# GREEN TECHNOLOGIES AND THEIR IMPACT ON THE CLIMATE AND NATURAL CAPITAL

DECEMBER 2020

CARMIGNAC
RISK MANAGERS

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# Foreword

**Andrew Howell, CFA, Head of Corporate Research from Emerging Markets Investors Alliance**

China's October 2020 pledge to achieve carbon neutrality by 2060 — made in the context of a strengthening of emissions targets by several other countries including Japan, Korea and the United Kingdom — signals that momentum towards reducing emissions is gathering pace around the world. Under the Paris Agreement, each country is free to map out its own carbon transition pathway, captured in Nationally Determined Contribution (NDC) plans. While NDCs differ from country to country, two elements play a central role in nearly all of them: decarbonization of power generation and electrification of transport. This makes sense: electricity generation is responsible for around 25% of global Green House Gas (GHG) emissions, the largest share of any source, while transportation is not far behind at 14%. Reducing emissions from both sources has become more feasible in recent years, thanks to:

- advances in solar and wind generation, bringing costs to levels that are competitive with, or cheaper than, conventional power generation, and
- the development of electric vehicle technology. On the back of these advances, we can expect a lot of investment in infrastructure associated with this energy transition: Bloomberg New Energy Finance (BNEF) forecasts at least US$11tn of fresh investment in green power generation in coming years.

But there is a less-discussed corollary of this coming boom in renewables and EV technologies: growth in mining activity. There is no escaping the math, which is detailed clearly in this report. Minerals are required for PV cells, wind turbines, battery storage and conductive cabling for connectivity. Even taking into account technological innovation and better recyclability, it is unavoidable that a range of commodities, from household names such as copper and aluminium to less familiar ones such as cobalt, lithium and rare earth metals, will need to be extracted in great quantity to make this transition possible.

This coming surge in demand raises important questions for the mining industry. Can these materials be produced reliably, safely and in a way that ensures the wellbeing of communities and the environment? This is a fair question to ask. After all, the mining industry has been associated with a range of negative impacts over its long history, encompassing health & safety, human rights violations, pollution and water scarcity.

Such impacts can be highly visible, as in the failure of the tailings dam at Brumadinho, Brazil in early 2019, killing hundreds and causing environmental devastation. More often, given the remoteness of many mining operations, the negative impacts are less manifest but can be more pernicious. It is thus critical that the mining industry rises to the challenge of meeting the world's demand for transition metals in a way that meets the expectations of society.

How can mining companies do this? A number of institutions can play a role in assisting producers achieve better standards of responsibility, as well as by calling them out when these standards are not met.

- First are industry-led efforts, such as the International Council on Mining and Metals (ICMM), a group of 27 of the world's largest miners dedicated to a sustainable mining and metals industry. Commodity-specific groups including the Copper Alliance, the Responsible Steel Initiative and the Aluminium Stewardship Initiative serve similar goals, as does the World Gold Council through its responsible gold mining standard. All have drafted standards of best practice and encourage their members and the broader industry to comply with these standards.
- Outside of these industry groups, other organizations have developed their own standards to emphasize the perspective of a wider range of stakeholders. The Initiative for Responsible Mining Assurance (IRMA) has developed a responsible mining standard and offers third-party verification and certification for mine-sites. The Responsible Mining Foundation (RMF) rates the practices of mining companies on economic, environmental, social and governance issues to encourage best practice throughout the industry. Many non-governmental organizations campaign tirelessly for best practice in mining, including the Natural Resources Governance Institute (NRGI), Oxfam, Earthworks and MiningWatch Canada.

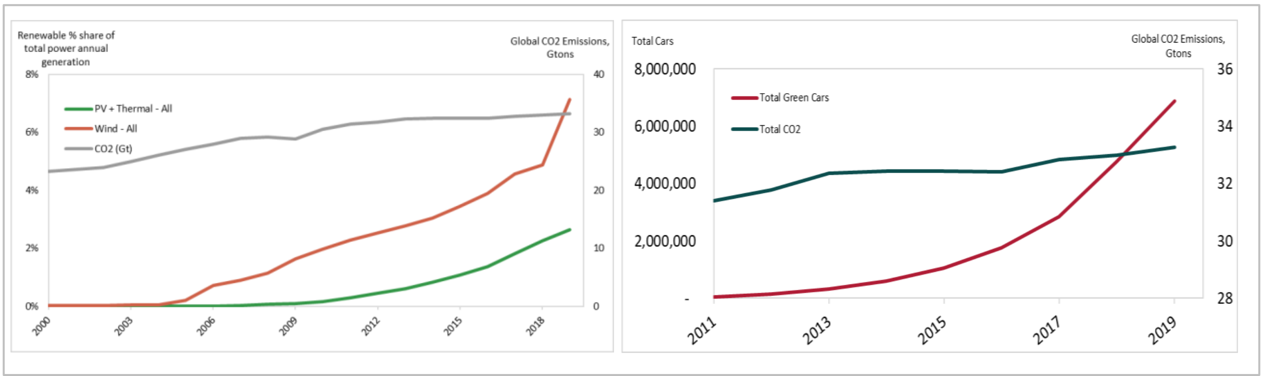
Investors too have an important role to play in encouraging better practice. The new Global Industry Standard on Tailings Management, which was developed in the wake of the Brumadinho tailings disaster and released in August 2020, received a strong early push from a group of institutional investors led by the Church of England Pensions Board and the Swedish Council on Ethics for the AP Funds. More recently, investor engagement likely played a role in the departure of the chief executive of Rio Tinto following the destruction of a heritage site at Juukan Gorge against the wishes of local indigenous groups. Investor institutions such as the Principles for Responsible Investment (PRI), the World Business Council for Sustainable Investment (WBCSD), the Institutional Investors Group on Climate Change (IIGCC) and the Emerging Markets Investors Alliance can all play a role in helping investors align on key issues and advocate for change.

For investors, the frameworks developed by civil society provide useful guides in pushing for best practice. The RMF's Framework 2020 is a good example of a broad set of guidelines for mining companies to follow, mapping 6 parameters including economic development, business conduct, lifecycle management, community wellbeing, working conditions and environmental responsibility. Investors should encourage management teams to adhere to standards such as these, while taking steps to compel adherence within their supply chain. This type of engagement can help assure that the industry meets coming needs in a way that maximizes the benefits for society.

## Introduction

Following the last two annual surveys of global business leaders in Davos, the increasing protest and call to action by civil societies globally (especially from the younger generation), and the increasingly pressing publications of scientific forecasts, the severe urgency to mitigate and adapt to climate change is increasingly evident. While the 2010s were spent on discussion and debate, the 2020s are now the decade that requires drastic action; this may be our last chance to keep the global temperature rise below the recommended 1.5 degrees, as set out by climate scientists in the IPCC's 1.5°C Special Report[1] . Policymakers are stepping up with initiatives such as, the European Green Deal announced in December 2019[2],the EU post-COVID-19 recovery plan that pledged trillions of Euros towards greening business ecosystems, and the Chinese net-zero 2060 commitment, for example. Correspondingly, green investments are increasing, with former vice-president Al Gore positing that green investment is the single largest investment opportunity since the industrial revolution.

Despite this push for green growth, focus has been centred on only the tip of the iceberg: the production of green technologies such as those for producing renewable energy, electric vehicles and energy storage, in sectors that emit less than 40% of global greenhouse gases (GHGs)[3] . Indeed, while we have observed increasing renewable power share of global energy generation, $CO_2$ emissions continue to rise; this same trend is observed with electric vehicles as seen in *Figure 1*.




[1] IPCC Special Report 1.5 Degrees, 8th October 2018 https://www.ipcc.ch/sr15/
[2] European Green Deal – 11th December 2019 https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en
[3] IPCC AR5, 31st March 2014 https://www.ipcc.ch/report/ar5/syr/

*Figure 1 LHS: Rise of global renewable power generation vs global $CO_2$ emissions; RHS: Rise of global electric vehicles sales versus global $CO_2$ level* [4]

As such, simply the production of renewable power and electric vehicles is not enough to meet climate targets; we must also look further across the supporting industries and supply chains of green technologies to ascertain how they affect both greenhouse gases and natural capital resources. The importance of this is demonstrated by *Figure 2*, which shows analysis carried by Siemens Gamesa, a leading wind turbine producer, whereby materials used in the construction of a wind turbine contribute more than 70% of the total CO2. Until now, society and policymakers have shown minimal attention to these essential elements of environmentally progressive technologies. Understanding the supply chains for these technologies will become even more critical as the uptake of green technologies increases, as there will be a significant increase in demand of new minerals; sourcing of such minerals which has implications for both carbon emissions and our natural resources, including forests and biodiversity that are vital to mitigate climate change.

