TURNING THE TIDE

Public sentiment has been hugely influential in our shift from fossil-fuelled power generation to clean and renewable energy sources. The question now is, how do we turn the tide on the mining sector's "dirty" image and reveal how the mining supply chain and renewables can combine to limit global warming to at or below 2˚C?

The mining sector is a significant contributor of greenhouse gas emissions.

There is no hiding from the fact that the mining sector is a significant contributor of greenhouse gas emissions. It is publicly viewed as a "dirty" industry alongside other fossil fuel-based industries such as the oil and gas sector, and rightly so.

The mining sector is reportedly responsible for 4 percent to 7 percent of global greenhouse gas emissions resulting from direct emissions from owned or controlled sources (Scope 1) and indirect emissions from generation of purchased energy (Scope 2)[1]. If we extend the scope to all other indirect emissions that occur in the value chain (Scope 3), this estimate rises to approximately 28 percent of global emissions.

In 2019, approximately 1.5 billion tons of iron ore were traded. 23 percent was exported by Brazil (some 335 million tons) and 72 percent (some 1 billion tons) was imported by China. Using this supply chain as an example, the ore is transported up to 1,000 kilometres by land and shipped more than 20,000 kilometres by sea. Due to the sheer volume of ore and distances travelled, emissions associated with the freight and associated infrastructure such as ports are of increasing interest as a component of the supply chain and contribute to the exposure of the mining sector.

Achieving below 2˚C will require a large-scale transition to clean energy.

The 2015 Paris Agreement establishes a clear goal to limit the increase of global temperatures to "well below" 2 degrees Celsius (°C) and ideally to 1.5°C, compared to pre-industrial levels, by the end of this century. Hitting that target and delivering a low-carbon future will require a large-scale transition to clean energy and substantial decarbonisation across the global economy, particularly in the mining sector.

According to the International Renewable Energy Agency's (IRENA) latest reporting[2], the total share of renewable energy would need to rise from around 14 percent of total primary energy supply in 2017 to around 65 percent in 2050. The renewable energy mix would also change, with the share of renewables from bioenergy decreasing from two-thirds to one-

[1] https://www.mckinsey.com/business-functions/sustainability/our-insights/climate-risk-and-decarbonization-what-every-mining-ceo-needs-to-know

[2] IRENA (2020) Global Renewables Outlook: Energy Transformation 2050

third, and with a much higher share of solar- and wind-based energy. As an example, the global cumulative installed capacity of wind power will need to increase by more than ten-fold by 2050. For solar power, global capacity will need to grow from a total of 384 gigawatts in 2017, to 8,519 gigawatts by 2050.

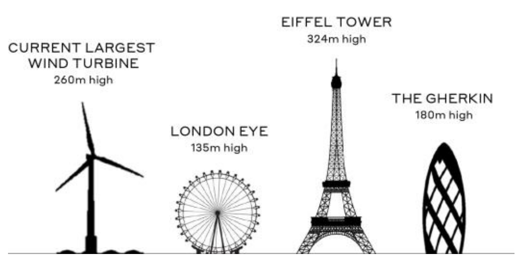
The rollout of renewables cannot be delivered without the mining sector.

This large-scale transition will undoubtably be mineral intensive and the extent of the mining sectors role has finally been the subject of a comprehensive study prepared by the World Bank Group[3]. The need to connect some 840 million homes without electricity access today and decarbonise the transportation sector with some 135 million electric vehicles in the next 10 years[4] are just two example challenges that lie ahead. Clean energy technologies will require more materials than fossil-based electricity generation technologies and increasing the installation of these technologies will lead to a larger material footprint.

For context, solar photovoltaic has been the most rapidly deployed renewable energy technology globally, with generation capacity increasing by some 28 percent from 2017 to 2018[5]. This trend is expected to accelerate, with growth projections in Africa exceeding 3,000 percent from now through 2040. Solar photovoltaic technologies rely primarily on the supply of aluminium accounting for 85 percent of most solar panel components including cells, frames and attachments, copper accounting for 11 percent and silver. When considering the most materially intensive forecast scenario, the World Bank Group estimates the solar sector to generate a cumulative demand of 160 million tons of aluminium and 20 million tons of copper through to 2050.

Like solar PV, wind energy has also been one of the fastest growing renewables. Installed capacity reached 566 GW in 2018[6] and is expected to reach 5,044 GW by 2050[7]. Increases in wind turbine size, higher efficiency, lower cost of capital, and economies of scale have lowered wind electricity generation prices to the point where it is competitive with fossil fuel generation in many areas.

