploration projects and reduce legal and political risks;
- address permitting bottlenecks to encourage and facilitate investments in new facilities – e.g. for mines, processing plants, recycling plants;
- take note of the call to join up permitting of Technology Readiness Levels (TRLs) for new low- and near-zero carbon processes to ensure that the entire innovation, scale-up and industrial roll-out process is addressed efficiently (link to building block 3, 'Support to R&I, production techniques and technological solutions');
- make better use of digital tools to speed up permitting procedures and encourage public authorities to increase staff numbers;
- ensure that permitting procedures deliver sound environmental and social assessments and that the public concerned is meaningfully involved, so as to ensure the highest public acceptance including the right to say no.

3. SUPPORT TO R&I, PRODUCTION TECHNIQUES AND TECHNOLOGICAL SOLUTIONS

Academia, universities, research organisations and innovators have an important role to play in facilitating industrial transformation through research and innovation (R&I) activities. However, industry and regulators also have a role to play in better communicating and raising awareness of industrial transformation because mining and metallurgy as topics for study and research have decreased in popularity in recent years.

The ERA low-carbon technology roadmap[76] in energy-intensive industries and the Mutual Learning Exercise on industrial decarbonisation prompted the conceptualisation of a R&I Deployment Agenda with a package of R&I policy measures on knowledge valorisation actions for boosting industrial R&I demonstrators and mobilising engagement and investments of relevant R&I stakeholders. The overall aim of the R&I Deployment agenda for energy-intensive industries is to contribute to efficient steering of available public funding under Horizon Europe in close synergies with other public programmes (notably Innovation Fund), to enable sufficient scaling up viable industrial demonstrators in line with agreed climate neutrality targets for 2030 and 2050. The current situation of R&D&I in metals processing points to a not so good outlook for all ERA Roadmap low-carbon technologies. The EU ranks in third position over the main seven world regions including US, China, Rest of World, Japan, Soth Korea, United Kingdom.

The EU has a variety of R&I funding programmes, with the Horizon Europe framework programme the best-known example. It includes relevant public-private partnerships such as Clean Steel or Processes4Planet. Ensuring the availability and access to European research and technology infrastructures are also key elements to foster the metals sectors' research and innovation capacity and competitiveness. There are also other schemes such as the Research Fund for Coal and Steel, the EU ETS Innovation Fund, the Global Gateway and initiatives under the European Green Deal that support EU companies and regions in transition with R&I funding. Moreover, support to Member States has been stepped up in the last 2 years, with large amounts of State aid provided to facilitate and de-risk the deployment of innovative technologies in order to decarbonise steelmaking and produce renewable hydrogen. These various schemes support the metals sectors' innovation potential at different stages of

> The Clean Steel Partnership was formally launched in June 2021 and the Memorandum of Understanding was signed by representatives of the Commission and the European Steel Technology Platform. The partnership is a mechanism for research and innovation to pilot and demonstrate breakthrough technologies up to Technology Readiness Level (TRL) 8 that can reduce CO_2 emissions stemming from EU steelmaking. Aligned with the European Green Deal targets, the partnership supports EU leadership in achieving the proper knowledge to transform the steel industry into a carbon-neutral one, serving as a catalyser for other strategic sectors. By 2027 it will implement at least two demonstration projects that could cut CO_2 emissions by 50% compared to 1990 levels and achieve TRL 8 by 2030 in at least 12 areas funded by the partnership. The main ambition is to reduce CO_2 emissions by 80-95% by 2050, ultimately achieving carbon neutrality. The Clean Steel Partnership is unique due to its two financing pillars, Horizon Europe and the Research Fund for Coal and Steel, which have been largely used for incremental research funding until now.

[76] https://research-and-innovation.ec.europa.eu/research-area/industrial-research-and-innovation/era-industrial-technology-roadmaps_en

technical readiness, funding theoretical research, technical demonstrations, industrial demonstrators and the full-scale deployment of breakthrough technologies.

Further details on support to R&I, production techniques and technological solutions is available in the Annex 2.

Some of the metals sectors, e.g. aluminium[77] and copper[78], have already published sectorial technology roadmaps for decarbonisation and increased circularity, other sectors should publish newly prepared or updated sectorial technology roadmaps.

Recommendations suggested by stakeholders grouped by Technology Readiness Levels (TRLs):

Conceptualisation of new techniques and technological solutions (TRL 1 to 5)

- publish metals industry technology roadmaps for decarbonisation and increased circularity;
- take note of the call to adjust the SSbD framework to be 'safer and more sustainable by design' and more easily applicable to metals so that the full life cycle of chemicals and materials is adequately covered. For example, reassess the need for the hazard-based 'cut-off' in step 1 of the framework;
- take note of the call to innovate safety testing and chemical risk assessment methods tailored to metals (link with building block 2 'Regulation & Public Governance').

Development of new techniques and technological solutions (TRL 6 to 7)

- take note of the call to increase cooperation between research institutions and universities and industry, encouraging applied research and access to relevant research and technology Infrastructures, and targeting key enabling technologies for industry;
- consider engaging in public-private partnerships (e.g. Processes4Planet and its initiatives, Hubs for Circularity) to develop and demonstrate energy efficiency and climate neutrality, circularity and zero-pollution metals industry processes;
- take note of the call to ensure appropriate financial and regulatory support [79] between different levels of technology readiness, including by establishing a community of practice to facilitate the authorisation for first-of-a-kind installations for low and near zero carbon industrial technologies;
- co-implement the Strategic Research and Innovation Plan, Strategic Materials Agenda and Strategic Research and Innovation Agenda of the European Technology Platform on Sustainable Mineral Resources to guide future R&I priorities.

Development of new techniques and technological solutions (TRL 8 to 9)

- consider active involvement of the European Innovation Centre for Industrial Transformation and Emissions (INCITE) on emerging processes or techniques for decarbonisation, clean-up and/or increasing circularity in the sector, It is expected that the industry provides data to enrich the knowledge base of INCITE;

[77] Aluminium (link)

[78] Copper (link)

[79] Subject to compliance with applicable State aid rules.

- consider assessing the potential for, and designing the scope of, cooperation among future potential users to address the investment gap so that innovative low and near zero carbon technologies can be brought to the market in a timely manner;
- support the development, commercialisation, deployment and uptake (including through ‘market pull’ and pre-commercial procurement) of new techniques and technological solutions.

4. INVESTMENTS AND FUNDING

As an energy-intensive sector enabling the green and digital transition, the metals sectors need to increase investments to support their own transition to low and near zero carbon production processes and ensure materials supply in increasing volumes for other sectors.

The scope of this building block includes mining and metals sectors investments relating to:

- sustainable growth in EU capacity for mining, refining and primary production [80], while preserving a high level of human health and environmental protection;
- decarbonisation of processes, including associated R&I needs and production costs;
- access to sufficient quantities of reliable, renewable and low-carbon energy at globally competitive prices;
- funding and financing of exploration and mining to secure primary raw materials supply;
- increasing the circularity of the sector by design for reuse, recycling and higher quality of metals recycling and higher scrap utilisation rates, including for critical raw materials (this is covered in building block 5 'Access to Primary and Secondary Raw Materials');
- human capital, the Just Transition and skills, including reskilling and upskilling with regard to digital and green skills, requires investment.

Given the long asset life and long-term investment horizon in the sector, a stable and supportive policy environment is key to incentivising investments with predictability. Attention must be paid to the international competitiveness of EU companies (link to building block 1 'Sustainable competitiveness'). However, today some of the EU's existing mining and metals production capacity is at risk of 'leakage' outside the region due to the simplicity and predictability of the latest support measures provided by other jurisdictions. According to the Report by Mario Draghi[81], Critical Raw Materials are subject to a global race to secure supply chains and Europe is currently falling behind. Japan Japan[82], South Korea[83], Canada[84] and Australia[85] have all announced critical minerals investment packages in the last few years.,

Investment needs in the sector

The sector is facing specific challenges in terms of investment and innovation. First, mining and metals projects require in general high capital for initial investments at early stages in their life cycle. The investment needs in mining are particularly high at the very beginning during the exploration phase, which is generally associated with high costs and high risks. Second, innovative, carbon-neutral processes like the direct reduction of iron ore with hydrogen, will require pilot and demonstration plants and will take time to scale up and break even. Third, the roll-out of other technologies, such as those for low-carbon electricity, natural gas using CCU or CCS and hydrogen-based low-carbon metals production, is expected on an industrial scale in the near future. The combination of high costs and long development cycles for new technologies creates commercial uncertainty. This adds to uncertainty over the development and adoption decisions of other players (e.g. downstream users) across the value chain. The

[80] This also covers the reopening of currently curtailed production.

[81] "The future of European competitiveness: Report by Mario Draghi". See link.

[82] Japan's new international resource strategy to secure rare metals / Special Contents -Energy Japan- / Agency for Natural Resources and Energy

[83] Press Releases < PRESS CENTER - Ministry of Trade, industry and Energy

[84] The Canadian Critical Minerals Strategy - Canada.ca

[85] Critical Minerals Strategy 2023–2030 | Department of Industry Science and Resources

dismantling or rebuilding of existing plants may be opposed by shareholders if these assets are not fully depreciated and are still generating revenue (stranded assets).

High capital costs are likely to be combined with significantly higher operating costs for low and near zero carbon production processes, in particular due to the shift towards decarbonised energy sources such as renewables, renewable and low-carbon hydrogen, CCU, CCS and other low-carbon technologies. Additional capital and operating costs (including energy) of new low and near zero carbon processes may require some form of support to create a business case. Part of the additional costs will need to be shared across value-chain participants, although this may not be sufficient. Lead markets for sustainable (low and near zero carbon) products and/or financial public support may also be needed, including social and green criteria in public procurement contracts.

Access to primary (including low and near zero carbon) and secondary raw materials is key for the EU green and digital transition. To date, there is no adequate financing provided by e.g. the Critical Raw Materials Act that is aligned with its 2030 production benchmarks. Furthermore, unlike other regions the EU funds few raw materials projects in resource-rich third countries. In addition to Innovation Fund support to reduce or/and use critical raw materials more efficiently, stakeholders suggest to set up a Raw Materials Bank inspired by the Hydrogen Bank to provide time-limited, output-based support applicable to both the capital and operating costs of strategic projects chosen during the implementation of the Critical Raw Materials Act.

Key recommendations suggested by stakeholders include:

- Consider increase of funding at EU level of related R&I programmes and activities, prolong the Clean Steel Partnership under Horizon Europe, support the Co-funded Partnership on Raw Materials, and secure funding for the sector in the upcoming Framework Programme for Research and Innovation (FP10) and in other relevant initiatives.
- Take note of the call for the need to ensure that financial support is always linked to clear intermediary milestones aimed at complying with the EU environmental and social targets (e.g. climate neutrality by 2050).
- Consider providing financial support for retrofits and transformation aimed at effective and innovative low and near zero carbon technologies, sustainable solutions and products.
- Consider creating a dedicated and strong public funding tool (e.g. Competitiveness Fund) at EU level to support the industrial transition, including a strong focus on raw materials and circularity along the entire value chain in order to balance actions taken in other regions, while respecting the single market rules and avoiding fragmentation.
- Take note of the call for the need to promote, beyond the Innovation Fund, within the EU and among Member States the use of EU ETS revenues to support industrial scale projects and the decarbonisation of sectors exposed to international competition (supporting both capital and operating costs).
- Take note of the call to dedicate part of the financial resources from the Carbon Border Adjustment Mechanism to sectors covered by the mechanism in order to support capital investment and operating costs linked to their decarbonisation, with conditionalities on Just Transition planning to maintain and create good-quality jobs.
- Consider launching a dedicated Global Gateway raw materials investment plan to secure access to overseas projects backed by the European Investment Bank, export credit agencies, development finance institutions and others. Ensure that third-party key stakeholders, including workers' representatives, are involved in all planning and decision-making.

- Consider incentivising the build-up of knowledge and expertise among financial market participants on raw materials funding matters.
- Consider securing adequate funding beyond 2027 to support the transition and less developed regions in their efforts to decarbonise their basic metals industry.

Public funding

When market incentives and regulation are not sufficient to drive investments, public funding can be a way to limit the risk of investment. Several EU funding programmes already support investment to achieve the twin transition of the metals industry [86] (e.g. 10 large clean steel projects have received public support, either via state aid or via the EU Innovation Fund). Stakeholders stress that access to those funding mechanisms should generally be made easier and that all resources linked to the European Green Deal should be increased, with appropriate social and environmental conditionalities put in place [87].

To achieve the EU's mid- and long-term targets, investment gaps need to be urgently assessed, especially in the context of the crucial EU funds that will come to an end in 2026. Public de-risking of private investment into new and clean technologies, including clean steel and other base metals, is essential, and government funding must also play a crucial role in leveraging private investment. Stakeholders note that multiple analyses [88,89,90]have shown that tight fiscal rules will impede climate investments in the majority of EU Member States. According to stakeholders, central and eastern European countries will be particularly vulnerable as they will not be able to invest in decarbonisation and infrastructure needs [91].

Following the publication of the Transition Pathway for the Chemicals Industry, the Commission developed and published a paper to give improved clarity to stakeholders. It outlines how the EU's funding programmes could contribute to the co-implementation process of the pathway. In particular, the main objectives of this paper are to:

- describe those funding programmes whose objectives and main intervention areas reflect the actions of the transition pathway;
- provide guidance on existing funding opportunities for chemical companies (especially SMEs) and other stakeholders to finance activities contributing to the twin transition.

The paper was welcomed by stakeholders and could be adapted to make it applicable to the metals industry. Key recommendations suggested by stakeholders include:

- Consider adapting the Commission's EU funding overview for the mining and metals sectors.
- Take note of the call to ensure that information related to public financial support to private companies is always public, particularly on compliance with environmental and social goals.

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[86] Such as the European Innovation Council, the European Institute of Innovation and Technology, InnovFin (European Investment Bank), the European Structural and Investment Fund, the Just Transition Mechanism, InvestEU, the Innovation Fund, the European Fund for Strategic Investments, React-EU, Horizon Europe, the Digital Europe Programme, and The European Social Fund (for reskilling the workforce).

[87] https://antwerp-declaration.eu/pdf/declaration.pdf

[88] https://www.eib.org/attachments/lucalli/20230323_economic_investment_report_2023_2024_en.pdf (p. 7, p. 80, pp. 200 and after)

[89] https://www.ecb.europa.eu/press/fie/box/html/ecb.fiebox202406_01.en.html

[90] https://www.eea.europa.eu/publications/investments-into-the-sustainability-transition

[91] IndustriAll, see link

- Keep Member States and stakeholders informed of existing funding opportunities and conditions.
- Consider measures to reduce the administrative burden (at EU and national level) and improve coordination to facilitate access to effective funding for industry.
- Take note of the call to encourage simplification and consolidate mechanisms, platforms and schemes to reduce complexity and lower barriers for industrial players to engage in and benefit from EU initiatives.
- Consider urgently addressing investment gaps and ensuring adequate public funding for clean metals projects with social conditionalities, while preventing over-reliance on State aid, which could create fragmentation in Europe.
- Take note of the call to reassess the fiscal framework for the upcoming years to ensure that public investment in the steel and basic metals sectors is possible.
- Take note of the call to encourage Member States to develop national industrial plans to provide certainty and direct public and private investment. This would also ensure the coherent and strategic use of EU funds such as the Cohesion Fund, the Modernisation Fund and revenues from the EU ETS.
- Consider providing support to strengthen administrative capacities at Member State level in order to ensure comprehensive strategic planning and that all basic metals regions can benefit from public funding.
- Take note of the call to ensure social conditionalities for all public funding to promote decent jobs [92].