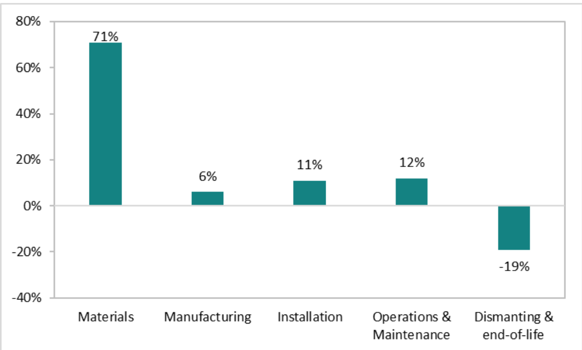



*Figure 2 percentage of global warming contribution from each life cycle stage (g CO2 eq/ kWh)*[5]

As investors it is important to look below the surface in order to understand issues such as these because we have a fiduciary duty to our clients. We must invest in companies that will be critical in the green transition, but not just those that appear the most obvious. Furthermore, we must take an active stewardship approach with regard to our clients' assets, by engaging with companies within these industries, such as mining and other highly polluting sectors along this supply chain, on such environmental or societal issues.

[4] Carmignac, Bloomberg New Energy Finance (BNEF), International Energy Agency (IEA) as of 31st December 2019

[5] Siemens Gamesa – A Clean Energy solution from cradle to grave on SG8.0-167 DD https://www.siemensgamesa.com/en-int/-/media/siemensgamesa/downloads/en/sustainability/environment/siemens-gamesa-environmental-product-declaration-epd-sg-8-0-167.pdf

In this paper, we will discuss the supply chains behind two prominent areas of technological advancement: green energy and green mobility (focusing on electric vehicles), in order to understand how they affect the climate and our natural capital. This will include the component industries and technologies as well as the materials and minerals that are needed for the transition to a lower carbon world.

# Mining A Living Planet

**Nitin Sukh, Head of Natural Capital from Planet Tracker**

## Mining and land use change

Mining features highly amongst a range of industrial activities that pose a threat to biodiversity due to associated deforestation, other land use changes, land degradation and other environmental externalities arising from extraction, the processing of metals and minerals and their transportation.

Besides having an impact on biodiversity and biodiverse landscapes, the mining sector is also dependent on biodiversity, natural capital and related ecosystems services. Hence disruptions to biodiversity and biodiverse rich landscapes can cause significant material financial risks.

Deforestation and forest degradation are occurring at alarming rates, contributing significantly to the ongoing loss of biodiversity and rise in GHG emissions. Since 1990, it is estimated that 420 million hectares of forest have been lost through conversion to other land uses, although the rate of deforestation has decreased over the past three decades.[6]

Between 2015 and 2020, the rate of deforestation was estimated at 10 million hectares per year, down from 16 million hectares per year in the 1990s. The area of primary forest worldwide has decreased by over 80 million hectares since 1990. [7]

Deforestation and the conversion of other wildlife habitat, such as wetlands, are predominantly driven by agriculture, urbanisation and industrial activities, such as mining. For example, mining activities drove 10% of total deforestation in the Brazilian Amazon, the largest and most biodiverse landscape on the planet.[8]

**What is biodiversity?**

Biodiversity refers to the variety of living species on Earth, including plants, animals, bacteria, and fungi.[1] Human activity has led to an average 68% fall in monitored vertebrate species populations between 1970 and 2016. Biodiverse landscapes, such as forests and wetlands, not only serve as habitat for living species but also secure natural capital assets from which ecosystems services flow.

**What is natural capital?**

Natural capital is another term for the stock of renewable and non-renewable resources, i.e. plants, animals, air, water, soils and minerals that combine to yield a flow of benefits to people. Any part of the natural world that benefits people, or that underpins the provision of benefits to people, is a form of natural capital. [6]

**What are ecosystems services?**

Ecosystems services flow from natural capital. To illustrate, ecosystems services can be regarded as the yield from healthy natural capital assets. A degradation in natural capital assets will therefore lead to a decline in the quality and flow of ecosystems services.

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[6] FAO (2020) – The State of the World's Forests
[7] FAO (2020) – The State of the World's Forests
[8] Sonter et al (2017) – Mining drives extensive deforestation in the Brazilian Amazon

## The importance of ecosystems services

Ecosystems services (where service is defined as 'a system supplying a public need') can provide economic, social, environmental, cultural, spiritual or physical wellbeing. The value of these benefits can be understood in qualitative or quantitative (including economic) terms, depending on context.[9] A destruction of biodiverse landscapes, through deforestation for example, wipes out the natural capital asset base required for the yield of ecosystems services.

Ecosystems services can be quantified using a broad range of techniques that have been developed by environmental economists and consultancies. Some companies have begun including the gains and losses in ecosystems services directly realised on account of company operations in their financial accounting processes. This practice is called environmental profit and loss accounting.[10]


*Figure 3: Biodiversity, Natural Capital and Ecosystems Services[11]*

## Mining's natural capital dependencies

Amongst the many ecosystems services flowing from natural capital assets, the most relevant ecosystems services that underwrite the mining sector can be found in the table below.

| Natural Capital Asset Provider | Type of ecosystems service | Benefits to mining sector | Materiality |
|---|---|---|---|
| Water | Ground water | Direct Physical input | Very High |
| Water | Surface water | | |
| Atmosphere | Water flow maintenance | Enables Production Process | Very High |
| Habitats | | | |
| Water | | | |
| Habitats | | Protection from Disruption | Medium |

[9] Natural Capital Coalition (2020) – What is natural capital?
[10] Kering (2017) – Accounting for environmental benefits in the environmental profit and loss
[11] Source: Natural Capital Coalition, 2016

| | | | |
|---|---|---|---|
| **Land Geomorphology**<br>**Soils and sediments** | Mass stabilisation and erosion control | | |
| **Atmosphere**<br>**Habitats**<br>**Soils and sediments**<br>**Species**<br>**Water** | Climate regulation | Protection from Disruption | High |

*Table 1: Mining's Natural Capital Dependencies[12] (Source: Natural Capital Finance Alliance – Encore, Planet Tracker)*

## Mining's natural capital impacts

Since mining activities are land, water and energy intensive they trigger a broad range of environmental externalities which cascade into a series of impacts on ecosystems services.

| Environmental externality | Examples | Mining related externalities | Related impacts on ecosystems services |
|---|---|---|---|
| **GHG emissions** | Volume of carbon dioxide ($CO_2$), methane ($CH_4$), nitrous oxide ($N_2O$), Sulphur hexafluoride ($SF_6$), Hydrofluorocarbons, (HFCs) and perfluorocarbons (PFCs). | Atmospheric pollution can occur from emission of greenhouse gases such methane and carbon dioxide are attributed to land use change, fossil fuel intensive mining, processing, transportation and smelting. For example, certain substances can self-combust under specific oxidative and high sulphur conditions, resulting in the release of methane and other greenhouse gases, which contribute to atmospheric pollution. | • Altered weather conditions in microclimate zones<br>• Habitat destruction & biodiversity declines |
| **Non-GHG pollutants** | Volume of fine particulate matter (PM2.5) and coarse particulate matter (PM10), Volatile Organic Compounds (VOCs), mono-nitrogen oxides (NO and $NO_2$, commonly referred to as $NO_x$), Sulphur dioxide ($SO_2$), Carbon monoxide (CO). | Cyanide used in leaching processes are susceptible to vaporisation, causing atmospheric release of cyanide (a toxic compound). On drying certain substances (e.g. coal gangue) the can turn into toxic dust that is lifted into the atmosphere and spread. | • Freshwater and marine acidification<br>• Habitat destruction & biodiversity declines |
| **Water pollutants** | Volume discharged to receiving water body of nutrients (e.g., nitrates and phosphates) or other substances (e.g., heavy metals and chemicals). | Mines can leach wastewater that is acidified or contains high concentrations of heavy metals and other toxic chemicals (e.g. sulphuric acid, cyanide, mercury, arsenic). These negatively impact habitats and species, for example by killing vegetation in the area of spread. This is very destructive in wetlands that are highly sensitive to changes in pH. Dust clouds and mineral deposition from mines can alter soil characteristics making it unsuitable for native vegetation. | • Freshwater and marine acidification<br>• Habitat destruction & biodiversity declines |

