The links in the critical minerals and metals value chains

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Key Takeaways

- Commodities are increasingly called upon in greater volumes to support the transition towards improved climate and energy security.
- Aluminium, cobalt, copper, iridium, lithium, nickel, platinum, rare earth elements, tin, nickel, silver, and zinc are some of the key materials required in the transition technologies.
- This blog is intended as a primer for non-specialists interested in better understanding the links in those commodities' value chains.

Mining companies involved in extracting critical metals and minerals will play a focal role in supporting the energy transition, as discussed in the first part of our blog series here. Enabling clean energy technologies to grow at the pace and scale needed to meet global climate targets will depend on the rate at which critical minerals can be found and mined. The WisdomTree Energy Transition Metals and Rare Earths Miners UCITS ETF (RARE) enables investors to tap into pure-play companies that produce the most important metals for the energy transition theme.

Sub-sector	Upstream	Midstream				
Metal categories	**Mining**	**Refining**	**Smelting**	**Conversion**	**Chemicals**	
Aluminium						
Cobalt						
Copper						
Iridium						
Lithium						

Nickel						
Platinum						
REE						
Silver						
Tin						
Zinc						

Source: Wood Mackenzie as of 31 March 2024

The Energy Transition Metals Value Chain (ETMVC) includes the exploration and processing of metals, including rare earth elements (REE), used in technologies associated with the energy transition such as electric vehicles (EVs), transmission, charging, energy storage, solar, wind and hydrogen. The companies that belong to the ETMVC are identified and classified into 11 metal categories (aluminium, cobalt, copper, iridium, lithium, nickel, platinum, silver, tin, zinc, and REE) and across six subsectors (chemicals, conversions, industry, mining, refining, and smelting). The ETMVC includes companies that move through different phases, from upstream mining and extraction through various midstream transformation processes, to the end products used in renewable power plants, EVs, and other features of the lower carbon economy. In the case of nickel, the outputs are so varied that it is best described as an industry in itself.

This blog is a primer for investors to better understand the underlying process within the ETMVC for companies providing a supply of commodities critical to the energy transition.

What are the key sub-sectors?

Aluminium

- Mining: Bauxite ore is the primary source of aluminium. Australia, China and Guinea are the largest producers of bauxite.
- Refining: Bauxite is refined into alumina (aluminium oxide) through the Bayer Process. Heat, pressure, and sodium hydroxide are used to separate aluminium oxide from impurities and iron ore.
- Smelting: Alumina (aluminium oxide) is the starting material used for smelting aluminium through the Hall Heroult process.

Cobalt

- Mining: A mix of large-scale industrial miners and small-scale freelance or artisanal miners are involved in cobalt mining. The Democratic Republic of the Congo (DRC) accounted for ~70% of mine supply of cobalt in 2023[1].

- Refining: Pyrometallurgy is a refining process where high temperatures are applied to the ore, causing it to melt and the cobalt to be separated.
- Chemicals: Cobalt ore is treated with chemicals to extract elemental cobalt. The process, known as hydrometallurgy, dissolves the ore and separates the cobalt.

Copper

- Mining: Most copper mining is open-pit (low cost, efficient, scalable) with underground mining (costly and technically challenging) also undertaken by some players. Copper ore is mined as copper sulphides and copper oxides, with the type of copper compounds determining the refining and smelting process. Chile is the world's largest copper producer, but Peru and the DRC are also key suppliers.
- Smelting: Smelting and refining applies primarily to copper sulphide ores, and smelting is the next step in the copper value chain after mining and beneficiation. Copper smelting involves the application of heat and chemical reducing agents to extract pure copper metal. Copper oxide ores are not smelted.
- Refining: After the copper ore is smelted, it is refined. Electrolytic refining is the most common refining method, whereby electricity is used to separate copper from impurities in a solution. Pyrometallurgical refining is also used to produce purer copper ore. Copper oxide ores are not smelted. Instead, they are processed through hydrometallurgy (leaching, solvent extraction, electrowinning) and are refined using electrowinning to produce a 99.9% pure copper cathode.

Iridium

- Mining: Iridium is often found as a by-product of copper and nickel mining, so its extraction mirrors that of those metals through a mix of open-pit and underground mines. South Africa is the dominant producer of iridium in the global market.

Lithium

- Mining: Lithium ore mining involves extraction via hard rock mining (higher costs, more energy, more sources) from ore such as spodumene, petalite and lepidolite. Lithium can also be extracted from brine sources (lower cost, slow, lower recovery), such as geothermal wells, salt lakes or hydrocarbon fields. Australia, China and Chile account for much of the world's lithium supply.
- Conversion: The lithium conversion process transforms lithium from one chemical form to another, usually to make it more suitable for various applications. The end chemicals are usually either lithium hydroxide or lithium carbonate.

Nickel

- Industry: Nickel is not just a simple case of concentrate production. There is nickel concentrate and others such as nickel pig iron (NPI), iron-nickel (FeNi), and high-pressure acid leach (HPAL). Nickel is grouped as an industry to account for all the different products. Indonesia is the world's largest nickel supplier.

Platinum

- Mining: Most platinum mining occurs underground and is often associated with nickel mining. Surface mining does take place, but it's less common. South Africa produces the vast majority of the world's platinum.

Rare Earth Elements (REE)

- Mining: REE mining involves the extraction of REE ores, which contain a mix of metals. As REEs are abundant in the earth's crust, removing topsoil, leaching ponds or drilling holes to pump chemicals releases ores. China is the principal producer of different REE ores and concentrates.
- Refining: 85% of global REE capacity is in China[2]. Refining involves various applications of heat and chemicals to separate REE from other elements contained in the ores.

Silver

- Mining: Silver is mined from various ores, including copper, nickel, gold, and lead. Depending on the depth and the type of ore, silver ore extraction involves open-pit or underground mining methods. Mexico is the largest producer, alongside Peru.
- Refining: The refining of silver ore involves purification and conversion to the end product (bars, coins, powder) through a range of techniques including electrolysis, fire refining or chemical precipitation.

Tin

- Mining: The two primary ways of extracting tin are surface mining from rock ores such as cassiterite and brine extraction. China is the largest tin producer by a comfortable margin.
- Smelting: Tin ore is processed to separate and concentrate the tin minerals using physical and chemical methods, such as crushing, grinding, flotation, and leaching.

Zinc

- Mining: Zinc extraction involves open-pit or underground mining methods depending on the depth and type of the ore. China is the world's largest zinc miner, and Australia and Peru also have notable upstream extraction operations.
- Smelting: Pyrometallurgical processes involving heat and reducing agents separate zinc from other elements. The electrolytic process, based on electricity and a solution, also purifies zinc before the metal is cast into ingots or sheets.

Strong policy support alongside higher investment is paving the way for a faster shift towards clean energy to keep net zero emissions by 2050 within reach. Clean energy technologies are evolving rapidly and in lockstep we expect the ETMVC to adapt. The WisdomTree Energy Transition Metals and Rare Earths Miners UCITS ETF (RARE) aims to capture the opportunity from the evolving nature of the energy transition technologies and their impact on global mining companies. At present, close to 60% of the

portfolio weight is allocated to companies with more than 75% revenue exposure to the energy transition metals and rare earths theme, highlighting a strong exposure to pure plays.

Sources

[1] Source: Wood Mackenzie Global cobalt strategic planning outlook Q1 2024.
[2] Source: Wood Mackenzie Global rare earth element planning outlook Q1 2024.

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