Private investment

Private investors are ready to play their part in the twin transition, recognising that the mining and metals sectors are pivotal to the net-zero transition and have a significant influence on other sectors of the economy that rely on the commodities it provides. Investors expect clear financial and environmental, social and governance (ESG) criteria to guide their investments (link to building block 8 'Social Dimension'). Investors want to ensure that commodities necessary for the transition are mined responsibly. Standards such as the Climate Action 100+ Net Zero Standard for Diversified Mining [93] and the OECD Due Diligence Guideline for Responsible Mineral Supply Chains [94] will help investors understand the credibility of mining company transition strategies, enabling them to improve their ability to assess their individual portfolio risks and opportunities. On the production of metals, investor groups have developed sector strategies, e.g. Investor interventions to accelerate net-zero steel [95]. These build on the work of the Energy Transitions Commission, the International Energy Authority, McKinsey and others. Through such strategies, investors will look to allocate capital to companies with credible transition plans and projects with verifiable progress.

The perspective of the private investment community is therefore valuable and useful for this pathway. Key recommendations from investors include:

- **Industry wide**
    a. Use public-private financing partnerships to de-risk investments in early-stage technologies.

[92] https://www.etuc.org/sites/default/files/document/file/2024-07/EN%20-%20Adopted%20Resolution%20-%20Social%20conditionalities%20for%20social%20progress.pdf

[93] https://www.climateaction100.org/wp-content/uploads/2023/09/Climate-Action-100-Net-Zero-Standard-Diversified-Mining.pdf, September 2023.

[94] https://www.duediligenceguidance.org/

[95] https://www.climateaction100.org/approach/global-sector-strategies/steel/

b. Improve the alignment of objectives along entire value chains, e.g. put together cross-sector working groups on how material efficiency can be significantly improved.
c. Adopt a multi-stakeholder approach to removing barriers to technological roll-out and addressing costs of unproven technologies.
d. Draw inspiration from other sectors, e.g. the Business Investment Platform of the EU Battery Alliance [96], which connects investors with industrial initiatives.

- **For companies**
  a. Develop and publish ambitious, credible and transparent transition plans for net zero with details on the technologies to be employed.
  b. Support the development and convergence of international certification standards for sustainable 'green' metals production and commit to adhering to those standards.
  c. Ensure full supply chain transparency (link to building block 8 'Social Dimension').
- **For investors**
  a. Identify the largest purchases of metals and undertake a systematic engagement process to obtain public commitments to buy 'green' metals.
  b. Provide capital explicitly to finance low-carbon production processes.
  c. Support policies consistent with accelerating the transition to net zero.

Sustainable finance (EU Taxonomy)

The EU Taxonomy defines a common language that helps the financial sector identify sustainable economic activities (i.e. already 'green', or transitioning towards it). It aims to define which economic activities can be considered environmentally sustainable, with reference to six different environmental objectives [97], to help channel investments towards them, provided they do not significantly harm any of the other objectives and comply with the minimum social safeguards. For non-ferrous metals, only the manufacturing of aluminium is currently explicitly covered by the taxonomy through the delegated act on climate change mitigation and adaptation[98]. However, several activities in the delegated act on the circular economy cover reuse and recycling activities that also encompass metals. As for other non-ferrous metals, work is currently ongoing in the Platform on Sustainable Finance.

On criteria for mining, industry stakeholders say that any criterion proposed needs to recognise and function within the unique set-up of each mine, for which there are limitations set by nature – geology, environment, climate, location etc. If not, there is the risk that valuable deposits may be left untapped. Criteria should ideally be unbiased on how a deposit is accessed (e.g. open pit, underground or brine mining operations) and on geography (the impact of mining not only depends on the deposit and its surroundings, but also on where it is found due to weather conditions, rainfall, water availability, droughts etc.). Activity-based criteria would avoid favouring particular business models, particular metals (it is the mineralisation that is extracted, not the metal), and particular 'grades' of deposit.

Key recommendations suggested by stakeholders include:

[96] https://www.eba250.com/actions-projects/business-investment-platform/

[97] Climate change mitigation, Climate change adaptation, Sustainable use and protection of water and marine resources, Transition to a circular economy, Pollution prevention and control, Protection and restoration of biodiversity and ecosystems.

[98] OJ L, 2023/2486, 21.11.2023, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32023R2486

- ensure that the EU's sustainable finance agenda recognises Europe's metals production as an essential part of supplying the energy transition and EU climate neutrality goals;
- improve the usability of the technical screening criteria in taxonomy to attract more private investments, while preserving the high environmental standard of the taxonomy;
- use technical screening criteria across relevant climate and environment objectives that are ambitious, while at the same time realistically achievable and implementable; they are developed based on life-cycle considerations, taking into account local specificities and factors outside an operation's control, ensuring a level playing field and reflecting company performance on a global level;
- develop robust and workable criteria for mining and refining for both 'substantial contribution' and 'do no significant harm', in line with the objectives of the Critical Raw Materials Act and the integrity of the taxonomy.

Investment estimates for the sector

The table below presents the available estimates provided by stakeholders [99] of investment needs for the mining and metals sectors (n/a = not available).

Life cycle stage	Capacity growth	Decarbonisation of processes
Mining	€100 bn by 2050	
Primary production – ferrous	Due to carbon leakage, capacity utilisation fell from 170 million metric tonnes in 2017 to 136 tonnes in 2022.	Needed by 2030: [100] CAPEX €31 bn OPEX €54 bn
Production – non-ferrous metals and alloys	Aluminium – n/a Copper – €12.5 bn by 2050 Gallium – €50 m to become self-sufficient for supply Other metals – n/a	Aluminium – €33 bn by 2050 Copper – €5.3 bn by 2050 (of which €1.3 bn by 2030) Other metals – n/a
Recycling	€5-€8 bn by 2030	n/a

Additionally, the sector needs access to large quantities of decarbonised electricity at globally competitive prices (link to building block 1 'Sustainable competitiveness'). The costs of producing, storing and supplying this energy are very high, but apply much more broadly than to the metals sectors alone. If this is not achieved, it is likely that the necessary investments in the EU mining and metals sectors **will not materialise** because the competitiveness of the sectors with respect to other regions will be adversely affected.

[99] These are gathered at industry association level. Additional information is available from individual companies on specific investments at particular locations. These may or may not be representative of investment costs at other sites because cost requirements can be different per location and per region.

[100] 60 projects, 82 million tonnes of CO_2 reduction annually by 2030, TRL of at least 7 out of 9.

5. ACCESS TO PRIMARY AND SECONDARY RAW MATERIALS

European demand for metals can be supplied through two routes, which are often intertwined:

1. Primary supply, which is metal production from raw ore through mining and processing.
2. Secondary supply, which is metal production from recycled material.

For almost all metals, the annual global demand and in certain instances also the purity and quality requirements are higher than the volume and quality that can be produced from the recovery and remelting of scrap alone. With the energy and sustainability transition being a commodity transition with exponential demand increases, a large amount of the metals needed annually must be produced from virgin metal ores, after having implemented all circular solutions (e.g. increased durability, reuse, recycling) that take priority due to their economic and environmental benefits. With greater focus on the provenance and footprint of the raw materials in products, low-carbon ores and concentrates are penetrating and gaining more market share. Furthermore, an ore is not a single commodity but comes with a host of by-products that can be separated, processed, refined and valorised. It is therefore very important that the metals industry has access to these primary raw materials, produced by responsible mining and processing that respects environmental laws and upholds human rights.

Metals are permanent materials [101], meaning they are used but not consumed. They are durable, reusable and highly recyclable without a significant loss of properties. While the reuse of metals is not yet widely implemented, recycling of end-of-life products is already an important driver for supply in established metals markets. Traded metal scrap is considered waste, but is also the fundamental secondary raw material to produce decarbonised metals. The future availability and accessibility of scrap is a vital issue for the metals industry in the coming decade. Without the secure and affordable availability of good-quality scrap, it will be impossible for the EU metals industry to achieve its goals: strategic autonomy, circular economy, climate neutrality by 2050, competitiveness, and energy and resource saving. Recycling metals typically uses between 5% and 30% [102] (depending on the metal) of the energy that is needed to produce new metal from using primary raw materials with no recycling.

The metals industry and in particular state-of-the-art metal recyclers are heavily engaged in increasing metals recovery and improving the quality of recovered materials. However, modelled assumptions suggest that the rapid increase in metals demand in the next 15 years needs to be supplied to a large extent by new primary metal as the secondary supply can only take on a more prominent role as of 2030/2040 [103]. The secondary supply potential can be limited by the volume of material already in use in society and the current technological and economic viability of its recovery, with the quality and purity requirements in some end-use applications also being relevant. Once clean energy technologies are available to recycle and the supply potential from this stream is reached, a limited supply will still need to be provided through the primary supply.

The increasing leakage of metal scrap and metal-containing waste from the EU (trade flows but also illegal activities) represents a loss of economic opportunities and value for the EU

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[101] Aluminium and the concept of Permanent Material (european-aluminium.eu)

[102] 5% for aluminium – Rio Tinto (2021); WVMetalle (2015); 10-20% for copper – International Copper Association (2017); 30% for steel – World Steel (2016).

[103] Metals for Clean Energy: Pathways to solving Europe's raw materials challenge. KU Leuven, April 2022.

waste treatment and metals industry. It therefore also constitutes a loss of resilience, which circular solutions within the EU could aim to address.

Digital transformation will play an important role in tracking the various metals and material flows in complex supply chains and value chains.

The potential for extending the lifetime and reuse of metallic products will also play a role in optimising the demand for metals.

The overspecification of products and materials is detrimental to reuse and recycling and should be avoided where feasible. The complexity of products is not always driven by the attempt to cover basic needs, but rather by marketing reasons, artificial replacement rates and planned obsolescence.

Further details on access to primary raw materials is available in the Annex 3.

Recommendations by stakeholders on primary raw materials include:

- start considering access to primary raw materials as more than a mere procurement management issue but as a strategic pillar of prosperity – and recognise the value of EU domestic mining production, if done in an economically, environmentally and socially sustainable manner;
- put in place an EU-wide campaign to demonstrate the political and strategic necessity of mining, while emphasising the need to conduct such operations in an environmentally and socially sustainable manner, and encompassing some demand-side optimisation of social standards and Just Transition dimensions;
- ensure the internationally competitive availability of ores suitable for low and near zero carbon production;
- execute the strategic implementation plan from the European innovation partnership on raw materials;
- implement the Critical Raw Materials Act's new rules to accelerate permitting for strategic projects at Member State level (link to building block 2 'Regulation & public governance') and adopt without delay the first list of strategic projects, including projects at extraction stage, to contribute to the CRMA benchmarks;
- incentivise private exploration: in addition to the Critical Raw Materials Act, provide for a positive exploration framework and funding (link to building block 4 'Investments & funding');
- recognise sustainable mining and processing in public procurement and tenders as well as in the sustainable finance framework (link to building block 4 'Investments & funding');
- EU raw materials fund: provide for a de-risking fund for raw material projects similar to the Juncker Plan of 2015 (link to building block 4 'Investments & funding');
- facilitate permitting for ancillary services and infrastructure for mining and processing operations, such as railway lines and electricity grids (link to building block 6 'Infrastructure'), while ensuring high environmental standards;
- continue developing strategic partnerships with raw materials-rich countries to secure resources for downstream industries where the domestic primary raw material supply will not be sufficient, while acknowledging their right to use resources for their own transition and their aspiration to move up the supply chains.

Circular economy action plan

The circular economy is an essential policy area as part of the European Green Deal. It is an approach that targets the closure of material loops and their return on the market. Resource efficiency is one of the underlying concepts. Eco-designing of products by manufacturers in a

proper way can significantly contribute to this, e.g. by creating products that can be used for longer, be reused, repaired or have a long life. The plan lists seven key product groups, including many that contain metals, e.g. packaging, batteries & vehicles, ICT & electronics, construction & buildings. High-quality recycling is widely referenced with the idea of securing hazard-free recycling cycles.

From the actions featured in the plan, the new Batteries Regulation [104], the recently published Waste Shipment Regulation [105] and the Commission proposal for the End-of-Life Vehicles Regulation [106] are of key importance for the metals sectors and an opportunity to increase waste flows directed to high-quality recyclers.

The recently adopted Ecodesign for Sustainable Products Regulation [107] also stems from the Circular Economy Action Plan. It extends the current Ecodesign Directive with a complete set of product sustainability and information requirements, and the number of products covered. The revised Construction Products Regulation also allows for recycled content obligations that could support the circularity of materials. The newly announced initiative, Circular Economy Act[108], will contribute to creating market demand for secondary materials and a single market for waste.

All of these developments are also strongly connected to various raw materials challenges and complement the EU Critical Raw Materials Act.

Access to secondary raw materials – circular economy

Scrap

Metals have the ability to be remelted many times without significant loss of inherent properties/ They are therefore fundamental to the circular economy. Thanks to their unique properties, metals are the most widely recycled materials in the world. Nevertheless, the demand for metal scrap exceeds availability due to increasing demand and longevity of its many uses. According to the OECD [109], 'the key constraint on increased secondary production is the finite amount of scrap which emerges in waste streams each year'.

As a result, the metals sectors and authorities should focus on measures that lead to the increased availability of high-quality scrap, including through product design, higher recycling rates, better sorting, dedicated recycling loops, as well as recycling it in the most efficient way. As stated in the Circular Economy Action Plan[110], the EU circular economy must be strengthened by boosting metals collection, separation and recycling, and by increasing recycling rates from key product value chains including electronics, batteries, automotive, construction, mechanical engineering, metalware and packaging.

Efficient management and the use of scrap from manufacturing processes also has an important role to play. This should focus on reducing the amount of manufacturing scrap and

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[104] Regulation (EU) 2023/1542.

[105] Regulation (EU) 2024/1157.

[106] COM(2023) 451 final.

[107] Regulation (EU) 2024/1781, link.

[108] Political guidelines for the next European Commission 2024−2029, link

[109] McCarthy, A. and P. Börkey (2018), 'Mapping support for primary and secondary metals production', OECD Environment Working Papers, OECD Publishing, Paris, http://dx.doi.org/10.1787/19970900.

[110] COM/2020/98 final, https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1583933814386&uri=COM:2020:98:FIN

improving process efficiency, including reusing manufacturing scrap as an integral part of the same process.

Similarly, the efficient management of manufacturing waste has an important role to play. This should focus on reducing the amount of manufacturing waste by improving the efficiency of manufacturing processes and, in case of unavoidable manufacturing waste, creating highly efficient collection, sorting and recycling processes to keep valuable materials available to an increasingly circular economy [111].