[12] Source: UNEP-FI – Encore 2020, Planet Tracker research 2020

| | | | |
|---|---|---|---|
| **Soil pollutants** | Volume of waste matter discharged and retained in soil over a given period. | Mines can leach wastewater that is acidified or contains high concentrations of heavy metals and other toxic chemicals (e.g. sulphuric acid, cyanide, mercury, arsenic). These negatively impact habitats and species, for example by killing vegetation in the area of spread. This is very destructive in wetlands that are highly sensitive to changes in pH. Dust clouds and mineral deposition from mines can alter soil characteristics making it unsuitable for native vegetation. | • Freshwater and marine acidification<br>• Habitat destruction & biodiversity declines<br>• Soil pollution<br>• Freshwater pollution<br>• Marine pollution |
| **Solid waste** | Volume of waste by classification (i.e., non-hazardous, hazardous, and radioactive), by specific material constituents (e.g., lead, plastic), or by disposal method (e.g., landfill, incineration, recycling, specialist processing) | Heavy metals released in ore heaps where leaching occurs can negatively impact vegetation and soil conditions when exposed to accidental spillage or leakage. | • Freshwater and marine acidification<br>• Habitat destruction & biodiversity declines<br>• Flooding<br>• Landslides<br>• Air pollution.<br>• Soil pollution<br>• Freshwater pollution<br>• Marine pollution |
| **Disturbances** | Decibels and duration of noise, lumens and duration of light, at site of impact. | Seismic activity from excavation blasting can result in the migration of species from localised areas. | • Habitat destruction & biodiversity declines<br>• Auditory pollution<br>• The spread of invasive species and pests |
| **Freshwater ecosystem use** | Area of wetland, ponds, lakes, streams, rivers or peatland necessary to provide ecosystem services such as water purification, fish spawning, areas of infrastructure necessary to use rivers and lakes such as bridges, dams, and flood barriers. | Mines can leach wastewater that is acidified or contains high concentrations of heavy metals and other toxic chemicals (e.g. sulphuric acid, cyanide, mercury, arsenic). These negatively impact aquatic and soil-based habitats and species, for example by killing vegetation in the area of spread. This is very destructive in wetlands that are highly sensitive to changes in pH. Dust clouds and mineral deposition from mines can alter soil characteristics making it unsuitable for native vegetation. | • Freshwater and marine acidification<br>• Habitat destruction & biodiversity declines<br>• Freshwater pollution<br>• Marine pollution<br>• Localised droughts - From the over extraction of water from groundwater and surrounding freshwater sources can reduce soil moisture in surrounding landscapes. This can adversely impact surrounding agricultural and forest<br>• Altered weather conditions in microclimate zones<br>• The release and spread of diseases otherwise contained by biodiverse landscapes<br>• The spread of invasive species and pests |

*Table 2: Mining's Natural Capital Impacts*[13]

[13] Source: UNEP-FI – Encore 2020, Planet Tracker research 2020

# Green Energy

In order to maintain global temperature rises of below 1.5°C, global $CO_2$ emissions will need to decline by about 45% from 2010 levels by 2030, and reach net zero around 2050. Having a cleaner energy source, such as from the electrification of our energy system, is one of the critical ways in which to meet this need. As electrification becomes a key component to decarbonise, moving from molecular energy source to electron energy source, electricity as part of our energy needs will have to be at least 1/3 by 2030 and 50% by 2050[14] as seen in *Figure 4*. Within electricity, the share of renewable electricity has been rising steadily despite delays in construction and lower energy demand during the COVID-19 pandemic period, the share of renewable is expected to rise to around 30% in 2020[15], and will need to continue to rise to between 52% to 67% by 2050 if we want to limit global temperature rises to 1.5°C with limited or no overshoot[16]. This is estimated to be equivalent to over 520 gigawatts (GW) of new capacity every year from today[17].

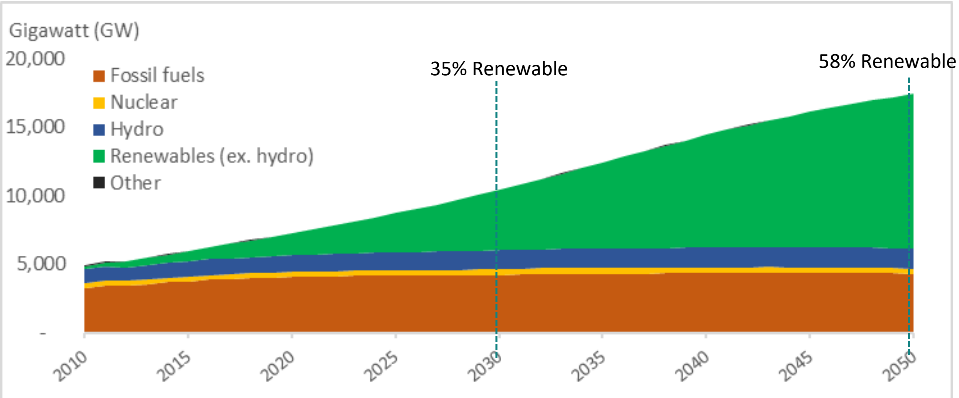


*Figure 4 Cumulative electricity capacity additions globally[18]*

Nearly 78% of the net new generating capacity added (globally) in 2019 was in wind, solar, biomass and waste, geothermal and small hydro[19], with similar trend observed in Q1 2020 as seen in *Figure 5*. Despite the economic slowdown during the pandemic, the total share of electricity generated from renewables has increased even though the overall electric usage has reduced.

[14] IPCC 1.5 Degrees report, Chapter 2, 8th October 2018
[15] IEA Global Energy Review 2020, 28th April 2020
[16] IPCC 1.5 Degrees report, Chapter 2, 8th October 2018
[17] IRENA Global Renewables Energy Outlook 2020, April 2020
[18] Bloomberg New Energy Finance (BNEF) New Energy Outlook 2019, 18th June 2019
[19] UNEP FI Global Trends in Renewables Energy Investment 2020, June 2020
https://www.fs-unep-centre.org/global-trends-in-renewable-energy-investment-2020/#downloads

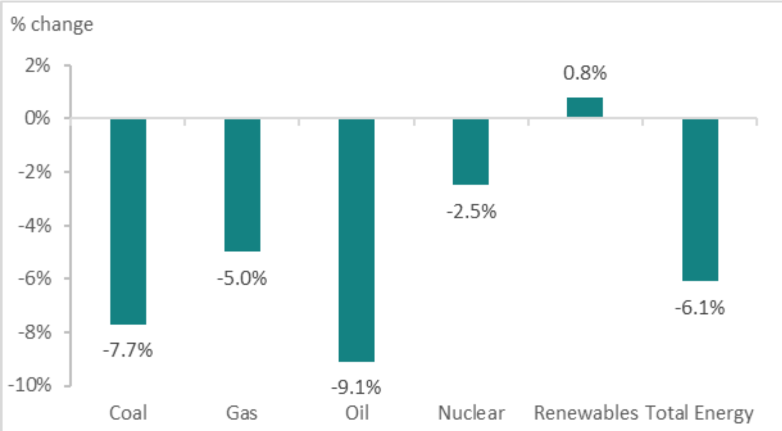


*Figure 5: Projected change in energy demand by fuel type in 2020 relative to 2019*[20]

Renewable build out does come with challenges which ranges from financing and regulation to supply chain management, project management systems and availability of metals. We will focus on the two most widely used renewable sources for discussion in this paper – wind (both onshore and offshore) and solar, in addition to energy storage which is a key part of the system. We will also discuss the key materials and minerals to consider for the build out of the entire renewable energy systems in Section 3.

## Wind Power

As the levelized cost of electricity (LCOE) for renewable has been decreasing over the last decade to the same level as a conventional fossil fuel source, wind as an energy source is expected to grow quite rapidly over the next three decades, to play a role in generating more than a third of total electricity generation needs by 2050. A study by IRENA shows that building close to 6,000 GW of wind power by 2050 could mitigate around 6.3 gigatons of CO2, which represents 27% of the overall emissions reductions needed to meet the Paris Agreement climate goals. Looking at much closer to date, referring to *Figure 6*, we expect wind power to grow at least 3 to 4 times globally from today's level over the next decade.

[20] IEA Global Energy Review 2020, 28th April 2020

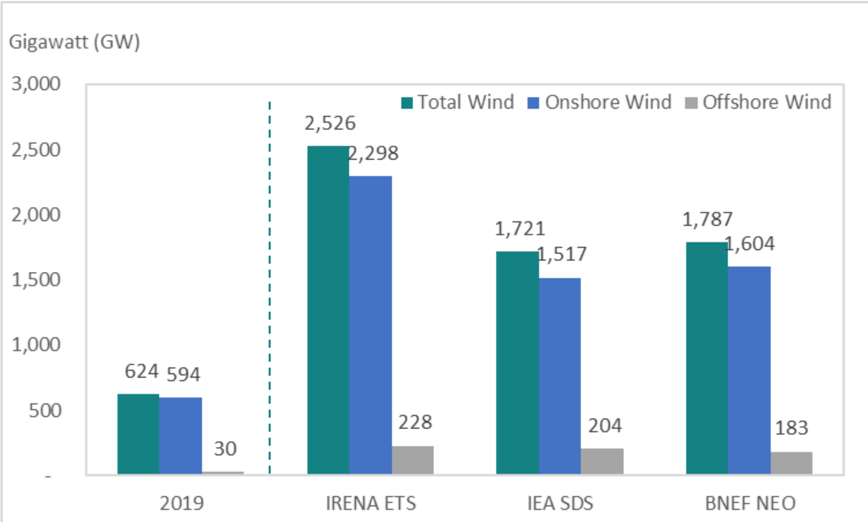


*Figure 6 Wind outlook globally to 2030 using scenarios from IRENA Energy Transformation Scenario (ETS), IEA Sustainable Development Scenario (SDS) and BNEF New Energy Outlook (NEO)*[21]

With innovation, and continuous enhancement, bigger wind turbines are being researched and planned as shown in Figure 7. We will be able to see wind turbines that produce more than 10GW, bringing the load factor up from current levels of 40%. This will drive down the levelized cost of electricity, encouraging further build out of both onshore and offshore wind fields.