The largest onshore wind turbines now exceed 6 MW of peak generation capacity, enough to power more than 5,000 homes in the West. The largest offshore wind turbines are more than twice that size (13 MW)[8] and can be anywhere from 150 to 260 meters in height from base to blade tip, shadowing London landmarks such as the London Eye and the Gherkin.



[3] Minerals for Climate Action: The Mineral Intensity of the Clean Energy Transition, World Bank Group, 2020
[4] IEA 2019b
[5] IRENA Renewable Energy Highlights 1 July 2020
[6] IEA 2019c
[7] IRENA: Deployment, investment, technology, grid integration and socio-economic aspects, October 2019
[8] https://www.equinor.com/en/news/20200922-dogger-bank.html

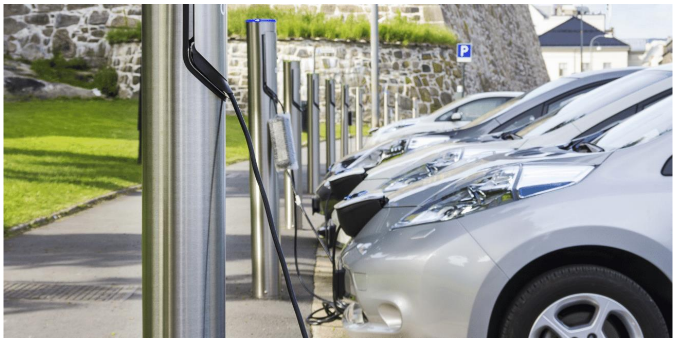
The main components of turbines including towers, nacelles, transition pieces and foundations are primarily made up of steel. Steel is primarily manufactured using a mix of iron ore, carbon, and other elements such as nickel, molybdenum, titanium, manganese, vanadium, or cobalt, depending on the type and quality of steel required for industrial applications.

Iron accounts for approximately 85 percent of material demand for wind turbines and copper around 4 percent. All other minerals combined represent nearly 11 percent of demand, primarily for the permanent magnets (neodymium), gearboxes (nickel), or cabling (aluminium). Considering the most materially intensive forecast scenario, the World Bank Group estimates the wind sector to generate a cumulative demand for some 350 million tons of iron, 50 million tons of zinc, and 20 million tons of copper and aluminium through to 2050.

New and emerging technologies is where the largest mineral demand increase in percentage terms is expected.

Geothermal, for example, accounts for a very small percentage of global electricity capacity since electricity can only be generated in locations with high or medium temperatures, typically close to tectonically active regions. Geothermal generates electricity from thermal energy located below the earth's surface and requires a very high quality of steel to be able to carry reservoirs of steam and hot water for power generation. Minerals such as titanium and molybdenum are needed for corrosion resistant alloys and to cope with the high heat and pressure. In addition to nickel and iron ore required for steel production, chromium represents a key mineral for thermal technologies.

Energy storage is considered essential for the low-carbon transition since it is used to power electric vehicles and is needed to store power from intermittent electricity generation from solar and wind, that can be released during peak hours. The battery space is emerging rapidly, with many alternatives under development. Predicting which of these technologies will emerge to commercial scale is challenging, but each could affect the demand profile for minerals. While cobalt and lithium are best known for being used in energy storage, batteries typically use a wide variety of minerals including aluminium, nickel, lead and manganese for the cathode and graphite for the anode.



Carbon capture and storage (CCS) is another example of the key technologies that is expected to be deployed under the transition to clean energy. It involves the capture of CO_2 from combustion of coal and gas and the transportation of CO_2 from the source to long-term storage solutions. CCS is expected to generate an increased demand for chromium, cobalt, copper, manganese, molybdenum and nickel as key minerals required for capturing the CO_2 or in the steel alloys needed for the plants, pipelines and logistics networks including ports and vessels.

The use of fuel cells and hydrogen is expected to play a vital role in powering various industrial processes as well as transportation. The use of fuel cells and hydrogen has been explored for some time because of is potential to lower carbon emissions, however its deployment has been limited by high cost barriers and infrastructure constraints. Fuel cells offer a higher energy density per weight than batteries, which is why fuel cells have been emerging predominantly in buses and medium to heavy freight transport. Fuel cells and the electrolysis production of hydrogen generates a demand profile for platinum, ruthenium, chromium and nickel in additional to the wider mineral demand resulting from the transport of hydrogen.

Finally, the potential of recycling and reuse should be an important focus area. While the recycling and reuse of minerals can play a key role in reducing emissions, mining will still be required to supply the critical minerals needed to produce these low-carbon technologies. This is partly due to the lack of existing materials to recycle and reuse, along with associated costs and technological barriers.

We must raise awareness of the carbon footprint implications of the clean energy transition.