Mature non-ferrous recycling industries achieve end-of-life recycling rates of 30-60% on average and depending on the metal. On average, 58% of steel and more than 80% of stainless steel produced in Europe is currently made from scrap, while about 37% of the aluminium supplied in Europe comes from recycled sources. However, not all metals are recycled yet on a sufficient scale, with several non-ferrous critical raw materials for example having end-of-life recycling rates of less than 1% [112].

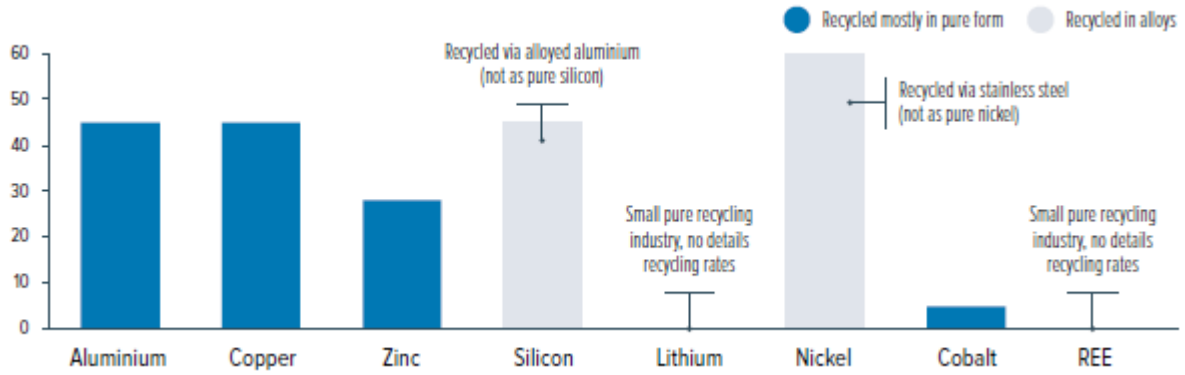

Figure – Global average end-of-life recycling rates for several non-ferrous metals. *Source: Metals for Clean Energy: Pathways to solving Europe's raw materials challenge,* KU Leuven, April 2022.

The recycling process consists of different steps:

- Product design for recycling. Products should be designed to ease their disassembly and dismantling. This means for instance that contamination of metals should be avoided (e.g. copper and steel), and the value of each material should be retained after recycling.
- Collection of end-of-life products.
- Sorting and pre-processing of waste streams. End-of-life products need to be broken up (or cut, crushed etc.) into small pieces to liberate and sort the different mixed materials. Sometimes pure streams can be separated, but often metals and materials are functionally attached to each other and can only be parted via metallurgical processing. However, metals do not always need to be recovered on a pure commodity basis; alloyed metals will often be recycled as alloyed metal (stainless steel, galvanised steel, aluminium alloys, brass…).
- End processing of metals by metallurgical processing of the sorted waste streams. Pyrometallurgical and hydrometallurgical technologies are used to separate the

[111] Regulation (EU) 2024/1157.

[112] Examples include bismuth, boron, gallium, lithium, rare earth elements. The end-of-life recycling rate can be low for different reasons, for example: lack of established and/or economic recycling channels; high loss rates across different life cycle phases; use in very long-lived applications. 'Losses and lifetimes of metals in the economy', Alexandre Charpentier Poncelet, Christoph Helbig, Philippe Loubet, Antoine Beylot, Stéphanie Muller, Jacques Villeneuve, Bertrand Laratte, Andrea Thorenz, Axel Tuma and Guido Sonnemann, Nature Sustainability 2022.

different metals. The flowsheet will depend on the type of waste stream and the metals that are recovered. Economic choices are often made on which materials to recover and which not.

There are several value-chain challenges that prevent metals from being recycled at their optimum level:

- lack of an economic business case or technical challenges when waste streams are too small or the metal content is very low;
- imperfect collection and sorting systems that prevent end-of-life metals from reaching recyclers;
- growing product complexity, miniaturisation (making much smaller versions) and metals mixing, which leads to increased recycling complexity;
- improper treatment of complex products like electronics waste (e.g. through informal recycling operations which leads to material losses) and vehicles due to the lack of separation of parts, components and materials;
- export of low-quality used products and waste to locations where there is a risk that the waste is not recycled or recycled less efficiently;
- limited information on the content of metals and localisation in products, and how best to access them;
- poor distinction and fine separation of parts that contain different metals before shredding;
- limited legal drivers to secure investments in innovative recovery processes.

The secondary metals supply is limited by the amount of metal that is available in waste or end-of-life products as well as the effectiveness of the recycling system. Metals have a varying average lifetime in the economy [113], e.g. 6 months for aluminium in a beverage can, 2 years for speciality metals in electronics, 20+ years for various metals in cars, 30+ years for aluminium, copper and steel in buildings, 100+ years for zinc used in roofing, just under 200 years for gold in jewellery. Given their historical growth rates there is still a gap between available secondary material and demand.

To maximise the supply potential, European players must overcome several bottlenecks in the collection, sorting and recycling systems for all existing and emerging metals waste streams, also taking into account the potential of recovery of those materials from extractive waste. For some non-ferrous metals, action will be needed to meet the Critical Raw Materials Act's 25% recycling target by 2030. For the mature base metals markets (steel, aluminium, copper, zinc), Europe has to increase its current recycling rates to continue recycling optimisation (collection and sorting), on top of some more metal in stock becoming available to recycle. For high-growth markets (silicon in solar photovoltaics, battery raw materials in electric vehicle batteries; rare earth elements in permanent magnets), Europe will need to start/scale up new recycling processes and capacity for treating waste from clean energy technologies. Financing is needed for companies to build up capacity in a challenging period before scrap volumes ramp up quickly after 2030.

The metals sectors need to develop better collection and sorting (what is not collected cannot be recycled) as well as new treatment facilities. There are still many waste fractions that are rich in metals but have low collection rates (urban mining).

[113] 'Losses and lifetimes of metals in the economy', Alexandre Charpentier Poncelet, Christoph Helbig, Philippe Loubet, Antoine Beylot, Stéphanie Muller, Jacques Villeneuve, Bertrand Laratte, Andrea Thorenz, Axel Tuma and Guido Sonnemann, Nature Sustainability 2022.

Non-ferrous and ferrous scrap is already considered a scarce – and therefore strategic – resource, and over 40 countries already apply trade restrictions. However, ferrous scrap is currently the most exported type of waste from the EU – 17.8 Mt in 2022, equal to 55% of all EU waste exports[114]. According to projections of scrap availability and future consumption patterns based on the transformation that the European steel industry will undergo in 2030-2050, there will not be sufficient scrap available to cover EU low-carbon steel production needs. The global shortage of scrap and increasing demand outside Europe risk increasing scrap leakage out of the EU.

As well as opportunities, challenges exist with regard to increased collecting, sorting, treatment and recycling of metals. Certain elements, including some non-ferrous metals, when not managed properly can accumulate in steel or non-ferrous metals and cannot be removed. Today this problem is manageable as a large part of metal production still stems from primary raw materials. As more scrap is used for metal production, this requires more thorough scrap management to avoid tramp elements (elements that cannot be removed easily by current smelting processes and can cause problems as impurities during working processes) entering metals production. For stainless steel, recycling has additional challenges. The key objective is to recover chromium, nickel, molybdenum and other alloying elements in stainless steel scrap. An extra challenge in this is to prevent magnetic stainless steel (ferritic) containing chromium from being lost in the carbon steel recycling.

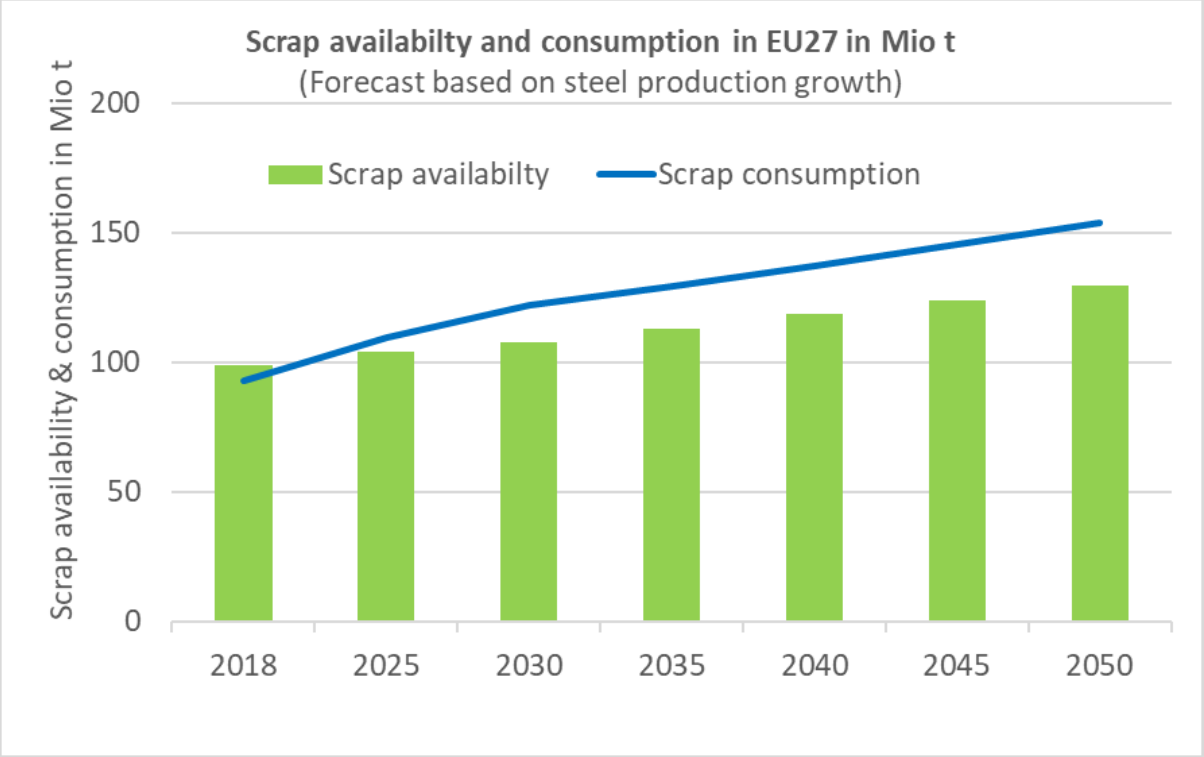

Figure – EU steel scrap availability and consumption projections. *Source: Eurofer.*

Not all destination countries of EU waste have similar ambitions as the EU on environment, health and safety, and social standards. A lot of ferrous and non-ferrous metals embedded in ships, vehicles and electronics that reached their end of life but could have been recycled within the EU are still exported. One of the Commission's objectives is not to ship EU waste challenges to third countries. The EU's waste shipment legislation would benefit from optimisation in order to secure a level playing field for European high-quality recyclers and

[114] Source: Eurostat

remove barriers to intra-EU waste shipments. According to industrial stakeholders, the two major barriers to intra-EU waste shipments and imports are: (i) a burdensome administrative procedure for transporting hazardous waste; and (ii) the lack of harmonised definitions leading to delays for waste shipments, with waste codes and classifications differing across Member States. Addressing these issues will help to establish a level playing field and similar conditions for treatment of waste exported outside the EU, providing more harmonisation at EU level.

The change at international level with the amendments on e-waste codes under the Basel Convention[115] will enter into force on 01/01/2025. After this date, both hazardous and non-hazardous e-waste transboundary movements will be subject to the Prior Informed Consent procedure according to the Basel Convention. Delays in approving the notifications is expected to dramatically increase transport costs (suddenly all e-scraps will be classified as hazardous), especially as the smelters are far from central Europe. A new digital system is being developed, but will be in place at the earliest in 2027. EU industries would therefore like to see a period of 2 years for implementation of the new requirements. This would allow for all parties (e-scrap recyclers, suppliers, national authorities) to prepare for the changes.

The non-inclusion of ferrous scrap in the Critical Raw Materials Act and in the recently agreed Waste Shipment Regulation risks jeopardising the sufficient supply and quality of this valuable raw material. Despite some progress made to improve recycling and export criteria, an important way forward to ensure low-carbon steel and resilient cleantech value chains are made in Europe is to recognise ferrous scrap as a strategic raw material and include it in all relevant legislations. Improvements in monitoring, environmentally sound management criteria and audit obligations for waste shipments are positive, since penalties to ensure enforcement have been watered down there is a need for a robust and effective implementation of the two legislations.

By-products

The use of by-products [116] (not recycled from waste or previous use) is resource efficient because they replace primary materials. The metals industry produces by-products such as slag, sludge and filter dust (for steel: about 34.4 Mt via the ore-based route, and 13.3Mt via the scrap-based route in 2021). These are valuable resources for other sectors, e.g. construction, contributing to industrial symbiosis and creating a circular industrial ecosystem. Over 95% of by-products generated by the steel industry are put to valuable use. For zinc refining, 90% of by-products are valorised (these include sulphuric acid, base metals like lead, copper and cadmium, and minor metals such as silver, cobalt and indium).

Stakeholders' recommendations on scrap, waste and by-products include:

- further develop EU waste collection, the sorting and recycling industry and infrastructure into a leadership position by making it more economically viable in order to secure supply, strategic autonomy and competitiveness, and support the transition described in the European Green Deal;
- ensure that European scrap and waste are directed to high-quality treatment facilities, preferably in Europe, equipped for strategic material recovery;
- develop the pan-EU digital system to electronically exchange data on waste shipments, thereby reducing the administrative burden when obtaining consent to ship waste and improving the monitoring of waste flows (quantities, destinations);
- advance work on the inclusion of new European waste codes for growing waste streams of significant importance and volume, e.g. battery black mass;

[115] The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal was adopted on 22 March 1989, link

[116] As defined in Article 5 of the Waste Framework Directive.

- implement and monitor enforcement of the recently adopted Waste Shipment Regulation;
- recognise ferrous metal waste as a strategic secondary raw material and include it in all relevant legislation to ensure its availability for processing in the EU;
- undertake more thorough waste management in the recycling industry to avoid tramp elements entering metals production through the waste input;
- increase the EU metal recycling sector's access to metal waste by removing barriers to intra-EU waste shipments;
- better address illegal shipments, among others by further clarifying the classification of material containing metals as waste or not, e.g. by establishing clear criteria;
- introduce extra measures and ensure a robust and effective implementation of the legal provisions, to with the aim of guaranteeing that metals waste is only exported from Europe to facilities able to prove their capacity to operate under similar environmental conditions in accordance with the Waste Shipment Regulation on the environmentally sound management of waste;
- facilitate conditions for importing waste batteries and for electrical and electronic waste to be recycled in the EU by properly implementing waste import rules from the Waste Shipment Regulation [117] to maintain a well-functioning, efficient and timely system with appropriate levels of cost and bureaucracy;
- incentivise the maximum valorisation of by-products;
- allow a period of 2 years for implementation of the new requirements under the Basel Convention. This would allow for all parties (e-scrap recyclers, suppliers, national authorities) to prepare for the changes and for the digital system for notifications to be implemented.

[117] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32024R1157.