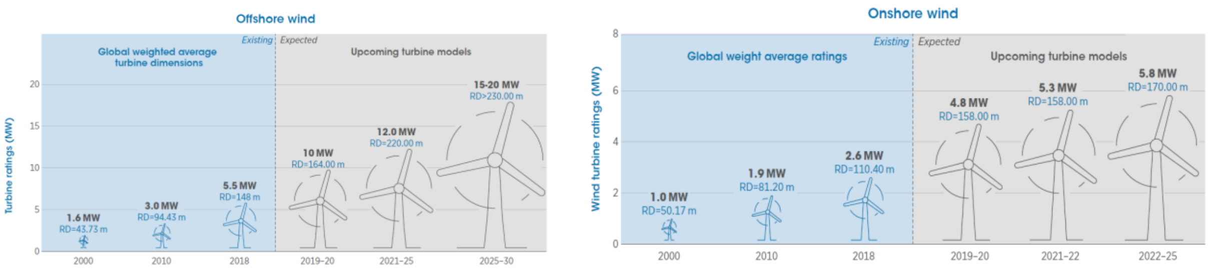


*Figure 7 The average size of offshore wind turbines grew by a factor of 3.4 in less than two decades and is expected to grow to output capacity of 15–20 MW by 2030 while the size of onshore wind turbine is expected to grow by more than 5 times over the last 2 decades*[22]

[21] Source: As at 31st December 2018 - Carmignac, IRENA, BNEF and IEA

[22] IRENA – The future of Wind A Global Transformation Paper October 2019, GE Renewable Energy, 2018; IRENA, 2019c, 2016b; MHI Vestas, 2018

As wind turbines gets bigger and play a more important role in the energy system, the electrical system and structure gets more complex as referred to in *Figure 8* and *Figure 9* . Hence more components, services and materials are needed to be built for the large energy transition.

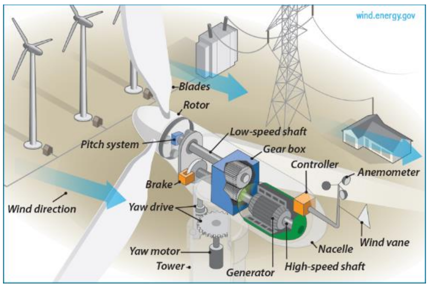


*Figure 8 Inside of a wind turbine and ecosystem of onshore wind*[23]

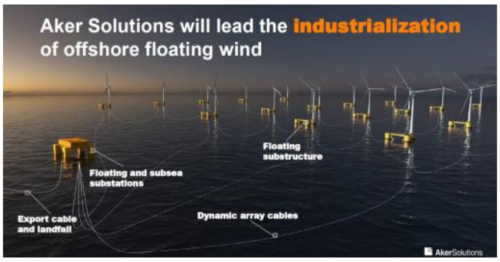


*Figure 9 Ecosystem of offshore floating and example provided by Aker Solutions*[24]

This complex system contains a mix of both easily sourced and hard to procure key materials. We will focus just on the wind turbine itself. As shown in *Figure 10* and *Figure 11*, the main materials needed are steel, copper, aluminium, concrete, rare earth minerals in the form of Neodymium and Dysprosium and carbon fibre or possibly polyurethane.

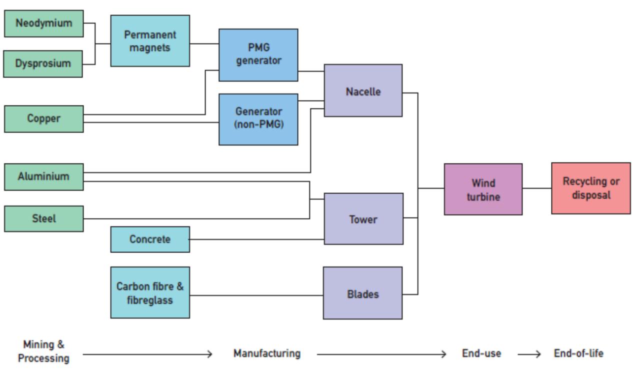


*Figure 10 Overview of wind power supply chain*[25]

[23] The inside of a Wind Turbine by the office of energy efficiency & renewable energy , https://www.energy.gov/eere/wind/inside-wind-turbine
[24] Aker Solutions Annual Presentation 27th February 2020
[25] Dominish, E., Florin, N. and Teske, S., 17th April 2019, Responsible Minerals Sourcing for Renewable Energy. Report prepared for Earthworks by the Institute for Sustainable Futures, University of Technology Sydney

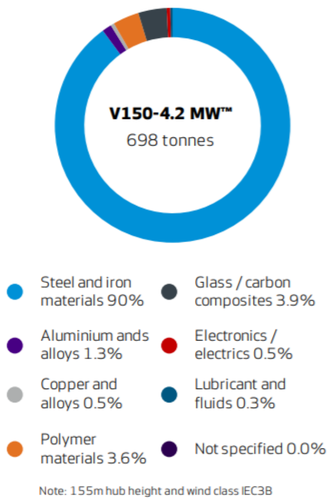


*Figure 11 Materials required in a Vestas V150 4.2MW turbine*[26]

When comparing onshore and offshore wind turbines, offshore will be more material intensive for 2 reasons. First of all, an entire offshore wind system will require additional cabling for the collector, to connect from offshore wind farms to offshore substations then to onshore substations, which drives the increase in copper demand. The other reason is due to the differences in the components between onshore and offshore wind. Generally onshore wind runs with a gearbox which is usually easier to build, however can be costly, heavy and less reliable. Some wind turbines, especially offshore turbines are being replaced by a direct drive generator which does not need a gearbox, hence much lower maintenance is needed while running on higher speed. These direct drive wind turbines tend to use permanent magnet generators (PMG), which requires a type of rare earth materials known as Neodymium. [27] Even though the quantity is small within a turbine, due to the growth expected from offshore wind, there is an expected increase in demand for Neodymium.

| Material (t/GW) | Offshore | Onshore |
|---|---|---|
| Aluminium (Al) | 500 | 1,600 |
| Copper (Cu) | 3,000 | 950 |
| Neodymium (Nd) | 180 | 51 |
| Nickel (Ni) | 240 | 440 |

*Table 3 Key differences in raw materials across direct drive (typical offshore) and gear box (onshore)*[28]

[26] Vestas Material Use Turbines February 2018
https://www.vestas.com/~/media/vestas/about/sustainability/pdfs/201802_material%20use%20brochure.pdf
[27] World Bank Group June 2017, The Growing Role of Minerals and Metals for a Low-Carbon Future
[28] Carmignac 30th June 2020

Different types of build and mechanism of the turbines will drive different material requirements as seen in *Table 3*. Using our estimates of materials needed per GW and projecting from the IEA SDS scenario, we expect the demand for these materials to grow by at least 2.5 times for onshore and close to 7 times for offshore wind, from total materials used up to today to build the capacity we have as seen on *Figure 12*.