So, whilst we reflect on this increasing demand for minerals and increased activity of mining supply chains, how do we overcome one of the major challenges faced by the mining sector; public sentiment? How do we embark on this mineral intensive route to cleaner energy whilst the mining sector faces mounting pressure from activists to stop carbon emissions and projects considered harmful to the environment? How will new mining projects raise funding when enthusiasm for investment in fossil fuels and mining is shrinking, and the mining sector risks facing a market that is smaller, pricier and subject to a much higher degree of investor oversight?

The first step is undoubtably to raise awareness of the new route ahead, specifically the carbon footprint implications of the clean energy transition.

Despite the higher mineral intensity of renewable energy technologies, the scale of associated greenhouse gas emissions is a fraction of that of fossil fuel technologies. The greenhouse gas footprint of the extraction and processing of minerals necessary for green technologies will likely be higher than fossil fuel generation. However, once the emissions that result from extracting coal and gas, and ultimately burning it to generate electricity, are considered, fossil fuel generation has a substantially greater carbon footprint. Recent estimates for the 2°C or below pathway reveal that renewable energy and storage technologies will contribute just 6 percent of the CO_2 contributed by coal and gas through to 2050. In other words, the lifetime carbon footprint of clean energy is believed to be considerably less than coal and gas alternatives.

The transition must be performed in a responsible manner and target all components of the supply chain.

Of course, this scenario can only be made a reality if the carbon and material footprints relating to the clean energy supply chains are successfully managed. This takes us to step two, implementation.

All stakeholders along the mineral and renewable energy supply chains will have a vital role to play in the transition to cleaner energy to achieve Sustainable Development Goal 7 (Affordable and Clean Energy for All). It is essential that this transition does not come at the cost of the climate, the environment and people, particularly communities directly affected by mining supply chains. This includes the environmental and social risks (for example, water, ecosystems, and so on) associated with increased extractive, processing and transport activities.

The manufacturing of clean technologies including solar panels, wind turbines, and batteries will undeniably shape the demand profile and supply chains of critical minerals for the foreseeable future. This presents material implications for a wide variety of industries and for mineral-rich developing countries. These countries stand to gain an economic boost from the rise in demand for minerals but also need to manage the material and climate footprints associated with increased mining activities.

This will require a high degree of innovation and environmental strategy across the whole supply chain to ensure responsible mineral extraction, transport logistics including road, rail, ports and shipping, installation, operation, decommissioning and recycling. Whilst progress is underway with several big mining companies implementing their own sustainability committees, significantly more action will be required to limit global warming to at or below 2°C.

The scope for Future Ready encompasses both old and new.

In some instances, the demand for specific minerals is set to increase by 500 percent and whilst the relative volumes of these minerals are manageable, it will require the exploration and development of new mines and export routes in typically remote locations. For existing diverse supply chains, such as iron ore (steel) and bauxite (aluminium), the increased demand will most likely require capacity expansions. Furthermore, the climate targets extend through to 2050, which means at least an additional 30-years design life should be considered for existing supply chain infrastructure.

So where do we start and what more can we be doing to control the carbon footprint of future projects?

At the mine, the drive to reduce carbon emissions has influenced the modernisation of mine vehicle fleets through hydrogen power. In Chile, Alta Ley has formed a consortium of companies to produce a dual fuel system using hydrogen and diesel to power existing combustion engines. In October 2020, Anglo American announced plans to introduce hydrogen mining truck fleets across seven sites by 2030. Anglo reports that the trucks will allow for 50 percent to 70 percent reduction in emissions (Scope 1 and 2 for open-pit mines). The company intends to test the first conversion at its platinum mine in South Africa in 2021.

In 2020, WSP in the UK announced it would lead the engineering consultancy sector by being the first to drive down the carbon footprint of its designs and advice to clients. Technology will play a vital role in this commitment, leveraging planning and design software to assess and select the most technical, economical and environmentally viable road and rail corridors. AI technology is being introduced to rapidly generate and evaluate millions of alternative routes for linear infrastructure, taking into consideration earthwork volumes, impacted landowners and affected species. In addition to the more obvious CO_2 reduction opportunities during the construction and operations phase, technology can help minimise the carbon footprint of new road and rail infrastructure.

Large miners have already sought to reduce their carbon footprint through incorporation of renewable energy. Rio Tinto has agreed to run its Utah copper mine through wind power reducing its carbon footprint at the mine by nearly 65 percent. Anglo American has entered a deal with Enel for its Chilean mines to be powered by renewable energy thereby reducing its carbon emissions by more than 70 percent. The Fortescue Metals Group recently moved its carbon neutrality target forward by 10-years and through Fortescue Future Industries (FFI), Fortescue is developing a ship design powered by green ammonia and testing large battery technology in its haul trucks, hydrogen fuel cell power for its drill rigs and technology that enables its locomotives to run on green ammonia.

