ODDO BHF

FOCUS *on Metals*

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Metallurgy, the main tool of the industrial transition

> *"Europe must conduct precisely the reverse policy to help decarbonize global metal industries. We must reduce our metallurgical deficits and encourage local competitive production by ensuring that local processing industries get attractive prices for their raw materials"*

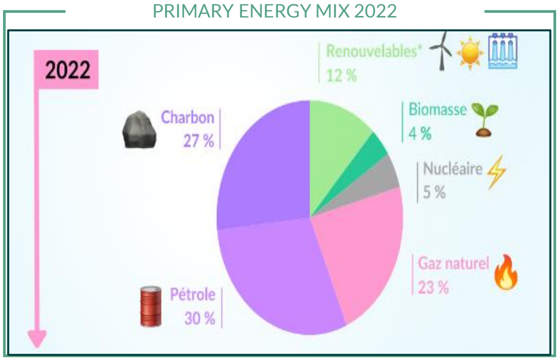
"In the next 30 years, we will have extracted as much [metals] as since the start of humanity!" – Philippe Varin in his report on Securing the Supply of Mineral Raw Materials.

At several decisive moments in our history, metallurgy has played a critical role in developing human civilizations, including during the Bronze Age (-3000/-1200 BC) and the Iron Age (-1200/-550 BC). However, its role has been somewhat overlooked since we entered the fossil fuel era, powered by coal in the 19th century and, even more so, by oil and gas in the 20th and 21st centuries.

In the coming decades we will face a radical transformation of the foundation of the global energy system, encompassing buildings, transport and many other areas, particularly in industry. This is a considerable challenge, as the world's current primary energy mix is 80% based on fossil fuels – i.e., oil & gas and coal.

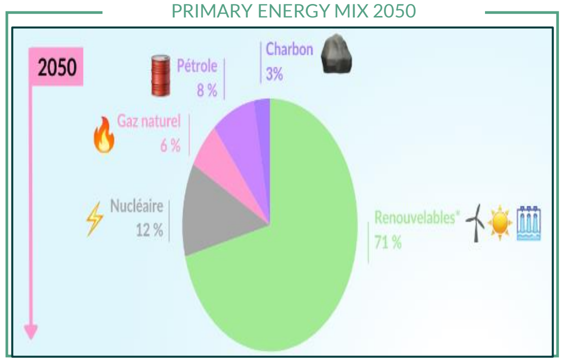
This exit from fossil fuels can only happen with massive electrification. Electricity's share in global primary energy consumption will have to increase from 20% to 53% by 2050.

PRIMARY ENERGY MIX 2022



Sources : scénario "Net Zero" IEA, 2023

PRIMARY ENERGY MIX 2050



Sources : scénario "Net Zero" IEA, 2023

Electrification is based on three main pillars:

- **Electricity generation**, most of which will have to be decarbonated (via renewables and partly nuclear)
- **Densification of the electric grid**, mainly to adapt to **intermittent production**. It will also be crucial to integrate greater means of electricity storage.
- **Electrification of uses**, particularly in the transport and industry sectors.

In each of these pillars, metallurgy will play a key role, and we are seeing a direct correlation between **reduced consumption of fossil fuels and increased investment in metals.**

The table below illustrates how critical aluminium and copper are in the energy transition and the development of new technologies:

CRITICAL MINERAL NEEDS FOR CLEAN ENERGY TECHNOLOGIES

	Copper	Aluminium
Solar PV	High	High
Wind	High	Moderate
Hydro	Moderate	Moderate
CSP	Moderate	High
Bioenergy	High	Moderate
Geothermal	Low	Low
Nuclear	Moderate	Low
Electricity networks	High	High
EVs and battery storage	High	High
Hydrogen	Low	Moderate

Importance: High ● Moderate ● Low ●

Sources : IEA

The necessary rapid adaptation of our economies raises questions on the EU policy that will allow it to maintain and expand its industrial competitiveness and ensure its sovereignty. Europe faces two giants: China, with its dominant state- and - highly subsidized industrial sector*, and the United States, which are ramping up their re-industrialization thanks to unparalleled energy costs and to subsidies of policies such as the Inflation Reduction Act (IRA).