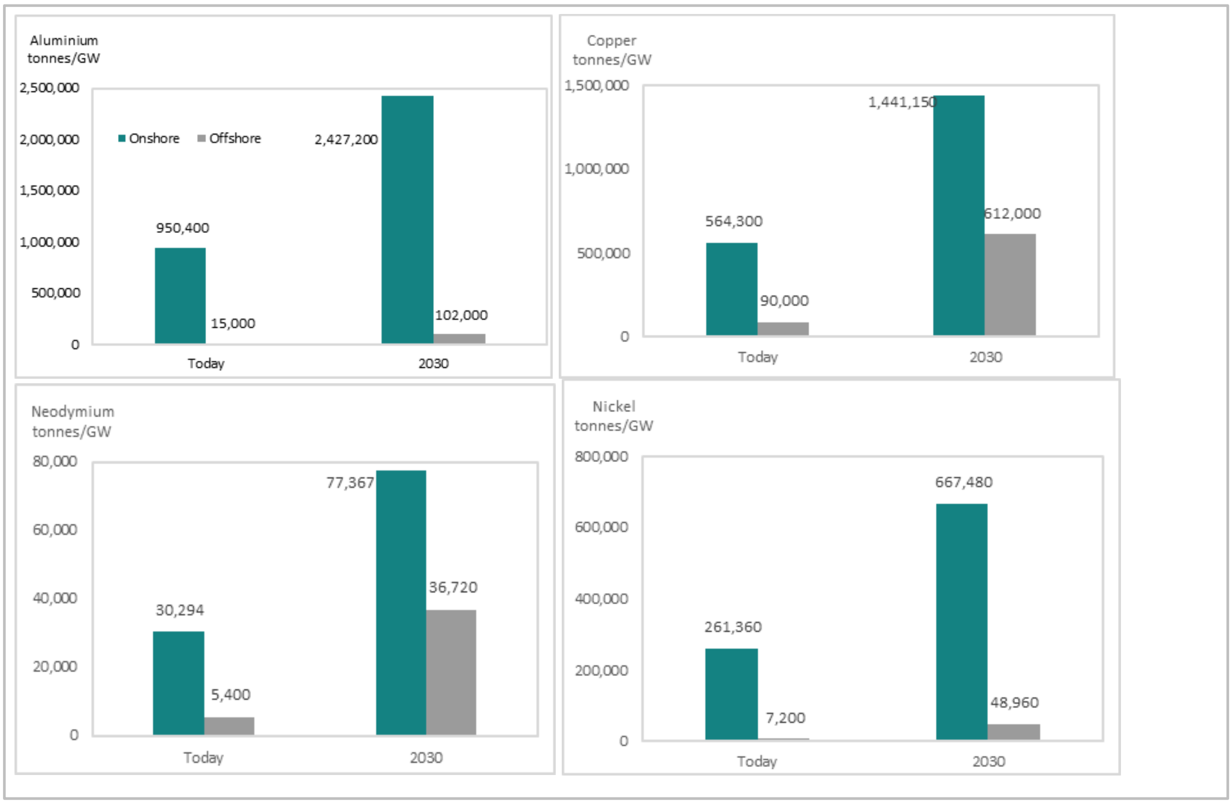


*Figure 12 Metals projection up to 2030 for wind energy build out*[29]

[29] Estimated by Carmignac as at June 2020

### Solar PV

Solar continues to take the lead and will be the dominant renewable energy producer[30] following its competitive LCOE with further aggressive downward trend[31].

According to IRENA's analysis solar PV power installations could grow almost six-fold over the next ten years, reaching a cumulative capacity of more than 3000 GW globally by 2030 and rising to more than 8500 GW by 2050, *Figure 13*. This implies total installed capacity in 2050 almost fifteen times higher than in 2019. At a global level, around 60% of total solar PV capacity in 2050 would be utility scale, with the remaining 40% distributed (rooftop)[32]

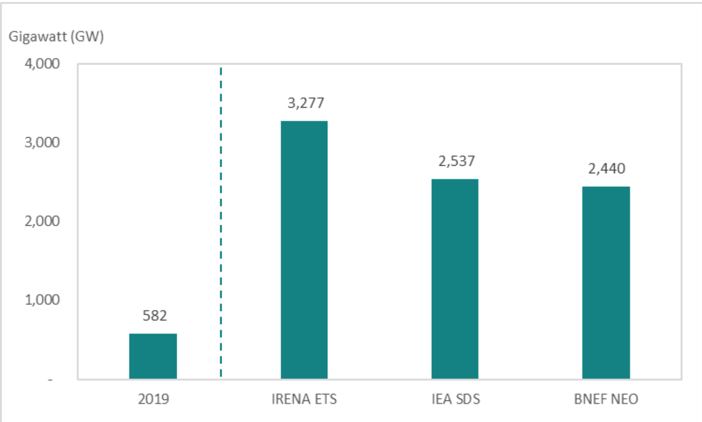


*Figure 13 Solar PV outlook to 2030 using scenarios from IRENA Energy Transformation Scenario (ETS), IEA Sustainable Development Scenario (SDS) and BNEF New Energy Outlook (NEO)[33]*

The most commonly installed solar cell globally is Crystalline silicon cells which makes up about 90% of the current market share and comes in the form of single crystalline, polycrystalline or amorphous silicon as shown in *Figure 14*.

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[30] Bloomberg New Energy Finance (BNEF) New Energy Outlook 2019, 18th June 2019

[31] BNEF 2H 2019 LCOE Update 28th April 2020

[32] IRENA Future of Solar Photovoltaic November 2019 https://www.irena.org/publications/2019/Nov/Future-of-Solar-Photovoltaic

[33] Source: As at December 2018 - Carmignac, IRENA, BNEF and IEA

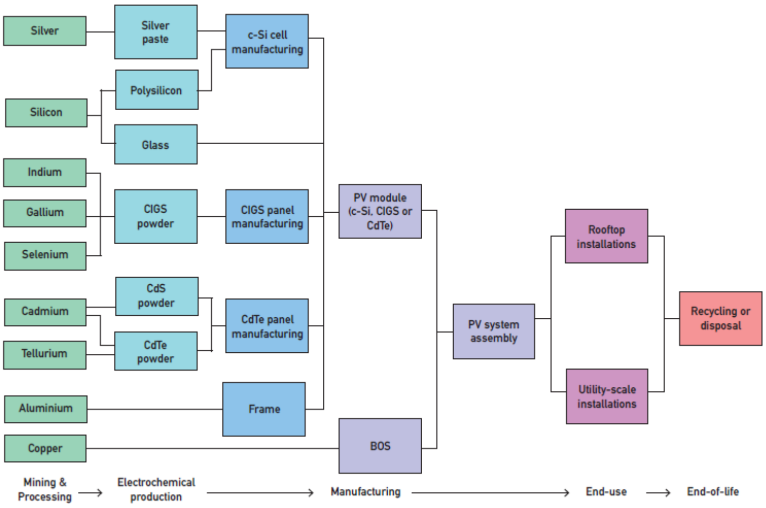


*Figure 14 Overview of a solar PV supply chain[28]*

The key materials for solar PV are glass, polymer, aluminium, silicon, copper and silver[34]. Even though silver is only less than 0.1% of a solar PV module, globally, solar PV demands around 9% of total global production of silver. Just like wind power, seen in *Table 4* copper remains a key component as connector[35].

| Material (t/GW) | Crystalline Silicon (C-Si) |
|---|---|
| Aluminium (Al) | 7.5 |
| Copper (Cu) | 4.6 |
| Silver (Ag) | 0.2 |

*Table 4 Key materials for solar PV[36]*

Hence, like wind we expect the demand of aluminium to grow by 5 times, copper by 5 times and silver by 5 times from today's level in *Figure 15* .

[34] Dominish, E., Florin, N. and Teske, S., 2019, Responsible Minerals Sourcing for Renewable Energy. Report prepared for Earthworks by the Institute for Sustainable Futures, University of Technology Sydney.
[35] World Bank Group June 2017, The Growing Role of Minerals and Metals for a Low-Carbon Future
[36] Carmignac as at 30th June 2020

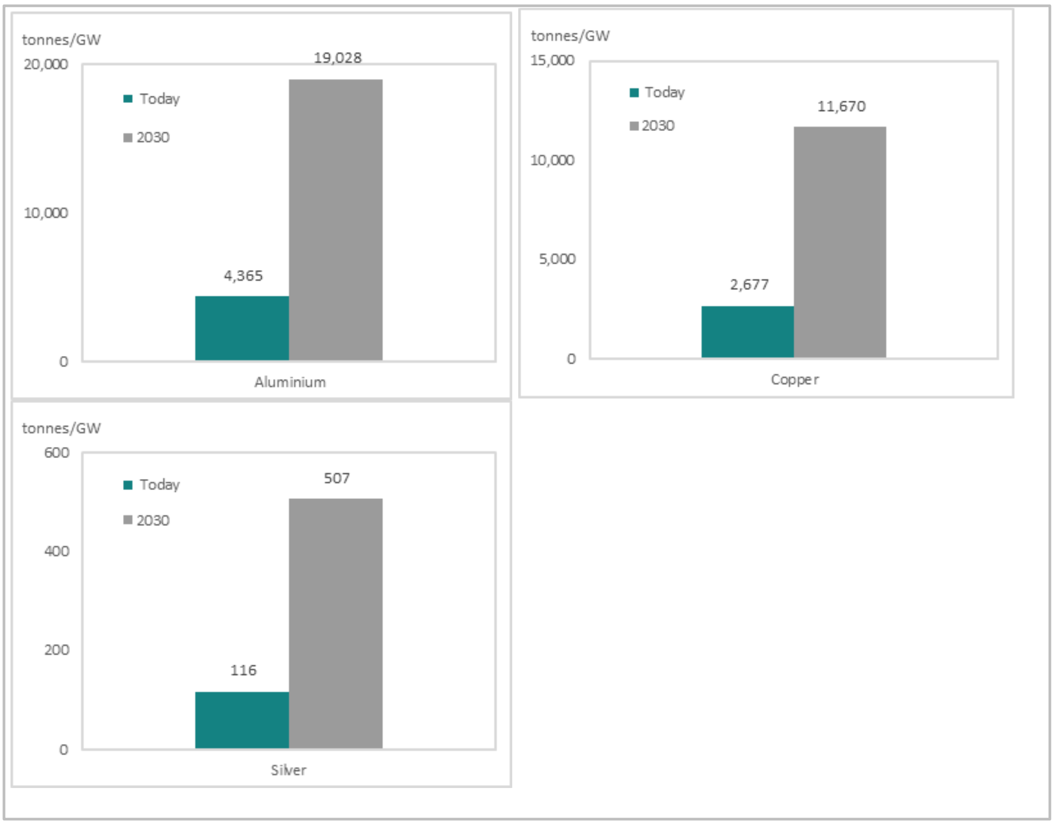


*Figure 15 Metals projection up to 2030 for solar energy build out*[37]