The implementation of value chain optimisation for pit-to-port operations enables better decision making through transparency, interactivity and analysis. These digital systems improve connectivity of assets and make it easier for operators to monitor and control production, inventory, asset utilisation, energy consumption and continuous improvement.

Integration and collaborative data sharing between third-party assets, such as independent mines and third-party rail and port operators is where the biggest challenge lies. In December 2020, the Port of Rotterdam announced the successful desktop trial of Just-in-Time ship operations[9], demonstrating how emissions can be cut considerably by reducing idling time outside the port. Whilst this trial was specific to the container sector, Just-in-Time is applicable to the mining sector and the digital connectivity of assets could help to minimise operational downtime and reduce power usage through tailored port operations such as direct loading (storage bypass).

At the export port, suppliers of modern state-of-the-art ship loaders offer environmental designs that minimise the impact of noise and dust emissions on the surroundings through covered booms and discharge chutes. Similarly, at the import port, a range of suppliers offer high capacity enclosed rail mounted and mobile unloading solutions that minimise material spillage and support quick vessel turn-around times. For grab operations, fixed or mobile hoppers play a similar role in maximising capacity and minimising dust and spillage.

Some projects may not have the export volumes to justify a dedicated bulk terminal. In this instance, the use of specialised bulk containers and container rotation systems could be a viable alternative avoiding investments in new storage, conveying systems and ship loading systems. These containers are BK2 compliant, so suitable for transporting dangerous cargo on road and rail, and can be handled at existing container terminals, by conventional container handling equipment such as reach stackers, mobile harbour cranes and STS cranes. The containers are sealed before pit-to-port transportation, avoiding contamination or spillage, and are

[9] https://www.porttechnology.org/news/port-of-rotterdam-hails-just-in-time-success/

emptied in the hold of the vessel before being transferred back to the mine.

Operational downtime due to rain can drastically reduce the practical capacity of a port and thus export volumes. Rain covers and canopies are solutions that have been deployed at barge terminals, particularly in the agribulk sector, but have yet to materialise in deep-sea port operations. This is primarily due to the required amplitude of the covers, since they need to reach heights of up to 70 meters, equivalent to a 22-story building. This represents a huge engineering challenge, because the structure must be resistant to strong winds and prevent lateral rain ingress caused by wind.

This said, "squeezing the lemon" and enhancing the capacity of brownfield facilities through downtime reduction avoids the need for greenfield developments or costly expansions with much larger carbon footprints.

In 2020, WSP in the UK was commissioned to conduct a feasibility study for a hydrogen "super-hub" at the Port of Southampton, UK. Southampton emits around 2.6 million tonnes of CO_2 from a combination of industrial activity and properties connected to the gas distribution network for heat. The study aims to assess schemes incorporating carbon capture, usage and storage (CCUS) technology that could reduce these emissions in combination with localised hydrogen production.

A similar concept could benefit multiple stakeholders at major mineral exporting locations such as Kamsar, Guinea. Guinea's bauxite-aluminium industry is undergoing a significant expansion of investment, concession agreements, and in-country mining and refining operations.

Many of these export facilities require transhipment operations, whereby barges (running on Marine Diesel Oil) are loaded with bauxite at a port and transferred to an offshore location where the bauxite is transferred to deep-sea vessels. This operation is not unique to Guinea, nor bauxite handling, and is undertaken globally in locations with restricted water depths.

Whilst transhipment operations provide many benefits and ultimately facilitate the commercial viability of this type of project, the additional step in the supply chain only adds to the operational carbon footprint.

Like the green evolution of mining vehicle fleets previously mentioned, marine operations could follow the hydrogen route. As a final example, plans to deploy hydrogen powered barges are already underway in Europe, with the RH_2INE collaboration aiming to have at least 10 barges running on hydrogen along the Rhine-Alpine Corridor – the main freight route between the port of Rotterdam and Cologne – by 2024.

Conclusions

So, whilst the gap between aspiration and the reality in tackling climate change remains as significant as ever, and as it stands, the mining sector is heading against the current. However, it is apparent that metals and minerals are essential for a renewable, efficient and energy-secure future. Instead of calls to abandon the mining sector, we should focus efforts on turning the tide on its "dirty" image and help advise, plan, design and implement appropriate engineering and technological solutions along the mineral supply chains to achieve meaningful change. If done correctly, limiting the carbon footprint of minerals needed for the clean energy transition will help to boost economic growth and reduce environmental risks in resource-rich developing countries and provide our best hope of delivering on multiple Paris Agreement goals.

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