ELECTRIFICATION RELIES MOST OF ALL ON METALLURGY

According to the International Energy Agency (IEA), global electricity generation will rise more than 2.5-fold under the "Net Zero Emission" scenario between 2022 and 2050, with far more rapid growth during this period (3,5% annually) than during the last decade (2.5%). **This will require simultaneous and consistent policies in three areas**:

1. Electricity generation

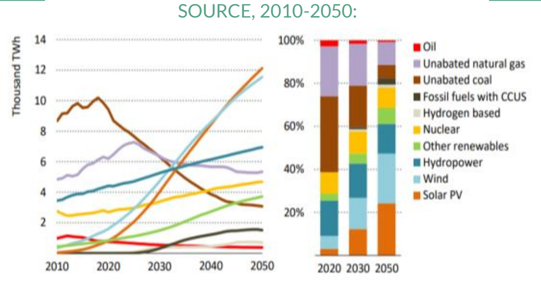
The IEA trajectory assumes annual additions of 630 gigawatts (GW) of photovoltaic (PV) solar power and of 390 GW of wind power by 2030 worldwide. These figures are almost four times the record levels set in 2020.

THE MAIN STAGES OF DEPLOYING RENEWABLES ENERGIES

Sector		2020	2030	2050
Electricity sector				
Renewables share in generation		29%	61%	88%
Annual capacity additions (GW):	Total solar PV	134	630	630
	Total wind	114	390	350
	– of which: Offshore wind	5	80	70
	Dispatchable renewables	31	120	90

Sources : IEA

GLOBAL ELECTRICITY GENERATION BY SOURCE, 2010-2050:



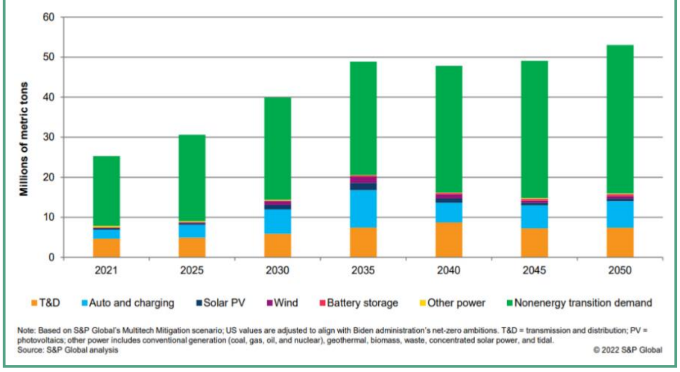
Sources : IEA

* 2017 OECD report: measuring distortion in aluminium supply chain

What does this mean in terms of metals? There are many impacts.

The transition towards renewable energies, particularly in the wind and solar sectors is generating heavy demand for copper, which is becoming critical.

ESTIMATED COPPER DEMAND, 2021-2050:



Sources : S&P Global

Photovoltaic solar power requires large amount of aluminium and copper. On average, installing 1 MW of photovoltaic capacity requires 21 tonnes of aluminium . Hence, the 630 GW in capacity added each year requires 13 million tonnes of additional aluminium. Installing 1 MW of photovoltaic capacity requires 2.9 tonnes of copper, meaning that capacity of 630 GW requires 1,827,000 tonnes of additional copper.

For onshore and offshore wind turbines, installing 1 MW of wind power requires an average of 2.8 tonnes of copper and 386 kg of aluminium . Hence, for additional annual capacity of 390 GW, we would need another 1,099,800 tonnes of copper and another 151,000 tonnes of aluminium.

However, in addition to ensuring sufficient production of metals to meet growing demand, it is crucial to meet the challenge of renewable energy intermittency , i.e., to derive greater value from electricity generation having variable levels. Unless these challenges are met, these investments could be compromised economically.