## Energy Storage

With the rollout of renewable energy, comes volatility to the energy supply as renewable energy such as wind and solar is weather dependent and may not be able to supply energy at consistent amounts and frequency required to keep the grid stable. Energy storage is becoming the key challenge as the global economy moves from fossil fuel energy to renewable electricity and the needs of keeping the grid stable while ensuring security of supply. Energy storage comes in many forms from pumped hydropower to bioenergy and batteries. Battery manufacturers are gearing up for large demand increases relating to energy storage. We expect there will be an explosion of large-scale energy storage installed globally, with more than 1000 GW by 2040 as seen in *Figure 16*.

[37] Carmignac as at 30th June 2020

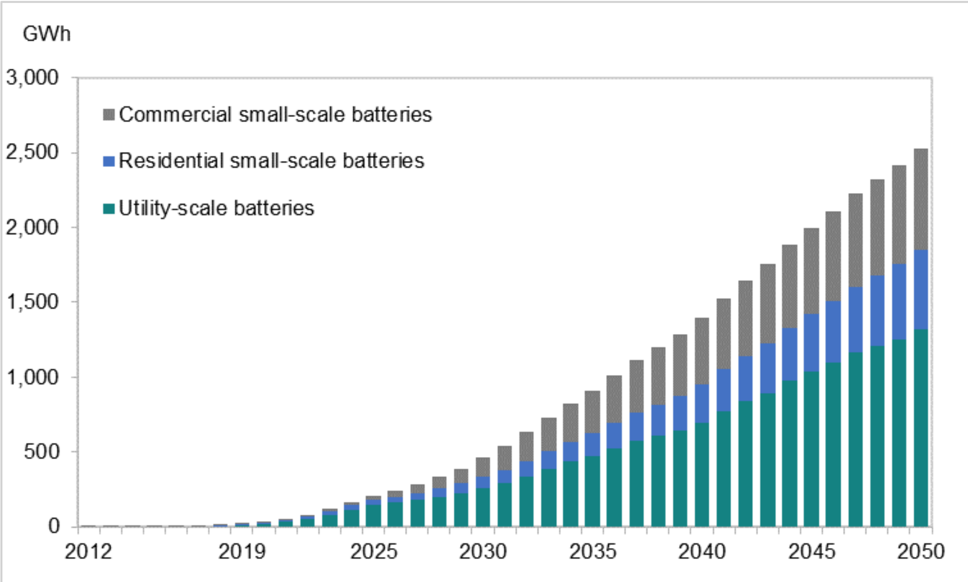


*Figure 16 Energy storage build out projections*[38]

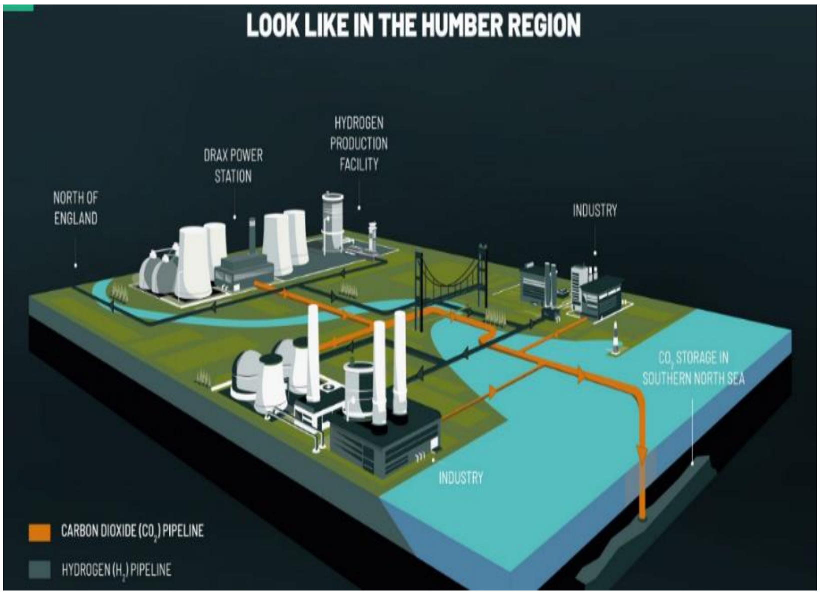


*Figure 17 Illustrations of Zero Humber project*[39]

[38] BNEF New Energy Outlook June 2019
[39] https://www.zerocarbonhumber.co.uk/

More research is still on going for other source of cleaner energy from biomass to carbon capture and storage, and hydrogen. For example, Zero Carbon Humber as seen in Figure 17, that is currently being built by Drax in partnership with other industrial companies like Equinor, aims to be a carbon neutral plant that utilises the biomass, hydrogen and carbon capture and storage of the biomass output and their neighbouring industry companies. [40]

All these energy storage systems will require large scale metals to install the new pipes, valves and electric cables. Hence, we foresee the increase in mining of copper, nickel, cobalt, lead and iron ore at large scale to meet this demand.

[40] Drax Carbon Capture for Growth https://www.drax.com/energy-policy/capture-for-growth-zero-carbon-humber-report/#chapter-1

# Green Mobility - Electric Vehicles (EV)

Vehicles with a form of electric power, either full electric (BEV) or hybrids (PHEV), are redrawing the landscape of the automotive industry. Sales are expected to overtake traditional internal combustion engines (ICE) in the next two decades as seen in *Figure 18*. This push is being driven by regulators, striking very optimistic and demanding targets. The UK's decision of no new petrol or diesel cars sold by 2035 is an example of such driving regulation.

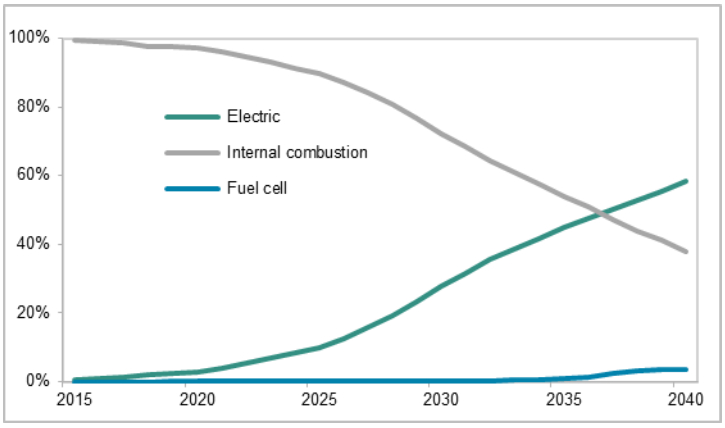


*Figure 18 Estimated outlook of global vehicle sales*[41]

However, this push is not naturally driven by suppliers or consumers, therefore, some concerns could be raised regarding raw material sourcing and a lack of infrastructures to support consumers EV demand.

[41] Bloomberg New Energy Finance (BNEF), Electric Vehicle Outlook 2020, 19th May 2020

## Automotive manufacturing

In anticipation of these regulations kicking in, car manufacturers have increased spending on the electrification of their fleet of vehicles, bringing in new models and developing new technologies with examples in *Figure 19* . The car market may soon be flooded with new electric car models.