6. INFRASTRUCTURE

This building block covers the physical and organisational structure and facilities for: (i) energy generation, storage and supply; (ii) storage and transport of CO_2; (iii) transport of raw materials and metals; (iv) collection and pre-processing of secondary raw materials; and (v) collection, storage and transmission of (digital) data in terms of capacity and security. The ambition of climate neutrality – not only in the metals sectors, but also in all other industrial sectors – triggers a higher demand for metals. The transition to decarbonised production and keeping up with the expected increase in demand for some metals, without creating new strategic dependencies, require an overhaul of the existing infrastructure – in terms of both volume (increased capacity) and quality (greater reliability).

Access to energy and primary and secondary raw materials and the corresponding infrastructure are of extreme importance for the metals sectors. The necessary infrastructure will need to be built or scaled up to secure access to energy and raw materials, and in particular to electricity, hydrogen, and recycled ferrous and non-ferrous scrap and other high-value secondary raw materials. Industrial waste materials, such as steel slag, mine tailings or red muds, can react with CO_2 and store mineralised carbon if used in long-lived construction products. Infrastructure will also support both industrial symbiosis[118] and better integration of processes within industrial clusters (e.g. capturing, storing and transporting CO_2 from an emitting plant to a potential user in another industry). The development of such structures could face the following barriers: (i) the lack of infrastructure around certain mining and industrial sites, especially on inland locations, and in central and eastern Europe; and (ii) the slow approval procedures at Member State level for energy and industrial processes. The necessary permitting procedures and infrastructure for energy transition and raw materials diversification must be put in place[119].

Expanding the energy grid is necessary to transport clean and renewable energy from and to all sites, not only those sites close to electricity-generation plants. Bottlenecks must be identified and minimised, and cross-border interconnectors must be put in place to enable the free flow of energy between countries. Existing energy sources must be adapted so that they respond to demand and provide flexible generation units and storage. Progress must be made in new sources of flexibility such as power-to-X[120] and new types of storage (e.g. for (high-temperature) heat, electricity, renewable or low-carbon hydrogen). Under certain conditions, the hyper-intensive nature of the metals sectors in terms of electricity use can help in this respect, by modulating production from electrified processes (e.g. for zinc and primary aluminium metal)[121] to take advantage of periods where supply of renewable electricity is higher than demand. This can help to keep the electricity grid in balance.

Finally, the availability and deployment of carbon capture and storage (CCS)[122] and carbon capture and utilisation (CCU) capacity are essential enablers for climate neutrality, to be used in capturing the residual emissions that cannot be avoided and in decarbonising those production sites where alternative solutions, e.g. electrification or hydrogen use, are not

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[118] Industrial symbiosis is the process by which waste or by-products from an industry or industrial process become the raw materials for another.

[119] Similar to the action 'Facilitate and accelerate permitting procedures for plant investments and participate in communities of practice on permits' under Topic 6.3 'Manage and convert existing assets' of the Transition pathway for the chemical industry.

[120] Technology that converts renewable electricity from solar or wind farms into other forms of energy (e.g. renewable hydrogen, renewable methanol).

[121] This is the 'virtual battery' concept, where renewable energy is stored as a finished metal. Some non-ferrous metals plants can adjust production to produce more metal when it is possible, and less metal when needed.

[122] CCS is a set of technologies that aim to capture, transport and store CO_2 emitted from power plants and industrial facilities.

feasible. For this reason, bilateral agreements could be concluded between countries that ship captured CO_2 and those that receive it, to facilitate the access of landlocked production sites to CO_2 storage sites.

Electricity and hydrogen

The production, storage and supply of large volumes of these two low-carbon energy sources at globally competitive prices are strongly linked to infrastructure aspects, and these are dealt with in building block 1 on sustainable competitiveness.

Recycling

Metal scrap is typically a very good low-carbon feedstock for metals production. Compared to the primary production route, it requires less energy and generates less GHG emissions. Metal scrap should be viewed as a strategic (critical), valuable resource that should be managed carefully. The development of infrastructure to collect, sort, treat, recycle, recover and reuse metals (e.g. improved collection and sorting of alloys) is fully dealt with in building block 5 on access to primary and secondary raw materials.

CCS and CCU

CCS and CCU are effective and necessary solutions, especially for those process emissions that cannot be decarbonised, helping to achieve net-zero GHG emissions in EU while maintaining a competitive, growing and innovative European industrial base. Developing shared CO2 transport and storage infrastructure across Europe will make it possible for these processes to access cost-efficient mitigation options. Some CCU applications can be deployed to permanently store CO2 in products, while others can provide a carbon feedstock for industry as an alternative to carbon derived from fossil fuels. Therefore, CCS/CCU technologies can play a role in preserving industrial activity in EUe and are a key enabler of new products and technologies.

Among the main barriers preventing the metals industry from deploying these technologies is insufficient access to CO2 offtake, transport and storage as well as the lengthy and complex implementation process, especially in this phase of the transition. The Commission, through the Horizon Europe framework programme, has already supported the development of industrial symbiosis in the bio-based industrial eco-systems. More recently, the ETS Innovation Fund has started to support small- and large-scale projects focusing on scaling up the development and use of CCU and CCS technologies and infrastructure. In some specific cases, the Recovery and Resilience Facility has provided support to CCS/CCU technologies used as a supplementary and transition technology for industrial decarbonisation processes. In addition, through local industrial symbiosis (the Hubs4Circularity concept), the CO2 produced by the metals industry can be used in another energy-intensive sector, e.g. by a chemical facility nearby, avoiding the need to scale up infrastructure for transporting and using CO2.

Key recommendations by stakeholders include:

- facilitate cross-border transport in the internal market with harmonisation of weight & dimensions rules for heavier trucks use among Member States;
- in line with the Communication on industrial carbon management, acknowledge and further support the role of CCU/CCS in sectors with hard-to-abate emissions in the absence of other solutions (actions envisaged in the Communication should be rolled out across various EU policies to ensure regulatory consistency);

- continue to use the Innovation Fund to support the deployment and upscaling of CCS and CCU technologies and infrastructure that aim to capture, transport and store CO_2 emissions, in particular unavoidable emissions from industrial processes;
- accelerate approval procedures for new CCS/CCU infrastructure projects.

Digital

The digital transformation of the mining and metals industry and the deployment of available technologies for production and distribution will accelerate the industry's path towards achieving the digital, green and resilience objectives.

The mining and metals industry must increase its use of digital technologies (e.g. the 'internet of things', big data, artificial intelligence, automation, smart sensors, digital twins, and robotics) for product design, process design, more efficient production, and more efficient logistics, e.g. paperless transport; real-time logistics planning and steering; and reducing idle transport capacity.

To take full advantage of the enabling power of digitalisation, the industry requires high-speed and reliable digital infrastructure. There is a need for new standards for digital platforms to enable the exchange of information. The EU's ambition to build a resilient, climate-neutral and green economy cannot be achieved without setting EU standards for digital platforms. These standards must be set in a way that promotes greater technical and semantic interoperability, to ensure sound procedures and a balanced representation of the mining and metals industry. Furthermore, the governance systems for these digital platforms should be designed in a way that ensures the protection of confidential business information. The Commission's new standardisation strategy aims to support these goals by focusing on developing standards and standardisation deliverables to fulfil the standardisation needs and improving the overall governance and integrity of the European standardisation system. This digital shift brings with it both cybersecurity risks and the problem of human resistance to change. The Commission fosters innovation – including in standards – by creating investment programmes such as InvestEU or the Digital Europe Programme.

To support the development and deployment of new and available technologies for the digitalisation of mining and metals, action should be taken building on, in particular, the policies and actions set out in the European strategy for data[123].

Key recommendations by stakeholders include:

- deploy safe, high-speed and reliable digital infrastructure;
- deploy technologies to improve mining and metals-manufacturing processes and data gathering, and apply learnings from other industry sectors.

Transport

Although road transport is still a very important means of transport, a pan-European rail infrastructure would enable a significant modal shift from roads to rail for the transport of raw materials and metals products. Stakeholders report the following as challenging the development of such infrastructure: (i) the lack of an integrated system for managing international rail-freight traffic and capacity; and (ii) the poor quality of rail transport in general. Regulations have been put in place to support: (i) the development of energy interconnections and energy infrastructure (the trans-European energy network (TEN-E)); and (ii) the Green Deal ambitions for modal shift and improvements in freight-transport efficiency (trans-

[123] See COM(2020) 66 final, *A European strategy for data*, https://europa.eu/!BB46Mq.

European transport network (TEN-T)). EU funding, such as through the recovery and resilience plan, also targets rail transport and infrastructure, recognising its pivotal role in decarbonising industrial transportation.

There is also scope for increased use of inland waterways for transport of raw materials and metals products, to shift volumes away from roads, while ensuring the protection of water bodies[124]. This could also have a significant impact on reducing the carbon footprint associated with transport.

To support the development of sustainable transport of raw materials and metals products, necessary measures should be taken.

Key recommendations by stakeholders include:

- increase the availability and capacity of multi-modal terminals that are close to industrial clusters;
- improve the use of rail transport;
- improve the use of inland waterways.

[124] The quality of water bodies should be protected in line with the Water Framework Directive. Before engaging in water transportation, a careful assessment should be performed to prevent hazardous practices.

7. SKILLS

Driven by the twin (green and digital) transition, which demand technology-enabling metals, the EU raw materials sector is growing, generating a net total of 1.2 million new jobs in the coming decades[125]. The transition cannot take place without the proper development of skills for geologists, mining and processing engineers, metallurgists, mechanical engineers, mine workers, sorters, recyclers, and high-tech professions relevant for the sector and for the digitalisation and automation of the equipment used. The mining and metals sectors will continue to compete with other sectors for skilled workers and subject-matter experts (e.g. sustainability, health and safety, environment), with competition likely to increase in the short term, so it is essential that the sector is perceived positively by workers and consumers. Improving working conditions in the entire supply chain, including by ensuring attractive pay and good working conditions, is needed to both retain the current workforce and attract future workers, especially young people. The ferrous and non-ferrous metals sectors have historical significance in advancing industries. It plays a crucial role in shaping modern infrastructure, driving electronics manufacturing, and fostering the growth of renewable energy technologies. Nevertheless, the sector suffers from an outdated and unappealing image and is being seen as unattractive and old-fashioned by many people. Over time, the industry has changed, but public perception has not kept pace with these updates and the current reality. Correcting this 'image problem' will be an ongoing task, demanding consistent collaboration between industry and policymakers to show the sector's vital role in the green and digital transition to all stakeholders[126], especially the younger generation exploring career options. The industry must demonstrate its intent to invest in the green and digital transition, in terms of both facilities and workforce, to show that the sector is a worthwhile career option with longevity and professional development opportunities. The situation differs across the EU as in some Member States (e.g. Sweden), young employees and students already list metals mining and processing companies among the most attractive employers.

In addition to broader stakeholder involvement, social dialogue (at tripartite or bipartite level) must be the instrument for European metal workers to plan job-to-job transitions. Effective workers' participation at sectoral or company level and collective agreements, setting out the conditions of the transition of the workforce, must play a fundamental role. This is important in order to retain current workers, with skills in short supply, but also to demonstrate to future potential workers that the sector can transform while ensuring that workers and regions are not left behind, with job security being of utmost importance to job seekers.

The twin transition may lead to the commissioning of new production facilities, with further upgrades for some, while potentially closing down others. While the impact of site closures is obvious, it is important to remember that even some process changes, as opposed to closures, could severely impact the workforce. For example, the move from a blast furnace to an electric arc furnace in the steel industry will require different skills and can result in significant job losses. The dual transition requires finding solutions for these impacted workers to ensure a just transition. This means that change must be anticipated and managed through social dialogue, in which the effective and timely information and consultation of trade unions and workers is a prerequisite.

Digitalisation and decarbonisation objectives at sector and company level must be supplemented by transition strategies setting out the job-to-job transition, including reskilling

[125] According to a study organised by McKinsey and the European Raw Materials Alliance (ERMA). Full reference to be added.

[126] Commission staff working document, *For a resilient, innovative, sustainable and digital energy-intensive industries ecosystem: Scenarios for a transition pathway*, SWD(2021) 277 final.

and upskilling programmes and job transfer plans of workers. Trade unions and worker representatives must receive timely information and be effectively consulted on these programmes.

Investing in the workforce is crucial for attracting qualified individuals to drive the transformation of the mining and metals industry. The sector's pivotal role in the twin transition allows young people to make a meaningful impact. The industry must demonstrate these positives to young people while also ensuring that workers are able to work in safe environments with good conditions and attractive pay.

The topic of skills cannot be looked at in isolation. Industrial and employment policies are also needed to ensure good-quality industrial jobs in a sector that faces fierce global competition, in line with the measures taken by EIT RawMaterials[127]. Social partners must work with vocational education and training (VET) providers and policymakers to analyse current and future skills needs at site, regional and European level, and investment is needed to ensure high-quality VET for all workers, with special attention to underrepresented groups.

Previous metals sectors work on skills

Drawing on prior studies and research conducted in both the non-ferrous and ferrous sectors[128][129], the below policy and communication recommendations are proposed by stakeholders.

I. Policy recommendations

- create common European tools for monitoring and anticipating skills needs, this could take the form of a central EU observatory for the metals industry, facilitating cooperation between social partners, education providers, and employment services, along with EU and national policymakers.
- a growing need for T-shaped (technical and transversal) skill sets require for sectoral organisations at EU level and companies to collaborate and to design programmes that aim to equip workers with competencies that enable them to adapt to new requirements, technologies, and working methods.
- recognising that workers of the future must engage in lifelong learning, expand and promote on-the-job forms of training, taking into consideration the challenges it presents to how work is organised for various occupational groups.
- ensure a right to training for all, all individual workers must have an individual right to training negotiated collectively to secure access to training for all workers, including vulnerable groups.
- endorse mentorship programmes, including reverse mentorship, to preserve valuable knowledge and facilitate its transfer from older to younger workers.
- increase cooperation between public authorities, education providers, and social partners as well as contractors of metals companies using a large-scale skills partnership for energy-intensive industries under the EU Pact for Skills[130] to promote

[127] https://eitrawmaterials.eu/academy/.

[128] 'Blueprint for Sectoral Cooperation on Skills: Towards an EU Strategy Addressing the Skills Needs of the Steel Sector. European vision on steel-related skills and supporting actions to solve the skills gap today and tomorrow in Europe.' European Commission – Executive Agency for Small and Medium-sized Enterprises (EASME), Unit A1 – COSME, May 2020. ISBN 978-92-9202-939-5.

[129] Blueprint 'New Skills Agenda Steel': Industry-driven sustainable European Skills Agenda and Strategy (ESSA) – Policy Recommendations. European Steel Skills Agenda, 2023. Erasmus+ Program, Key Action 2 – Cooperation for innovation and the exchange of good practices.

[130] Energy Intensive Industries (europa.eu)

digital and advanced-technology skills, dual education, and lifelong learning and to foster a unified approach to addressing skills needs.

- avoid the risk of excluding medium- and low-skilled profiles, ensure inclusivity through structured and timely social dialogue and take appropriate action at both company and trade-union level to prevent any group of workers from being left behind.
- incorporate underrepresented groups, including women and migrants in the metals industry, addressing a critical need while fostering diversity and equal opportunity, with some best-practice examples to be shared such as #MujeresDeAcero[131].