The following must therefore be done:

- **Expand the development of transmission grids** in order to pool surplus electricity.
- **Expand storage capacities**, particularly through hydropower and batteries.
- **Promote the development of dispatchable electro-intensive industrial applications**, offering flexible energy consumption to better adapt to fluctuations in renewable energy supply.

2.Transport and storage

The electric grid has historically been built as a distribution system emanating from centralized production hubs powered by coal, oil & gas or nuclear power.

The energy transition consists in replacing this concentrated, centralized, stable and dispatchable electricity generation with a mode of production that is both decentralized and intermittent. That's why grids must be expanded for optimum use of this electricity.

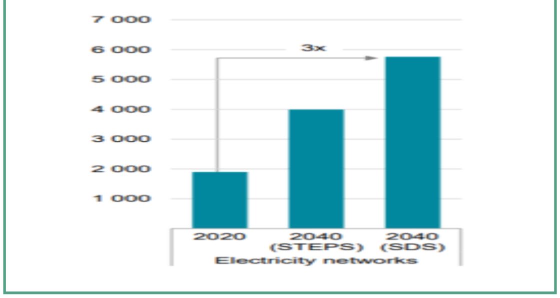
Meanwhile, storage must be expanded (pumped-storage hydropower plants, batteries, etc.) with electric flow inversion for grid charging and feeding.

Lastly, electrification of uses is creating new, far-flung points of consumption.

An increase in the level of complexity of the grids thus seems essential and will require massive investments in infrastructures with resulting heavy demand for both copper and aluminium. Electrical grids will be the main contributors to copper demand. The main metal that can partially replace copper is aluminium for electricity grids.

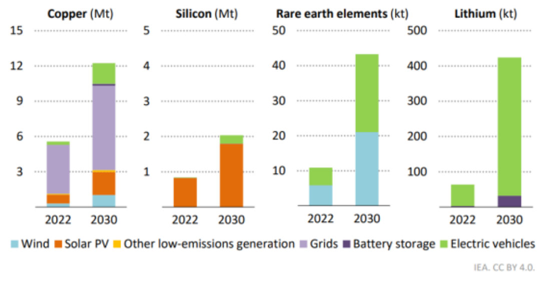
Sources: [1]Association Européen de l'Aluminium | [2] BloombergNEF | [3] BloombergNEF

ANNUAL CLEAN ENERGY DEPLOYMENT BY SCÉNARIO



Sources : IEA

CRITICAL METAL DEMAND BY NEED



Sources : IEA

3. Uses

First of all, **the auto sector, in which electrification will be the main avenue of investment for uses.**

Electrification of the auto fleet is generating demand for metals for both the charging infrastructure (see above) and for the vehicles themselves.

Regarding the vehicles, according to the IEA, six times as much metals are needed to make a standard electric vehicle than a conventional vehicle.

According to the international Copper Association, this much copper is required for each type of vehicle:

- ICE vehicle: 23 kg of copper
- Hybrid electric vehicle: 40 kg of copper
- Hybrid rechargeable electric vehicle: 60 kg of copper
- Battery electric vehicle: 83 kg of copper (almost four times more than in a gasoline-powered car)
- Hybrid electric bus: 89 kg of copper
- Battery electric bus: 224-369 kg of copper (depending on battery size).

Copper is essential for engine cables and batteries.

Electric vehicle bodies also require lots of **aluminium** to lower their weight. A study commissioned by European Aluminium found that the proportion of aluminium used in European cars (both ICE and electric) had risen by 18% from 2019 to 2022. As a result, a vehicle contained an average of 205 kg of aluminium in 2022, vs. 174 kg in 2019, thanks to electrification and efforts to make vehicles lighter. And the trend may last. The average use is expected to rise by 15.6% from 2022 to 2026 and could reach a weight of 237 kg.

Nickel, cobalt or lithium are used in the rechargeable batteries that they are equipped with.

Meanwhile, SUVs continue to gain ground: one vehicle out of two sold in the major economies is an SUV, and electric vehicles themselves are part of this trend.