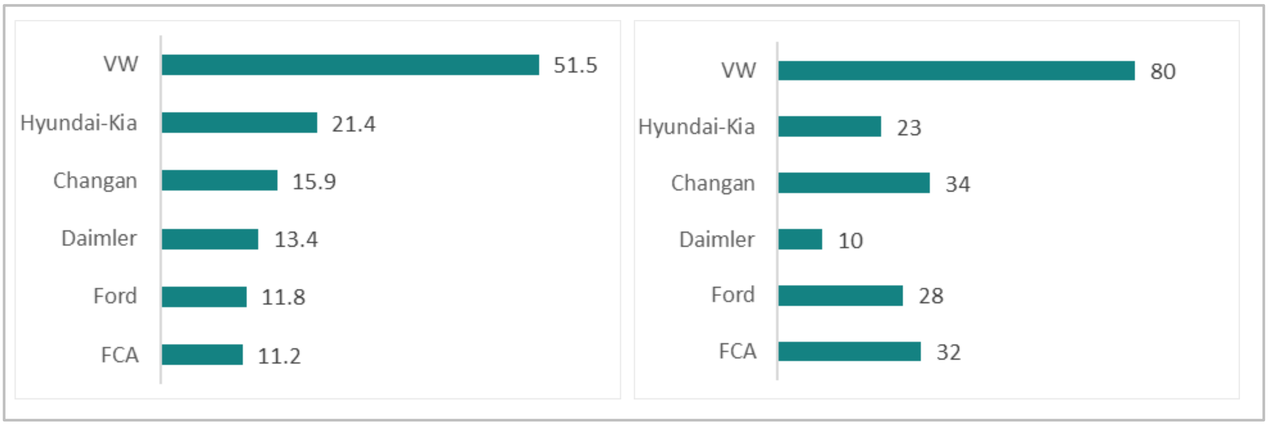


*Figure 19 – LHS: Electrification investments announced by selected automakers (US$ billion); RHS: Number of EV models to be launched by selected automakers by 2025*[42]

This will have significant implications on the price of electric powered cars. While today, prices remain a limiting factor to widespread adoption, EVs are predicted to become more affordable, with estimates pointing towards the mid-2020s as the crossover point with traditional ICE vehicles as shown in *Figure 20*.

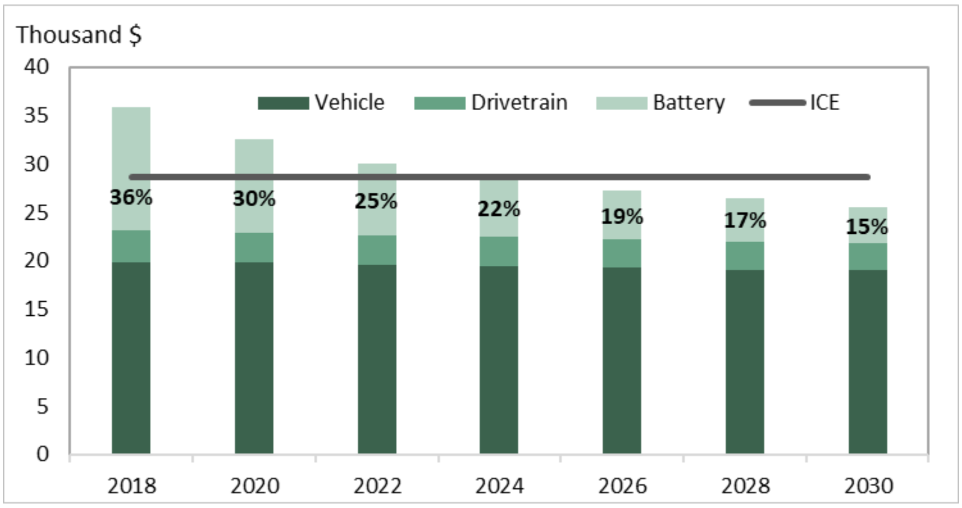


*Figure 20 Medium segment Battery Electric Vehicle (BEV) and Internal Combustion Engine (ICE) pre-tax prices*[43]

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[42] Marklines, company press releases, BNEF Electric Vehicle Outlook 2020, 19th May 2020

[43] BNEF Electric Vehicle Outlook 2020, 19th May 2020

For OEMs, much of an internal combustion vehicle's (ICV) manufacturing process can be adapted to accommodate EVs, however, major differences in the amount of metals used are to be noted. Looking at copper, unsurprisingly the battery component adds a significant portion of copper to the total EV requirements, however nearly twice as much of it is needed when manufacturing the rest of the vehicle, bringing the total to four times as much as shown in

*Figure* 21. This is because more wiring is needed to connect the battery to the other parts of the vehicle. It is a similar story with aluminium as shown in *Figure 22*, with nearly twice as much of it required for EVs compared to ICVs.

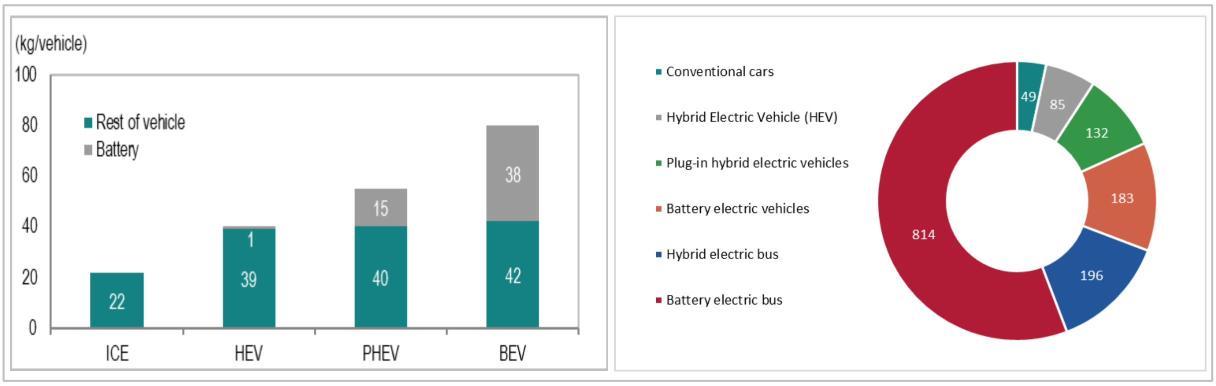


*Figure 21 LHS: Copper content per powertrain variant [44]; RHS: Copper requirements in different types of transports[45]*

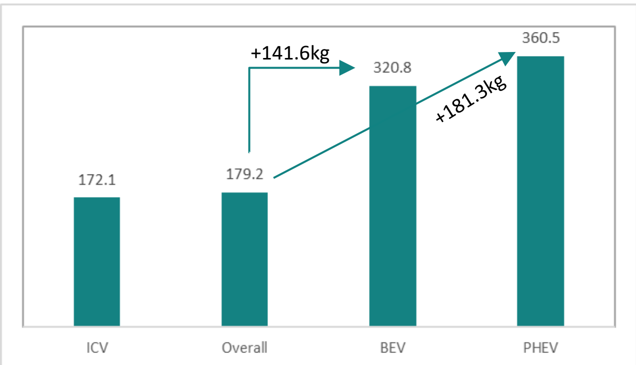


*Figure 22 Average Aluminium Content per vehicle - Comparison by Powertrain Variant (Net weight in kg)[46]*

[44] Estimated by Carmignac 30$^{th}$ June 2020

[45] Copper Drives Electric Vehicles, Copper Alliance https://www.copper.org/publications/pub_list/pdf/A6191-ElectricVehicles-Factsheet.pdf

[46] Comparison of Aluminium Content by European Aluminium 10$^{th}$ October 2019

Looking at the infrastructure that is needed to support EV roll-out, there is an imperative need for a large-scale build-out of charging points covering garage stations , shopping mall car parks and home charging points. We have already witnessed the rapid increase of these charging points over the last five years as shown in *Figure 23*, but this is only the beginning, as demonstrated by Enel's commitment to increasing their charging points by close to 9x from the 2019 level. Copper is the most critical metal from a charging infrastructure standpoint. The Copper Alliance suggested that each fast charger requires 8kg of copper compared to regular chargers requiring 0.7kg.[47]

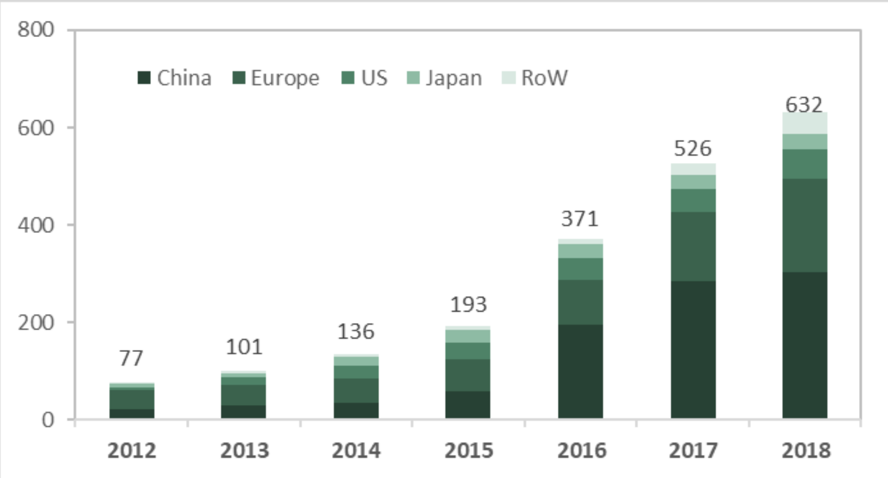


*Figure 23 Public charging outlets installed globally (in thousands)* [48]

This is a clear indication of the sheer amount of new cables that are needed to be installed, putting further strain on the copper supply chain. If we look at the entire ecosystem, close to 300% more copper is needed in comparison to ICVs.