II. Communication recommendations

- highlight the vital role of metals in modern society, emphasise that metals are present in nearly every facet of our contemporary lives.
- showcase high-skilled positions with an emphasis on digital competencies in the metals industry that no longer necessitate physical strength, and to underscore the diversity of tasks involved.
- highlight metals' contribution to circular economy and sustainability.
- facilitate job seekers' comprehension of how automation and robotics are reshaping the industry, making it possible for workers to alternate between on-site presence and remote work.
- emphasize industry's commitment to health and safety, effective communication should highlight the robust safety measures implemented by companies.
- collaborate with innovative metals companies that made substantial investments in infrastructure, transforming some plants into state-of-the-art facilities, to showcase significantly improved working conditions
- initiate campaigns that encourage students to pursue careers in metallurgy and studies in the areas of science, technology, engineering and maths (STEM), particularly in primary and high schools, leverage existing government and civil-society initiatives to support young people's and women's engagement in STEM subjects.
- encourage companies to use their employees as ambassadors in communication campaigns to raise awareness of the variety of career opportunities offered by the metals value chain.

Skills needs external to the metals sectors

Some institutions outside the mining and metals sectors conduct activities relating to metals, which require relevant skills and knowledge. Delays in these activities caused by skills shortages could slow down the growth and development of the sector and hinder the industrial transformation. Activities include for instance.

- Permitting of new projects and processes. The European Critical Raw Materials Act set a maximum period of 15 or 27 months for completing strategic projects. It is key to ensure that Member States' national and local administrations have the skills and resources to fast-track project permits at the required speed.
- Investment decisions. Many capital investments in new mines and processing plants will be needed to deliver the twin transitions and increase resilience. Investment decisions need to be timely and well-informed on risks – which can be facilitated by a good understanding of the characteristics of the sector and its various drivers.

[131] https://mujeresdeacero.unesid.org/.

8. SOCIAL DIMENSION

The European Green Deal emphasizes importance of supporting those regions, industries, workers, households and consumers that will face the greatest challenges coming from the social impact of the twin transition. This requires appropriate anticipation of change and socially responsible restructuring where necessary. In addition to continuous focus on workers' health, the metals industry should also pay attention to regional cohesion, the industry's impact on workforce and consumers, and improving gender equality and diversity in the sector.

A major precondition for implementing the twin (green and digital) transition is the broader population's understanding and support, including in the communities where initiatives are planned that would help the metals sectors to become green, digital and resilient. This requires appropriate anticipation of change and socially responsible restructuring where necessary. A key challenge is the fact that the benefits from some changes linked to the green and digital transition – for example securing raw materials supply – are widely spread across EU, while the potential upsides and downsides of the involved industrial operations are felt locally, both by local workers in the value chain and by the local community.

Experience shows that projects of the metals sectors in EU can only go forward if they are supported by the local communities and workers. Securing this support can be very challenging in some circumstances, for example for new mining projects, which are essential to secure a sustainable raw materials value chain for the European metals sectors. As industry partners, all businesses in the value chain have the responsibility to engage in a dialogue and communicate with local communities, workers and trade unions in an appropriate, effective and inclusive way. Support is also needed from governments to raise awareness of the strategic value of these projects for local communities and economies in addition to the wider European resilience, and to spread information about the advanced and mature technologies and practices used to ensure environmental/social protection.

Impact on workers, consumers and the environment

Currently, some 800 000 people work directly for the metals industry. However, the sector continues to report concerns, including an ageing workforce, a labour shortage, and a skills shortage. The twin transition require urgent action to safeguard the European metals sectors and to protect and develop these high-skilled, quality jobs in Europe, which have the potential to absorb workers from declining sectors through appropriate reskilling and upskilling measures.

To accomplish the transition, both industry and policymakers need to improve at communicating the real benefits of projects in metals sectors, but also at seriously addressing relevant concerns[132] and being transparent on projects and their impacts[133]. It is essential that social partners and local stakeholders (e.g. indigenous peoples) are involved early on and are given a stake in the project (e.g. through long-term, safe and well-paid job opportunities in affected territories, or through investment in local infrastructure, both physical and social). Social support is critical for effective policy implementation, which must be inclusive at all levels, including the local level.

[132] Eurometaux has embarked on a project to address concerns over potential emissions to the environment of several metals that enable rapidly growing value chains underpinning the twin transition, e.g. wind, solar, electric vehicles (including batteries), electronics, grid infrastructure. The results will soon be published via Eurometaux.eu.

[133] Commission staff working document, *For a resilient, innovative, sustainable and digital energy-intensive industries ecosystem: Scenarios for a transition pathway*, 2021.

While implementing the twin transition in the metals sectors, it is essential to ensure a just transition. This entails putting in place specific action and support to ensure that no worker or region in the EU is left behind, which is vital in ensuring public support for the twin transition. Employers must ensure that just transition is included in all transitional projects. The Council Recommendation on ensuring a fair transition towards climate neutrality[134] remains highly relevant in this respect.

It is important to ensure that the metals sectors and their supply chains are seen as attractive and important sectors, including with regard to the green and digital transition. One important aspect of attractiveness is to demonstrate that the sectors provide quality jobs with good working conditions.

Social dialogue, besides being a compulsory aspect of public policymaking, is vital to the sustainability and success of the metals sectors. The importance of quality social dialogue and strong collective bargaining has been emphasised by the recent adoption of the EU's Directive on adequate minimum wages, which sets high targets for collective-bargaining coverage. Member States are required to work with social partners and must draft national action plans if these targets are not achieved.

Key recommendations suggested by stakeholders include:

- consider establishing a European Just Transition Observatory to monitor the implementation of all policies and measures related to the European Green Deal which stakeholders should feed in to;
- Consider setting up local just transition working groups in metal regions in EU Member States made up of social partners, local community representatives and regional policy makers to prepare for and support the twin transition of the metals sectors' value chains;
- Ensure that social protection systems and employment policies are adequately designed to facilitate job-to-job transitions, including across sectors, by providing adequate schemes, income security, career guidance and care services (in line with the Council Recommendation on ensuring a fair transition towards climate neutrality).

Social acceptance of metals within value chains

The metals sectors are working hard on improving its environmental, social and governance (ESG) performance, including responsible sourcing and due diligence to address global supply chain concerns including (but not limited to) forced labour, child labour, conflict minerals, and environmental pollution. Strengthening sustainable and responsible sourcing of minerals and metals throughout global value chains[135] is important to ensure that the materials needed for Europe's twin transition are sourced responsibly and ethically, reducing the social and environmental risks in certain areas of global metals and minerals supply. Improved tracking of metals through the supply chain can be achieved with advanced digital techniques that can improve traceability and access to provenance information, increase transparency, and create trust among stakeholders. The digital product passport under the Ecodesign Directive and the Forced Labour Ban Regulation, if effectively implemented, can help improve the social and environmental sustainability of metals. Projects that revalorise mining waste can play a crucial role in making sure that mining sites are remediated safely using the latest available

[134] 2022/C 243/04, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32022H0627%2804%29.

[135] Many ores are concentrates that are mined outside the EU and then imported.

technologies with no health and environmental risk, and monitored, while contributing to the EU's raw materials supply.

Regulatory pressure on the metals value chain is increasing due to the development of EU legislative initiatives setting due-diligence requirements that have an impact on metals companies.

Due diligence is becoming a differentiating factor in customers' choices for metals products. Metals companies are adjusting their operations to meet social expectations and environmental standards, to demonstrate their raw materials are ethically and sustainably produced.

Europe's metals supply chain is committed to responsible sourcing and has been working for over a decade with other stakeholders to develop auditable standards that support responsible business practices.

The sector is committed to high ESG standards from the mine to the product and to recycling. It is considered important that EU and global policymaking is supporting these proactive efforts and mainstreaming responsibility across all supply sources. Global cooperation is important to ensure a level playing field and overall policy coherence.

Work covers two main areas:

1. supporting global action to develop responsible supply chain initiatives and auditing programmes for application in the sector (Responsible Steel[136], The Copper Mark[137], International Council on Mining and Metals (ICMM) Mining Principles[138], Aluminium Stewardship Initiatives[139], Cobalt Initiative, etc.), enabling the implementation of risk-based due diligence in a dynamic way; and
2. supporting proportional and coherent EU policies aiming to ensure the responsible and ethical sourcing of metals, including cross-cutting due-diligence legislation, and specific policies, e.g. on conflict minerals, forced labour, and critical raw materials or battery raw materials.

Europe's regulatory framework for due diligence is setting the agenda for responsible sourcing globally, and it is important that it is designed as effectively as possible[140].

Policymakers in Europe (or elsewhere) should work towards an effective and practical system that makes a real impact while avoiding excessive burdens on companies and ensuring a level playing field. It is essential that the raw materials imported to Europe are produced ethically and sustainably.

Key recommendations suggested by stakeholders include:

- recognise industry's efforts: due-diligence policies should build on the voluntary certification schemes that are in place already, aiming to improve alignment, boost take-up, prevent duplication of work, and improve transparency (global industry efforts are ongoing to align requirements of different certification schemes);

[136] https://www.responsiblesteel.org/.

[137] https://coppermark.org/.

[138] https://www.icmm.com/en-gb/our-principles.

[139] https://aluminium-stewardship.org/.

[140] To ensure that the due-diligence approach is consistent across various regulations, Eurometaux has conducted a study to analyse different legislative requirements and to demonstrate what the industry's schemes already offer in this regard..

- leverage internationally recognised standards and instruments: due-diligence policies should align with internationally recognised standards such as the UN Guiding Principles and OECD guidance, to promote coherence and to avoid duplication of work; due-diligence requirements of existing and forthcoming regulations should be harmonised;
- use an appropriate value-chain approach: due-diligence policies should be homogenous and inclusive across the entire value chain, avoiding excessive burden on the upstream sector; secondary raw materials should be considered separately due to difficulties in tracing their origins;
- implement efficient enforcement mechanisms: due-diligence policies should avoid creating an administrative burden on companies that might lead to their withdrawal, benefiting companies from less-regulated regions; from the metals sectors' perspective it is crucial that there is no burden of proof for companies, along with a presumption of innocence until proven otherwise, but trade unions and non-governmental organisations have an opposing view on this matter.

Diversity and equality in the sector

Gender equality, inclusion and diversity are among the EU's founding values. The proportion of women in the metals sector has historically been low, so measures and initiatives are necessary to address this shortcoming and the lack of diversity in the sector[141].

The sector requires recruitment of both men and women, the creation of innovative environments, and the utilisation of old and new technologies (including advanced digital approaches) to provide job opportunities for individuals of all ages.

Specific action can be taken to attract more women into the sector, including ensuring pay transparency and equal pay, promoting a gender-balanced workforce, and combating the barriers to career progression for women and job segregation between women and men. It is also important to promote equal access to parental leave and combat financial disadvantages of parenthood.

[141] International Women in Mining is a global not-for-profit organisation leading change for social sustainability in the extractives and resources sector.

III. NEXT STEPS IN THE IMPLEMENTATION OF THE TRANSITION PATHWAY

As part of the sectoral initiatives announced in the Clean Industrial Deal, the Steel and Metals Action Plan, will complement the horizontal measures announced by focusing on the specific needs of the steel and metals industries and complement them wherever needed. The Transition Pathway is an input used for the preparation of the Steel and Metals Action Plan. The co-creation process with stakeholders has shown how relevant and efficient it is to work together to support the twin (green and digital) transition of the metals sectors. However, the cooperation must not stop when the transition pathway is published. The co-creation of the Transition Pathway for the European Metals Sectors must be followed by an efficient co-implementation process involving and supported by all stakeholders, including Member States, to monitor progress on the metal industry's transition. The choice of relevant key performance indicators and appropriate organisational and governance structures is important from this perspective, taking into consideration learnings from other, similar processes.

KEY PERFORMANCE INDICATORS

A key performance indicator (KPI) is a measure of progress and can be defined as 'a quantifiable metric that measures the performance or progress in achieving specific goals and objectives'.

The approach used for chemicals is very relevant to the structure and objectives of the Transition Pathway for the European Metals Sectors and represents a significant body of work by the multi-stakeholder group. For the metals sectors, stakeholders propose that, **in the interest of time**, the same **principles** are followed, including use of two sets of indicators – one to measure competitiveness (resilience) of the sectors and the other to measure progress on the twin transition, with specific details of suitable KPIs to be determined **after** publication.

IMPLEMENTATION

Valuable learnings can be taken from experience gained in implementing other transition pathways, e.g. for tourism, construction and chemicals. Co-implementation of the Transition Pathway for Chemicals started in early 2023. This is the transition pathway closest to metals in terms of objectives and structure, so inspiration can be taken from this process. Based on these learnings, the Commission recommends to: (i) clarify who is responsible for each transition pathway action; (ii) set a clear time frame for the implementation of each action (short/medium/long term)[142]; and (iii) most importantly, assign a **priority level** to each action based on its scope. The task forces focusing on high-priority/short-term actions could be implemented first. A final learning is the importance of involving all stakeholders, especially EU Member States.

Implementation of the Transition Pathway for the European Metals Sectors

The co-implementation process will start by the publication of the transition pathway and by disseminating this pathway to all stakeholders. The Commission could organise a first co implementation meeting a few months after the publication of the transition pathway. The aim of this meeting would be to discuss – and agree on – the approach to take for such co-implementation also taking into consideration the newly announced initiatives on the Clean Industrial Deal, the Industrial Decarbonisation Accelerator Act and the Steel and Metals Action

[142] Short term: 1-3 years, medium term: 3-7 years, and long term: 2030 to 2050.

Plan. The co-implementation process of the transition pathway will consider necessary policy coordination across EU Member States. Indeed, the support of the EU Member States for the transition is crucial, to guide and to provide support at regional and local levels and to implement regulatory changes in a coordinated and harmonised manner.

The specific approach will be discussed and agreed with stakeholders participating in the co-implementation once the final version of the transition pathway for the metals industry is published. The following points should be considered:

- Due to the complex tasks planned during the implementation of the Transition Pathway for the European Metals Sectors, stakeholders suggest that a Commission expert group (or a sub-group) could constitute the appropriate organisational and governance structure.
- Stakeholders, including relevant Commission departments, could discuss specific chapters of the Transition Pathway for Metals as needed. Topics for discussion could include progress against objectives (e.g. KPIs and key transition pathway actions), and aspects that may alter the way forward, e.g. technology changes that impact metals demand.
- Additionally, stakeholders suggest that a high-level political transition dialogue could take place (similar to the approach in the Transition Pathway for Construction), to take stock of implementation. Coordination with other European institutions (Council and Parliament) could also increase synergies and improve the pathways' implementation.
- This pathway may be updated to take account of new developments and changes to EU legislation.

ANNEXES

Annex 1 – Additional information about metals

Metals are unique and different from other classes of material. Metals are naturally occurring elements, not engineered molecules. They are 'permanent' (used but not consumed) and cannot be destroyed. Their natural background concentrations in the environment at large can vary but are not zero, and can often be easily measured. The Earth is largely composed of metals and their minerals, and life has evolved in their presence. Several metals are essential to life[143,144] and are needed at certain levels by humans, animals, plants and bacteria.