Demand for metals has naturally risen proportionally as vehicles have become heavier.

FLEXIBILITY IS CRUCIAL FOR INDUSTRIAL APPLICATIONS

Europe will be encouraged – and even forced – to develop a dispatchable electro-intensive industry to absorb surplus electricity from renewable energies.

In France, RTE estimates in its core scenario that flexibility needs will come to 34 GW in 2050, which works out to an increase of about 1 GW each year, driven mainly by the boom in renewable energy sources. Globally, the IEA estimated in its 2021 report that needs for flexibility will quadruple in both developed and emerging economies.

The flexibility of certain industrial processes, particularly electro-intensive ones, is already partly estimated at almost 3 GW in France, according to RTE.

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- ⇨ Erasures are thus being made in some industries by spreading production out over time, by exploiting inertia in certain processes, or through existing margins in manufacturing schedules.
- ⇨ In metallurgy these erasures are systemic in processes such as electrolysis for exemple at Aluminium Dunkerque and Trimet in France and Germany. Participation in various flexibility mechanisms accounts for a cumulative pool of almost 80% of consumption power.

Restarting an **electro-intensive** metallurgy or chemical industry in Europe with dispatchable electricity consumption is no longer a utopia. Marginal MWh that could be captured will be priced competitively, even on a global scale.

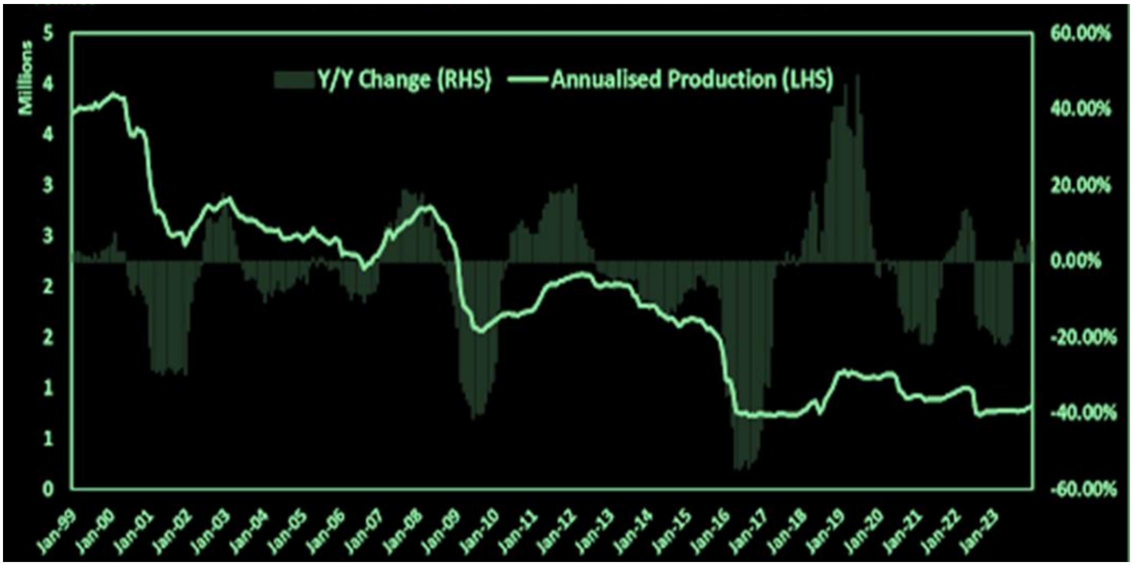
WHAT IS THE BEST POLICY FOR EUROPEAN METALLURGY?

The European Union has become aware of the importance of metallurgy in the climate transition. At the same time, it has taken note of how vulnerable its supply chains are and of its dependence on critical metals, from China in particular. However, when Europe establishes standards, regulations or laws (e.g., a carbon tax), it must be aware that, with just 10% to 15% of global consumption of these metals, it is a small player on the planetary stage. European policies must join a global competition in which China refines between 50% and 90% of metals.