Metals can be used in pure form or combined with other metals in 'alloys', giving an almost infinite range of properties. The technical functionalities of metals in alloys are quite specific, resulting in a very low potential for substitution. In addition to alloys, other important uses of metals' inorganic compounds include battery materials, photovoltaics and semiconductors, ceramic pigments, glasses and frits, catalysts, etc. Metals have for centuries been an important part of the materials 'innovation toolbox' due to alloys' special, unique and infinitely variable properties. Over time, both the number of metals in common use and the complexity of alloys are increasing, driven by powerful market forces such as societal demand for better / more cost-effective / more efficient products. However, marketing reasons also play a role without necessarily addressing the basic needs of the population. Overall, it is acknowledged that overspecification of products is a barrier to circularity.

The role of catalysts in key technologies

For many industry sectors, metal-based catalysts are critical to Europe achieving its net-zero aims. Catalysts facilitate the shift from fossil-based hydrogen to greener feedstocks like renewable energy sources and waste streams. Industry is continuously developing innovative catalysts to maximise resource and energy efficiency within existing infrastructure, facilitating the transition to lower carbon-intensive energy production. Catalysts play a vital role in carbon capture from fossil-based technologies and in the transportation of hydrogen via liquid organic hydrogen carriers (LOHCs). Catalyst-coated membranes are key in electrolysers, separating water into hydrogen and oxygen. Hydrogen, produced through these processes, is essential for methanol and ammonia production, with methanol serving as a crucial feedstock for sustainable aviation fuel (SAF). Catalysts are also instrumental in converting waste into alternative feedstocks. They enable the chemical recycling of plastic waste into pyrolysis oils, replacing fossil-fuel feedstocks in the production of new polymer materials. Similarly, waste cooking oils can be transformed into SAF.

[143] WHO 1996 *Trace elements in human nutrition and human health*, World Health Organization, Geneva.

[144] WHO 2002 *Principles and Methods for the Assessment of Risk from Essential Trace Elements*, World Health Organization, Geneva, Series Environmental Health Criteria, No 228, ISBN 92-4-157228-0.

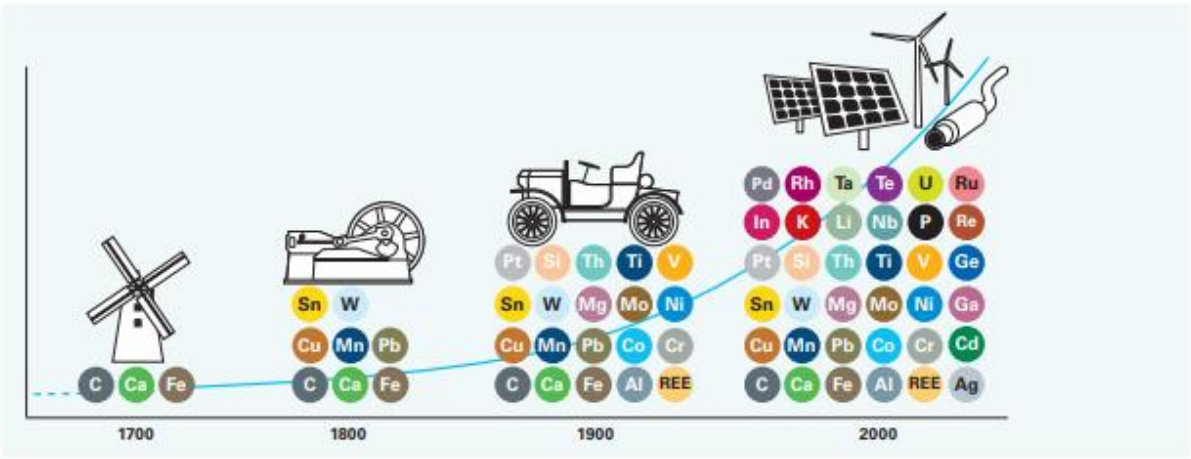

Figure – Elements widely used in energy pathways (position on the time axis is indicative only). *Source: Zepf V. et al., BP (2014): Materials critical to the energy industry. An introduction. 2nd edition.*

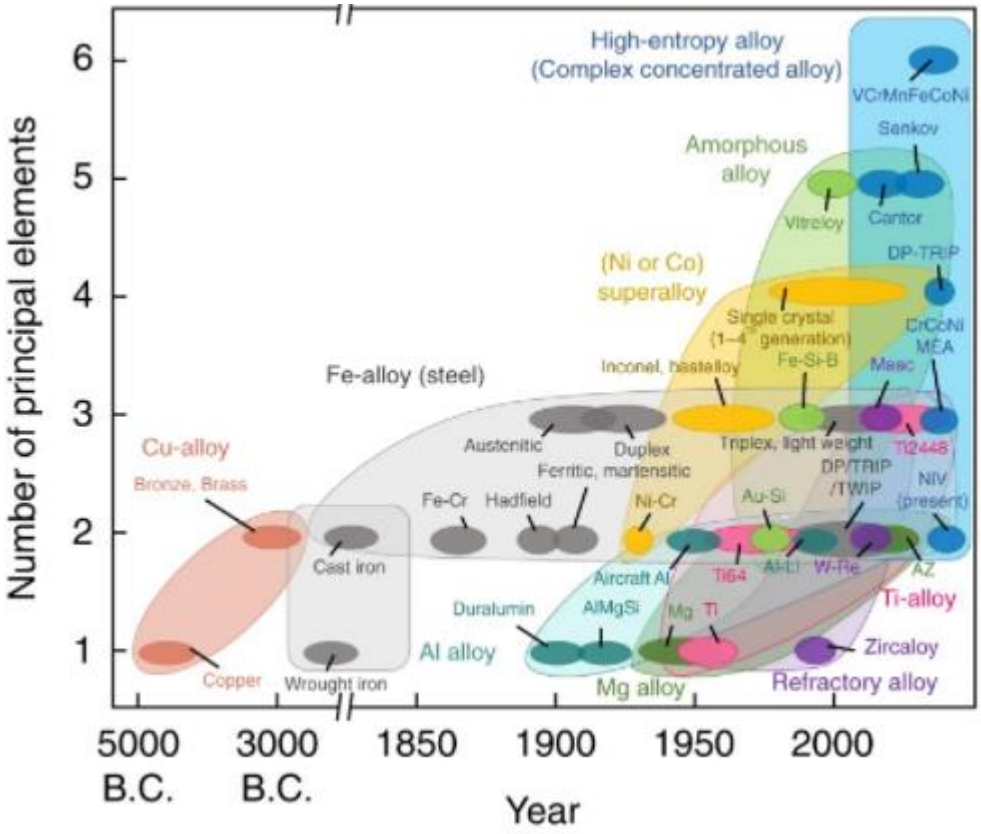

Figure – Alloy development over time – number of principal elements. *Source: Hyun Seok Oh et al., Nature Communications (2019): Engineering atomic-level complexity in high-entropy and complex concentrated alloys*

In Europe, the metals industry operates according to the EU's high social standards and strict environmental policy framework, complying with rules to limit air and water emissions, to manage industrial and extractive waste, to safely handle chemicals and to safeguard biodiversity. It is a highly integrated industry, keeping waste to a minimum by reusing by-products (e.g. slag), either in the metals sectors or in other sectors such as construction.

Striving for a competitive transformation

In addition to the metals industry being the largest industrial emitter of carbon dioxide in the EU, metals have a key role to play in reaching the ambition of a 'green' transition away from fossil fuels. Metals needed for renewable energy production will, in theory, enable future metals to be produced with a reduced carbon footprint. The metals industry clearly understands that it needs to do more and is determined to be at the forefront of the necessary transformative process required by the twin transition. However, the industry stresses that this journey of transformation depends on its ability to decarbonise and simultaneously stay competitive, while attracting global investment.

In this context, the current crisis brings into closer focus the resilience objective set by the updated EU industrial strategy. This strategy emphasises the benefit of increasing the resilience of the metals industry, i.e. its capacity to absorb external shocks due to a fragile geopolitical situation and a challenging competitive environment, with surging prices for energy and raw materials. The strategy sets out a list of actions to support the green and digital transition of EU industry and its resilience. These actions include a series of transition pathways to be developed jointly with EU Member States, industry and other stakeholders. These pathways identify the actions needed to achieve the twin transition, giving a better understanding of the scale, benefits and conditions required. This transition will also strengthen EU resilience and ensure a fast transition towards a sustainable value chain for the benefit of society (including the metals industry), so that it becomes a solution provider to the zero-pollution ambition.

To achieve this, the metals sectors call for coherence between all relevant EU policy areas and legislative proposals. In this way, the metals-dependent value chains that will deliver the twin transition in many EU industry sectors can function efficiently and effectively in the long term. This requires predictability for investments, legal certainty, the right framework conditions, international competitiveness and a level playing field, in particular in connection with energy and climate, raw materials, chemicals and trade policies.

Electricity and infrastructure

Access to abundant, globally competitive decarbonised electricity is fundamental for the uptake of clean metallurgy technologies, as also set out in the new Commission Communication on 2040 climate target[145]. The energy procurement costs faced by industry include: (i) wholesale market prices; (ii) network costs; (iii) public financing costs of renewable energy projects; and (iv) where relevant, the costs of financing measures to ensure the security of supply and resilience of the electricity system.

While the metals industry already has some of the most electro-intensive industrial processes, further increases in decarbonised electrification depends on:

1) globally competitive energy and electricity prices, starting in wholesale electricity markets;

2) the availability of abundant amounts of electricity;

3) the grid's ability to deal with intermittent renewable energy sources (RES) and to provide a base load for the metals industries operating continuous processes, as well as safe and cost-effective infrastructure for transporting electricity;

[145] Commission recommendation for 2040 emissions reduction target, https://ec.europa.eu/commission/presscorner/detail/en/ip_24_588

4) greater process flexibility in industrial-demand – on a voluntary basis and adequately compensated, where possible and cost-effective, considering technical, economic and organisational constraints – to better support the resilience of electricity systems against the increasing share of renewables in the EU.

In addition, better circularity solutions may help reduce additional energy needs.

Annex 2 – Additional information on support to R&I, production techniques and technological solutions

The primary-production life-cycle stage of metals has received much R&I attention as it is the most energy-intensive phase and therefore offers considerable opportunities for decarbonisation. Other life-cycle stages can also deliver improvements in efficiency, which will reduce its footprint overall. Metal recycling in particular contributes significantly to the decarbonisation objectives. In all life cycle stages there is the possibility to deploy new digital technologies in innovation to improve performance, including artificial intelligence (AI) [146], digital twins and robotics. There are existing metals-related activities in this space [147], and a body of work has been published for the chemicals sector [148] that has useful learnings for metals.

The innovations are often based on digitalisation and AI, and instead of stand-alone solutions they are often interlinked and system-dependent. To enable value utilisation and new sustainable technologies, system integration needs to be incorporated from low TRL levels 2-4.

Exploration, extraction and separation / concentration of ores

Mining activities are at the beginning of the metals value chains. Innovation plays a critical role in the mining industry as a tool to improve the efficiency of its processes, reduce costs and meet the increasing social and environmental concerns among communities and authorities. Technological progress has also been crucial to allow the exploitation of new deposits in more complex and challenging scenarios: lower ore grades, extreme weather conditions, deeper deposits, harder rock mass, and high-stress environments. Mining is going through the first stages of big changes due to digitalisation. This process could change how mining is done, going from human-run operations to autonomous or semi-autonomous remote-controlled mines [149].

R&I areas include more advanced exploration methods for locating economically viable deposits, developing more efficient and safer mining methods (particularly underground), and improved technologies for the separation and concentration of ores to isolate the valuable components for further processing into primary new metal. This is in tandem with advancing the technological feasibility of recovering materials through recycling and so-called urban mining.

Mining decarbonisation rests on three pillars: direct electrification, indirect electrification through the use of hydrogen as well as carbon capture and storage (CCS) and carbon capture and utilisation (CCU). Innovation in the direct electrification of machinery and trucks is well advanced and already in operation in certain mines. However, research for matureness in technology, optimisation and robustness/safety is still needed for it to be adopted by the majority of the mining industry. Indirect electrification through hydrogen still requires innovation given the difference in calorific value for heat generation compared to natural gas as well as safety issues when operating underground. CCS and CCU require innovative technologies that allow for the reduction of the (for now) prohibitive costs of sequestration. Furthermore,

[146] https://www.mckinsey.com/capabilities/mckinsey-digital/our-insights/freeport-mcmoran-turns-data-into-value

[147] CAPRI H2020 project – Cognitive Automation Platform for European Process Industry. End date 30 Sept 2023.

[148] 'Digital technologies for sustainability in the European chemical industry'. Arthur D. Little and Cefic, 2023.

[149] Innovation in the Mining Industry: Technological Trends and a Case Study of the Challenges of Disruptive Innovation. Sanchez, F; Hartlieb P. Mining, Metallurgy & Exploration (2020) 37:1385-1399.

technologies and standards are needed to store and transport CO_2. CCU is so far mainly focused on pilot projects for carbon mineralisation in chemically bound compounds and requires R&I and scale-up possibilities.

Mine remediation and mine rehabilitation are other R&I areas to explore. Tailings and waste reduction (sorting, dam integrity etc.) are R&I areas where emerging technologies can be observed, such as tailings heap coverage to avoid effluent and diffuse emissions to water, water abstraction, balance, soil surface restauration as well as the reduction of hazardous leachates by means of stabilisation of metals in waste materials. For instance, two noteworthy EU-funded projects, ReActiv (2020-2025) and RemovAL (2018-2023), specifically target bauxite residue and explore innovative processes to convert it into valuable inputs for various sectors (mainly cement and steel) by developing symbiotic value chains.

Production of primary (new) metal and alloys

Ferrous sector

With advanced technologies and under the right circumstances, the EU ferrous industry could achieve a revolutionary transformation in the way it makes steel and in its environmental impact [150]. However, this change is not an instantaneous shift: it is an iterative process that will require adjustments and a managed transition between phases[151]. The overall transformation would be enabled primarily by hydrogen-based steelmaking replacing the use of coal, and to a lesser extent by adapting fossil fuel-based steelmaking through process integration and the capture and use of waste carbon for the production of chemicals [152], together with increased recycling of ferrous scrap, iron and steel by-products using the electric arc furnace route. As covered in the Introduction, there are two main technological pathways to reduce CO_2 in the steel sector: ‘smart carbon usage’ and ‘carbon direct avoidance’.

[150] Pathways to a CO_2-neutral European Steel Industry; EUROFER 2019.

[151] https://www.estep.eu/projects/estep-projects/green-steel-for-europe/publications

[152] https://ec.europa.eu/docsroom/documents/54595, Topic 16: Feedstock Substitution; 16.4 CO_2 as an alternative feedstock.

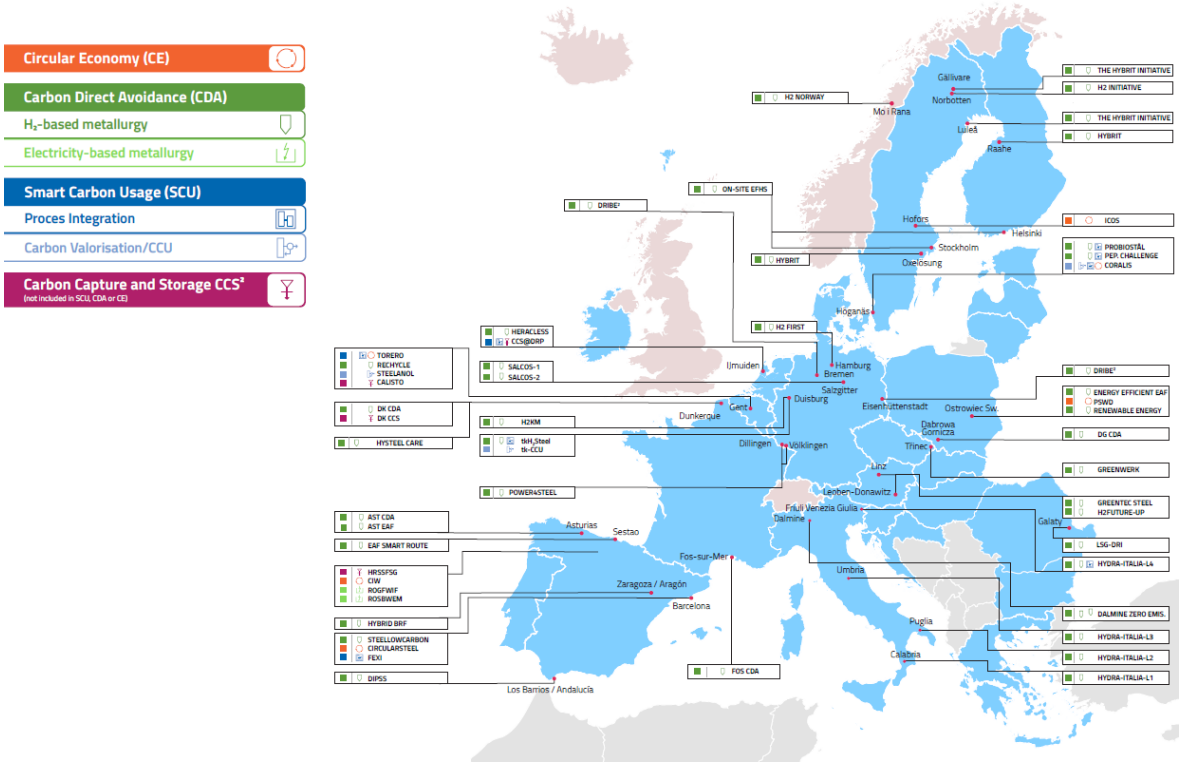

Figure: Key steel low-CO_2 projects, low-CO_2 emissions industry
Source: Eurofer[153]

These pathways, shown in the figure above, seek to substantially reduce the use of carbon compared to the current means of steel production or to avoid carbon emissions entirely. Furthermore, there are overarching circular economy projects that aim to improve the recycling of steel and its by-products and further improve resource efficiency. Within each pathway are groups of technological approaches.

Smart carbon usage includes:

- process integration, which looks at modifications to existing fossil fuels-based ironmaking/steelmaking processes that would help reduce the use of carbon in, and therefore the CO_2 emissions of, a best-in-class EU plant;
- carbon valorisation or carbon capture and utilisation, which includes all the options for using hydrogen, CO and CO_2 in steel plant gases or fumes as raw materials for the production of, or integration into, valuable products.

Carbon direct avoidance includes:

- hydrogen-based metallurgy, which uses hydrogen to replace carbon as the main reduction agent in the iron ore reduction stage; this hydrogen could be produced using fossil-free energy;
- electricity-based metallurgy, which uses electricity instead of carbon as the reduction agent for iron ore reduction, with a greater focus on fossil-free energy.

[153] https://www.eurofer.eu/issues/climate-and-energy/maps-of-key-low-carbon-steel-projects

Though not a primary decarbonisation route, during the transition CCS technology may also be needed to support progress along the potential CO_2 reduction pathway and address non-avoidable process emissions.

Non-ferrous sector

In the (electricity hyper-intensive) non-ferrous sector there is potential in theory to reduce (direct + indirect) GHG emissions beyond 90% compared to 1990 levels by 2050. The most important mitigation will come from the decarbonisation of EU power production, which alone would reduce total emissions from non-ferrous metals production by 81% compared to 1990. Further innovations such as the use of inert anodes in aluminium production, the electrification of extraction processes (e.g. move to hydrometallurgical and electrified pyrometallurgical processes), fuel shifts to lower emitting or bio-based inputs, the use of non-carbon reducing agents in smelting, higher efficiency in furnaces and better process management systems (including digitisation) can lead to further substantial GHG reductions [154]. On some topics, important R&I is also taking place outside Europe, e.g. the ELYSIS project [155]. Due to its potential, it is important to further focus on and extend R&I and support for piloting and demonstrating these technologies within Europe. Some of the most relevant topics for the non-ferrous sector include the electrification of processes and overcoming the current limitations of hydrogen and CCS.

Ferrous and non-ferrous metals innovations can also help other sectors to decarbonise faster, e.g. by using waste heat from metals production, higher levels of (electric) power demand response or by utilising by-products.

Manufacture and use of products

For complex products that contain metal components, there is scope for improved design for advanced, high material efficiency manufacturing methods such as additive manufacturing and mega-casting.

The metals industry and its downstream users are working continually to optimise the use of materials in products. Market forces drive the development of substitutes and alternatives, including advanced materials, in many areas. Notable recent examples include the reduction of cobalt in electric vehicle batteries, sodium-ion batteries, and research into non-rare earth-based permanent magnets. Continued support to R&I is important to continue this. While alternative technologies often do not replace the growing need for key strategic minerals, they do ensure that demand growth does not become problematic compared with the available supply. For example, platinum efficiency in fuel cells has improved by more than 90% since the 1990s, and progress will continue.

In addition to having a key role in the clean energy transition, R&I in the field of batteries and in advanced materials in general plays a crucial role in tackling many challenges of the developing world:

- The eradication of energy poverty, as addressed in the United Nations' Sustainable Development Goals (SDGs). SDG 7 'Affordable and Clean Energy' aims to ensure

[154] Wyns, T., Khandekar, G., *Metals for a Climate Neutral Europe: A 2050 Blueprint,* The Institute for European Studies at Vrije Universiteit Brussel, October 2019.

[155] https://www.elysis.com/en

universal access to affordable, reliable, sustainable and modern energy services by 2036 [156].

- The transition to 100% clean electricity by 2035, but also reaching net zero by 2050. Access to clean electricity increases the agricultural productivity of vulnerable communities and provides income diversification and educational opportunities for rural communities.
- Poor awareness of different battery technologies and the potential causes of battery failures because of gaps in standards (including packaging materials), poor training, theft, abuse, poor or inaccurate maintenance, poor installation, incompatibility issues and in some cases the wrong battery choice based on the application.
- Promotion of the socio-economic development of developing countries by enhancing the productive uses of energy (e.g. hydrogen production through battery electrolyser systems) and exploring different business models based on different stages of the batteries' life cycle to fit each community's needs.

The key objectives of the Strategic Materials Agenda [157] include the substitution of critical raw materials through new, innovative advanced materials solutions, which will also make Europe more resilient and sustainable.

When evaluating potential alternatives to metals, it is important to take an integrated approach to overall sustainability. The safe and sustainable by design (SSbD) framework [158] (which is an innovation approach and not a regulatory tool) can be difficult to apply to metals and alloys. Due to the presence of hazardous alloying elements, many materials cannot be considered SSbD even though they are used safely and sustainably. The SSbD concept therefore does not reflect the full contribution of metals to overall sustainability. To help overcome this, the metals sectors have developed the 'Safe and Sustainable Metal' concept, which considers all aspects of sustainability relevant for metals and metal compounds, including mixtures, articles and complex products. In addition to climate, circularity, criticality and chemicals management aspects, it adds societal, innovation and economic aspects in a full life-cycle perspective.

Recycling and end of life (circularity)

There is enormous potential for the enhanced recovery of base metals, rare earth metals and other by-products from primary and secondary production, waste streams and post-consumer scrap. Enabling this recovery could reduce Europe's import dependency and supply risk significantly. To be sustainable, the technologies used for enhanced recovery should be economically feasible and not lead to additional GHG emissions. Advances in hydrometallurgy show promise for both economical (low temperature) extraction and a low CO_2 footprint. Important innovations will also be required in order to allow for the efficient and climate-friendly recovery and recycling of metals given that more and more difficult-to-recycle secondary materials/products will have to be processed in the future. Also, the quality of recycling loops due to the presence of trace metals must be addressed to preserve the value of recycled materials and create, for instance, alloy-to-alloy recycling loops where the same alloy is reused for equivalent quality uses. This needs to be supported by appropriate legislation that is fit for purpose. On extended producer responsibility, products need to be designed for disassembly to making it easier to separate, recover and recycle metals.

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[156] Summary for policymakers in: 'Climate Change 2014: Impacts, Adaptation and Vulnerability Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change', Intergovernmental Panel on Climate Change (IPCC) 2014.

[157] AMI2030 Strategic Materials Agenda. Advanced Materials Initiative, April 2023. www.ami2030.eu

[158] Commission Recommendation 'Establishing a European assessment framework for 'safe and sustainable by design' chemicals and materials'. European Commission, 2022.

There is also the role of symbiotic value chains. By strategically interconnecting various stages of production through innovative symbiotic value chains, as in the case with Hubs4Circularity[159], waste from one process becomes a valuable input for another, creating a closed-loop ecosystem that not only minimises the environmental impact, but also improves overall sustainability in the utilisation of resources and energy.

Four priority areas for circularity innovation in the metals sectors have been identified that could be supported by the ETS Innovation Fund [160]: (i) enhanced sorting and recovery of scrap; (ii) better use of by-products from mining and smelting operations; (iii) metals recovery from low-grade ores, sludge and slag; and (iv) lowering the energy needs of certain recycling processes. Together, these aim to maximise metals recovery, while tackling the challenge of higher energy consumption from increasingly complex waste fractions.

Applying circularity to mining (e.g. providing construction material that would otherwise stem from virgin extraction, better use of tailings, tailings valorisation, sorting) must be explored further and funded beyond lab-scale applicability.

[159] Hubs4Circularity (h4c-community.eu)

[160] Workshop organised by Eurometaux and DG GROW, 2019.

Annex 3 – Access to primary raw materials

Sustainable mining

It is in the nature of mining that deposits are bound to the location where they occur – often in remote or pristine areas, as well as in areas inhabited by agricultural or indigenous communities. One key aspect of sustainable mining is that it operates with minimal environmental impact, in particular on strained ecosystems. This ensures minimal impact during operations, responsible land use throughout the mine life cycle, safety and security of the site and of extractive waste facilities, while employing state-of-the-art water management and protecting biodiversity. It also ensures that mine sites undergo environmental rehabilitation after closure to make them available for future use and that they are left in a condition suitable for reuse by current and future generations [161], helping restore natural ecosystems. Of equal importance for sustainable mining is the socio-economic impact on affected communities, particularly indigenous communities. It is estimated that more than half of energy transition minerals are located in these communities [162]. Against this background, it is important to ensure public participation in decision-making to guarantee free and informed consent as well as the right to say no and thereby strengthen the quality and public acceptance of decisions in a way that maximises the benefits to society and collective ownership. To this end, several initiatives have been launched, committing industry players to adhere to the highest possible ESG benchmarks and to achieving a net positive impact on the environment with their operations [163]. Compensatory measures should be avoided to ensure the environmental sustainability of mining. The Commission has committed to sustainable mining through the European innovation partnership on raw materials as well as in the provisions of the Critical Raw Materials Act and the Extractive Waste Directive.

European mining operates at the highest sustainability performance globally. The overall objective is to join efforts with other stakeholders to make Europe a competitive, sustainable society that recognises the advantages while making a business and societal case for mining in Europe. With these elements in place, the European mining industry can expand its role as a strategic supplier of efficient and, most of all, sustainable solutions. The mining industry has an important role to play in the supply chains that can provide efficient and sustainable solutions to meet the needs of modern society for metals and minerals.

At the same time, more active policies that promote different consumption patterns (e.g. different behavioural patterns to move societies from less material-intensive practices) will allow us to limit the need for minerals and metals, delivering a more resilient and autonomous society.

Ferrous sector

Iron makes up about 5-6% of the earth's crust. For the ferrous metals industry, access to primary raw materials means access to good-quality iron ore. High-grade iron ore typically contains a higher percentage of iron and low levels of silica and other unfavourable substances, which makes it more desirable for iron and steel production. The accessibility and geographic location of iron ore deposits can impact their economic viability and transportation costs. Deposits that are close to transportation routes or infrastructure, such as ports or railways, are generally more desirable for mining and processing. The largest deposits are

[161] Sustainability Parks – Boliden

[162] https://www.nature.com/articles/s41893-022-00994-6

[163] Project: Mining With Nature – Svemin

found in Australia, China, India and Brazil, but many other countries also have significant deposits. In Europe, iron ore deposits are currently being exploited in northern Sweden and Austria. Access to supply from suitable large-scale deposits is generally not a concern for the ferrous industry, although it is reliant on stable global supply chains. Low-carbon forms of iron ore (e.g. pellets) are becoming more important, but are currently limited in supply. In addition, demand for specific ore grades that match low and near zero carbon production requirements needs to be taken into account. Based on current production capacities, analysts see a significant gap between supply and demand for direct reduction grades. However, mining companies would have to start developing new mines with a high iron content or intensifying the processing of iron ore in order to achieve necessary enrichment very soon.

For stainless steel, which contains chromium and in many cases nickel, molybdenum, manganese and other alloying elements next to iron, access to ferroalloys is very important. Most nickel is sourced from ferronickel and most chromium is sourced from ferrochromium. For these raw materials, the European production is not sufficient and most ferroalloys need to be imported.

Some by-product apatite and hematite deposits that can be mined by iron ore miners are connected to phosphorous or rare earth elements deposits, both of which are crucial and considered strategic to food security and the sustainability transition.

Non-ferrous sector

Economically viable deposits of non-ferrous metals are generally much less widespread than iron ores. For example, aluminium is the third most widely found element in the earth's crust. However, the mining of bauxite is currently concentrated in tropical regions (e.g. Guinea, Australia, Brazil) and hardly takes place in Europe. Because of this and their high economic value and strategic nature, many non-ferrous metals are considered critical and have a significant supply risk for the EU due to a range of factors, including competition from other regions.

On a global level and across all non-ferrous metals, there are projects announced for new mining and smelting/refining capacity that will increase the primary supply in the next decade. Project pipelines indicate that supply growth will be strongest for lithium, cobalt, nickel and copper. Reserves and resources indicate material availability, but there is a risk that demand growth will outstrip supply growth. There are no major shifts expected in geographical supply origin, except for a growth in the importance of some regions (Indonesia for nickel).

However, the European project pipelines are much thinner than the global potential and the indications of Europe's own geological endowment (see figure). Both mining projects and smelting/refining projects have challenges. European mining project announcements for the next decade indicate that the largest – but uncertain – potential growth in Europe's supply is for lithium and rare earth elements. For the mature metals markets (copper, zinc, nickel), projects are being planned that would compensate for depletion but not provide major new growth.