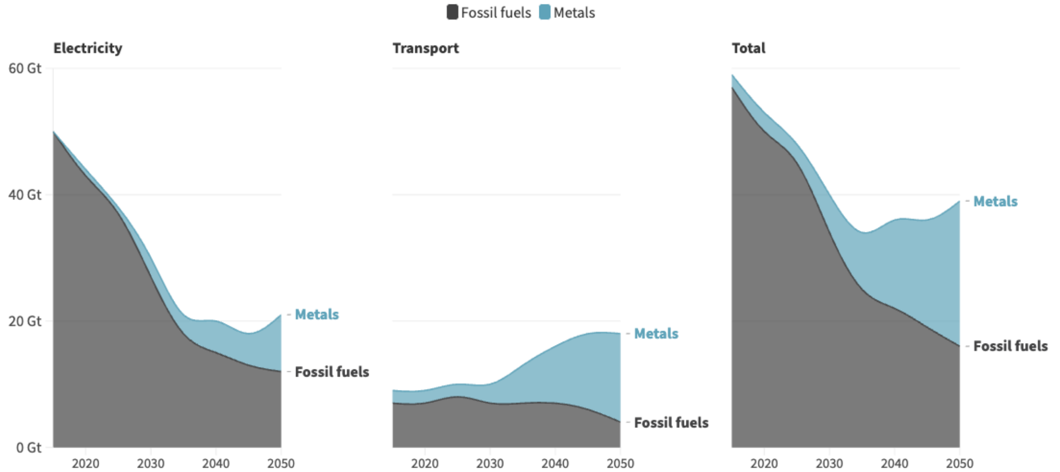
In defining these policies, lessons must be drawn from the experiences of our major competitors:

- The extraordinary development of Chinese metallurgy has been based on simultaneous encouragement of refining and bank facilitation of metal imports. The clear objective has been, and remains, to offer cheap raw materials to transforming industries. In parallel, heavy investments have been committed to restarting the transformation. China has successively been the top importer of aluminium, then alumina, and then bauxite. In contrast, the export of unprocessed products is discouraged through measures such as export taxes and non-retrieval of VAT.
- In contrast, the lesson of the total failure of US protectionist policies must not be overlooked (Section 232). Taxation of steel (25%) and aluminium (10%) ultimately produced no productive investments. On the contrary, the higher taxes benefited Canadian aluminium producers and Mexican processing industries. (See Annexe I: US aluminium production.)
- Mining must be restarted in Europe. Resources are significant, particularly in lithium are rare earths, **but the key to sovereignty will remain above all in the development of metal refining capacities that help establish long-term relationships with mining countries and to accompany them in developing their own industry**. These refining or electrolysis industries are electro-intensive and partly dispatchable. They have an essential role to play in adjusting intermittent electric supply and demand.
- As it is currently envisioned, the European Carbon Border Adjustment Mechanism for steel and aluminium and the reduction in carbon quotas pose major risks to European processing industries. For, by making raw materials more expensive without affecting most of the finished products, it will mainly encourage offshoring of an industry already being squeezed by energy costs.
- Europe must conduct precisely the reverse policy to help decarbonize global industries. We must reduce our metallurgical deficits and encourage local competitive production by ensure that local processing industries get attractive prices for their raw materials. To cite one example, if Europe produced another 5 million tonnes of aluminium (equal to its deficit) with its average carbon footprint (6.7T CO_2 per tonne of aluminium), it would contribute to closing equivalent capacity at the global level (of which more than 50% is still carbon-based with an average carbon footprint of 20T CO_2 per tonne of aluminium). This would result in a reduction of global emissions of 70 million tons of carbon emissions .

ANNEXE I – US PRIMARY ALUMINIUM PRODUCTION



ANNEXE II – TOTAL MATERIAL REQUIEREMENT FOR THE ENERGY TRANSITION



Source: Watari et al. (2021). Sustainable energy transitions require enhanced resource governance.

Disclaimer

Companies mentioned are examples and not investment recommendations. Past performances are not a reliable indicator of future performances and are not constant over time.

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