Mining projects in Europe have a high level of uncertainty compared with others in the world. There are several reasons for this, including low social acceptance among local communities, the need for higher incentive prices to make an economic case for lower-grade ores, and high operational costs that diminish the viability of the high CAPEX investment needed to start a mine. It is also related to the lack of geological knowledge and limited exploration activities in deeper areas. There are examples of projects being stalled or delayed due to local opposition, and other projects face delays from national permitting procedures.

The strength of European mining (in general, not only for metals) is its long tradition and world-class universities [164] for mining engineering, the innovation test beds [165] of miners and suppliers that test innovative and new equipment in real-life operations [166], the presence of the most important mining suppliers as well as an enormous knowledge base on responsible mining.

Yet historically, Europe shows a flat evolution in non-ferrous metals output, balancing growing and declining markets. This trend leads to an increasingly lower share of European production in global mining and metal production, often meaning that cheaper and less sustainable products increasingly price more sustainable production methods out of the market. As a result, stalled investments in the last few decades and rapid growth in other areas of the world (primarily China) have decreased the global significance of European production and shifted the gravitational centre of strategic standard-setting to these other regions.

As a result, the EU is very dependent on other regions for primary non-ferrous metals supply. Europe has an overriding ambition to reduce long-term metal dependency and diversify the EU supply sources of critical raw materials. This means succeeding in managing economic challenges to access and the increased tendency of using access to raw materials as a geopolitical tool (rare earth elements, tungsten, magnesium, gallium, germanium, graphite etc.), while also introducing new projects to increase the demand self-sufficiency ratio from EU own extraction. However, bigger changes to the investment climate are needed to support current operations and incentivise new projects.

[164] 64 European Universities alliances focused on mining, covering more than 560 institutions – data from Euromines.

[165] Mining-related patents in the EU: 15-20 000 – roughly 20% of global mining patents, with less than 2% of investments in exploration allocated to EU Member States; mining equipment patents: roughly 1 500 in the EU with a strong focus on sustainability, digitalisation and automation; EU R&D spending in mining accounts for 25% of global spending, while only 3% of global mining happens in Europe. Data from Euromines.

[166] RHI Magnesita and Australian cleantech MCi Carbon enter long-term strategic cooperation to decarbonise refractories | RHI Magnesita; Joint pre study on sustainable transition | Boliden; LKAB starts collaborating with NCC and Peab for its green transformation – LKAB.

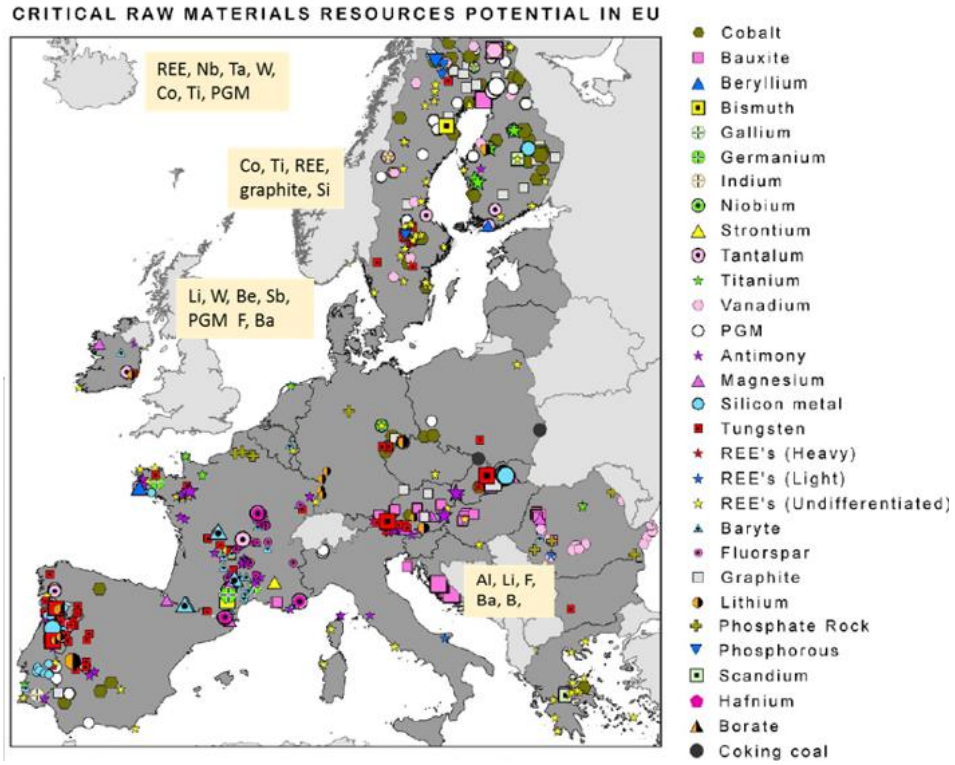

Figure – Critical raw materials resource potential in EU. *Source: EuroGeoSurveys combined with other EU data sources.*

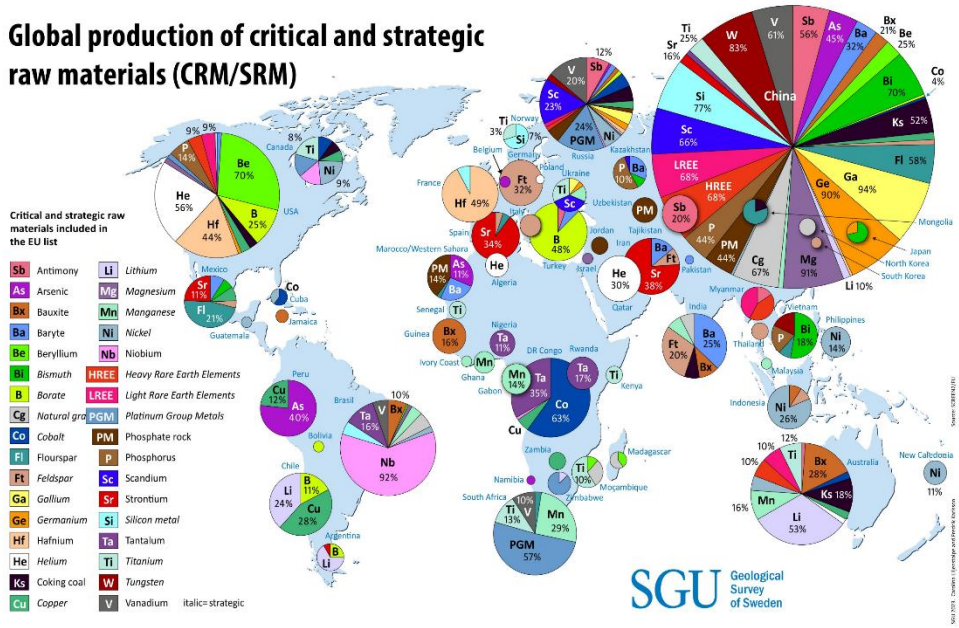

Figure – Global production of critical and strategic raw materials. *Source: Geological Survey of Sweden.*

In addition to the critical raw materials list and the long-standing periodical exercise of updating the EU Critical Raw Materials Strategy, it is the Critical Raw Materials Act, published in May 2024, that sets formal objectives for Europe to increase its domestic mining, processing and recycling capacity for strategic raw materials, and rules to accelerate permitting times alongside other measures. The Critical Raw Materials Act for the first time sets objectives for

Europe to establish a minimum level of domestic mining, processing and recycling supply for a range of strategic raw materials by 2030. It also includes a formal list of strategic/critical raw materials (including many non-ferrous metals), new rules for accelerated the permitting of strategic projects (which should take no longer than 12-27 months), as well as requirements for circularity and strategic partnerships with resource-rich countries that could contribute to local value addition, including downstream activities, and would be mutually beneficial to the EU and the partner country.

Annex 4 – Glossary

Carbon Border Adjustment Mechanism (CBAM)

The CBAM is a system designed in compliance with World Trade Organization rules and other international obligations of the EU. EU importers will buy carbon certificates corresponding to the carbon price that would have been paid had the goods been produced under the EU's carbon-pricing rules. Conversely, once a non-EU producer can show that they have already paid a price for the carbon used in the production of the imported goods in a non-EU country, the corresponding cost can be fully deducted for the EU importer. The CBAM will help reduce the risk of carbon leakage by encouraging producers in non-EU countries to green their production processes.

Carbon capture and storage

Carbon capture and storage technologies aim to capture as much as 85-90% of CO_2 emissions from power plants and heavy industry before transporting it by pipeline or ship and storing it permanently and safely at least 800 metres below the earth's surface.

Carbon capture and utilisation

Carbon capture and utilisation technologies may counteract climate change by removing CO_2 from the atmosphere and converting it into other materials such as fuels, chemicals and plastics.

Contract for difference (CfD)

This is a contract that is concluded by a public entity to encourage investment. It tops up the market price paid if the price is below a certain level, but requires the contract holder to pay back amounts where the market price is above a certain level. The net effect is that revenues and the price are stable, close to the cost of production, and do not exceed this cost.

Circular economy

A circular economy aims to maintain the value of products, materials and resources for as long as possible by returning them to the product cycle at the end of their use, while minimising the generation of waste.

Circular Economy Action Plan

The Circular Economy Action Plan is one of the main building blocks of the European Green Deal, the EU's new agenda for sustainable growth. The EU's transition to a circular economy will reduce pressure on natural resources and will create sustainable growth and jobs. It is also a prerequisite to achieve the EU's 2050 climate-neutrality target and to halt biodiversity loss.

Classification, Labelling and Packaging (CLP) Regulation

The CLP Regulation (Regulation (EC) No 1272/2008) is based on the United Nations' Globally Harmonized System of Classification and Labelling of Chemicals. Its purpose is to ensure a high level of protection of health and the environment, as well as the free movement of substances, mixtures and articles. Since 1 June 2015, it is the only piece of legislation on classification and labelling of substances and mixtures in force in the EU.

Cohesion Fund

The Cohesion Fund provides support to Member States with a gross national income per capita below 90% of the EU average to strengthen the EU's economic, social and territorial cohesion. It supports investments in the field of environment, and trans-European networks in the area of transport infrastructure.

Electricity market design (EMD)

EMD rules aim to boost renewables, better protect consumers, and improve industrial competitiveness. The new EMD rules consist of amending Directive (EU) 2024/1711 and amending Regulation (EU) 2024/1747. They were adopted on 21 May 2024 and entered into force on 16 July 2024.

Energy and Industry Geography Lab (EIGL)

The EIGL is a tool for geographical data related to energy, industry and infrastructure. The tool makes it possible to find and filter energy-related data, and create and share maps displaying these data. It enables analyses and assessments that support EU's transition to climate neutrality.

Energy-intensive industries (EIIs)

EIIs, embedded in many strategic value chains, make up more than half of the EU industry's energy consumption. EIIs produce goods and materials that help reduce emissions in other sectors of the economy, including transport, construction and power generation.

Chemicals strategy for sustainability

The EU's chemicals strategy aims to better protect people and the environment and boost innovation for safe and sustainable chemicals. Its main measures are banning the most harmful chemicals in consumer products – allowing their use only where essential – and boosting investment and the capacity to innovate in the production and use of chemicals that are safe and sustainable by design.

European Green Deal

The European Green Deal will transform the EU into a modern, resource-efficient and competitive economy in order to overcome challenges such as climate change and environmental degradation, which are an existential threat to Europe and the world.

Green public procurement (GPP)

The Communication *Public procurement for a better environment* defines GPP as 'a process whereby public authorities seek to procure goods, services and works with a reduced environmental impact throughout their life cycle when compared to goods, services and works with the same primary function that would otherwise be procured'. GPP is a voluntary instrument, which means that Member States and public authorities can determine the extent to which they implement it.

Horizon Europe research and innovation programme

Horizon Europe is the EU's key funding programme for research and innovation with a budget of EUR 95.5 billion for 2021-2027. It aims to tackle climate change, helps to achieve the UN's Sustainable Development Goals, and boosts the EU's competitiveness and growth. The programme facilitates collaboration and strengthens the impact of research and innovation in developing, supporting and implementing EU policies while tackling global challenges. It helps

create and better disseminate excellent knowledge and technologies. It creates jobs, fully engages the EU's talent pool, boosts economic growth, promotes industrial competitiveness, and optimises investment impact in a strengthened European Research Area. Legal entities from the EU and associated countries can participate.

Hubs for Circularity (H4Cs)

H4Cs are key instruments to advance the research and innovation agenda of European industries, helping to achieve the Green Deal's objectives. H4Cs have a strong technological focus and industrial dimension, but their implementation leverages aspects well beyond research and innovation. Specific implementation (including funding) strategies will have to be co-designed, ensuring the participation of all stakeholders – industry, small to medium-sized enterprises, research and technology organisations, local authorities, educational institutions and civil society.

Industrial symbiosis

Industrial symbiosis is the process by which wastes or by-products of an industry or industrial process become the raw materials for another. Application of this concept allows materials to be used in a more sustainable way and helps create a circular economy.

Intergovernmental Panel on Climate Change

The Intergovernmental Panel on Climate Change is the United Nations body for assessing climate change science. It produces regular assessments of the scientific basis of climate change, its impacts and future risks, and options for adaptation and mitigation. These reports inform governments' development of climate policy, and guide the UN's international climate change negotiation.

Just Transition Mechanism (JTM)

The JTM is a key tool to ensure that the transition towards a climate-neutral economy happens in a fair way, leaving no one behind. It provides targeted support to help mobilise around EUR 55 billion in the most affected regions over the 2021-2027 period, to alleviate the socio-economic impact of the transition.

Power purchase agreement (PPA)

A PPA is a power offtake agreement between two parties – an electricity producer and a buyer, such as an electricity consumer or trader. Generally, a PPA is a long-term contract, lasting 10 or 15 years.

Public-private partnership (PPP)

A PPP is a long-term contractual arrangement between the government and a private partner by which the private partner delivers and funds public services using a capital asset, sharing the associated risks. This broad definition shows that PPPs can be designed to achieve a wide array of objectives in various sectors, such as transport, social housing, and healthcare, and can be structured in various ways.

REACH

REACH stands for registration, evaluation, authorisation and restriction of chemicals. The REACH Regulation entered into force on 1 June 2007. It was adopted to ensure a high level

of protection human health and the environment from the risks that can be posed by chemicals, while enhancing competitiveness and innovation.

Renewable energy sources (RES)

RES such as wind, solar and hydroelectric power, ocean and geothermal energy, biomass and biofuels offer cleaner alternatives to fossil fuels.

Safe and sustainable by design (SSbD)

SSbD is a process to: (i) accelerate widespread market uptake of new and alternative chemical products and technologies that deliver greater consumer confidence in terms of safety and environmental and societal benefits; and (ii) advance the transition towards a circular economy and climate-neutral society.

Sustainable Products Initiative (SPI)

The SPI aims to make products placed on the EU market more sustainable. Consumers, the environment and the climate will benefit from products that are more durable, reusable, repairable, recyclable, and energy efficient.

Temporary Crisis and Transition Framework (TCTF)

The TCTF for State Aid measures to support the economy following the aggression against Ukraine by Russia was adopted on 9 March 2023 and amended on 21 November 2023.

Trans-European Networks for Energy (TEN-E)

The TEN-E policy is focused on linking the energy infrastructure of EU countries. As part of the policy, nine priority corridors and three priority thematic areas have been identified.

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