With demand in this mobility transition occurring at such a rapid rate, overall expectations of copper demand over the next decade will be between 5x and 7x current levels[49]. For aluminium rates of demand increase are similar at 5x current levels [50].

[47]*The Electric Vehicle Market and Copper Demand, June 2017, IDTechEx & Copper Alliance -* https://copperalliance.org/wp-content/uploads/2017/06/2017.06-E-Mobility-Factsheet-1.pdf
[48] BNEF Electric Vehicle Outlook 2020, 19th May 2020
[49] The Electric Vehicle Market and Copper Demand, June 2017 https://copperalliance.org/wp-content/uploads/2017/06/2017.06-E-Mobility-Factsheet-1.pdf
[50] Comparison of Aluminium Content by European Aluminium 10th October 2019

## Batteries

Batteries remain the single most important component of an electric vehicle and the dominant cost driver. As seen previously, the price crossover between EVs and ICVs may only happen thanks to a reduction in the manufacturing cost the battery. The reason why lower costs may prevail is due to significant technology innovations and economies of scale. However, this is dependent on a sustainable, uninterrupted supply of raw metals.

A typical Lithium-ion battery has four key components: the anode, the cathode, the separator and the electrolyte, with detailed explanation in *Figure 24*. Of these elements, the cathode is by far the most cost intensive, coming in at around half of the total battery cell cost, and has hence attracted most of the innovation interest from battery manufacturers.

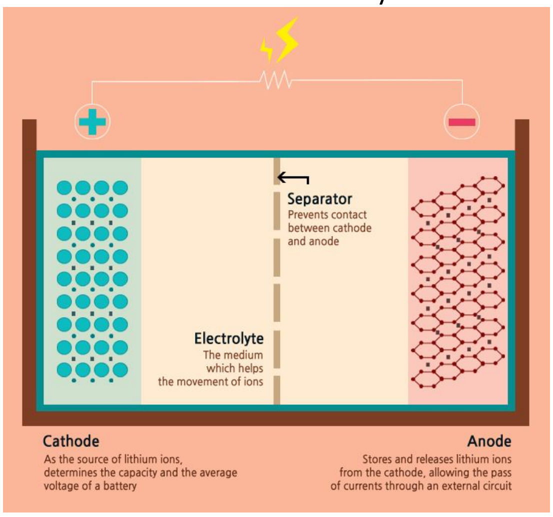


*Figure 24 Components of a Li-ion Battery*[51]

Looking at cathode chemistries in more detail, manufacturers have access to a wide array of compositions. A different cathode chemistry can allow a battery to change its characteristics, by, for example, favouring density and capacity over safety and reliability at different price points. The graph below, which represents the distribution of various cathode chemistries across the passenger EV market, shows that NMC (Nickel-Manganese-Cobalt) and NCA (Nickel-Cobalt-Aluminium) chemistries will continue to dominate. This is because consumers prioritise EVs with batteries which are lighter, allow for faster charging, and which have longer range.

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[51] Samsung SDI https://www.samsungsdi.com/column/technology/detail/55272.html?listType=gallery#:~:text=Let's%20look%20into%20Li%2Dion%20batteries%20inside%20out%20today.&text=Li%2Dion%20batteries%20consist%20of,of%20the%20components%20is%20missing

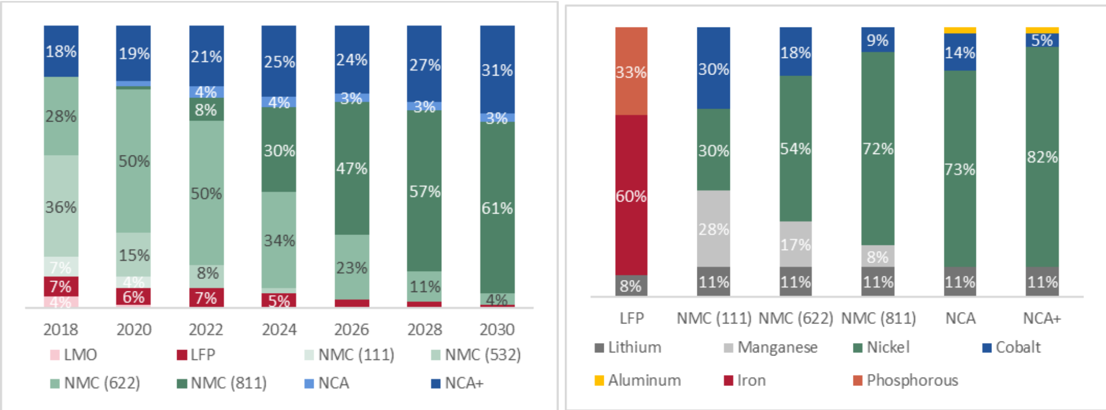


*Figure 25 LHS: Evolution of Cathode chemistry on passenger EVs; RHS: Metal content of cathode chemistries[52]*

Cathode manufacturers as shown in *Figure 25* will therefore only rely on a handful of metals (namely nickel, manganese, cobalt, aluminium and lithium) to satisfy the rapidly increasing EV consumer base. Looking at the entire battery pack, which contains multiple cells, copper is also required as conductor and aluminium as a lightweight and durable case to protect the battery cells. Demand for these metals are expected to grow in line with the growth expectations of EVs.

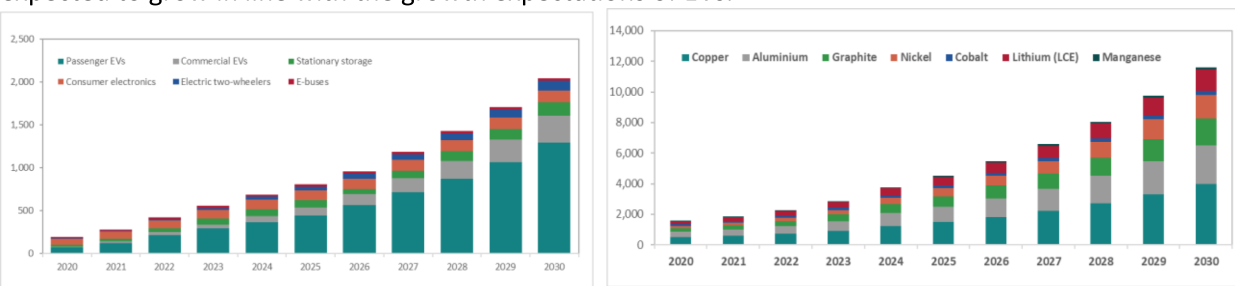


*Figure 26 LHS: Annual Li-ion battery demand in GWh; RHS: Metals demand from all Li-ion batteries ( thousand metric tons[53]*

Of these metals, three core and at-risk materials are Lithium, Nickel and Cobalt, which will all see significant demand increases over the next ten years, as shown in *Figure 26*.

The metals and mining industry will face pressures from car manufacturers and battery manufacturers as they race to lower costs, whilst at the same time demanding a significantly higher amount of raw materials to satisfy the mobility transition. Supply chain issues could cause large disruptions if metal reserves deplete to the extent where they cannot satisfy the increased production requirements from car manufacturers.

[52] BNEF Electric Vehicle Outlook 2020, 19th May 2020

[53] Bloomberg New Energy Finance (BNEF) New Energy Outlook 2019, 18th June 2019

Examples of such cases are already apparent, with car manufacturer, Jaguar Land Rover halting production of their Jaguar I-pace due to supply shortages from their battery manufacturer, and Volkswagen enlisting four different battery manufacturers to ensure a reliable supply for its new ID3 model.

## Critical metals

### A complex supply-chain

It is therefore clear from what we have discussed above that a growth in wind energy, solar energy, electric vehicles and energy storage will lead to a great demand rise for materials between 2 to 6 times by 2030, and more towards 2050.

Many materials are needed for these build outs; we identify the key materials that are highly needed and some that may not widely recycle today are copper, nickel, cobalt, silver, aluminium, lithium and neodymium (rare earth). Some of these materials are more readily available and accessible than others. To support the growth in demand, more mines will need to be created, which itself may have environmental and societal impact.

| Metals | Green Energy | | | | Mobility - Electric Vehicles | | Current Recyclability |
|---|---|---|---|---|---|---|---|
| | Wind | Solar Photovoltaic | Energy Storage | Carbon Capture & Storage (CCUS) | Electric Motor | Batteries | |
| **Aluminium** | X | X | X | X | X | | 70 to 80% recycled |
| **Copper** | X | X | | X | X | X | 34 to 95% recycled |
| **Nickel** | X | X | X | X | | X | 90% recycled |
| **Cobalt** | | | X | X | | X | 90% recycled |
| **Lithium** | | | | | | X | 10% recycled |
| **Neodymium** | X | | | | | X | Not currently recycled |
| **Silver** | | X | | | | X | Not currently recycled |

*Table 5 Applications helping to decarbonise the economy, along the commodities required and their current recyclability[54]*

[54] The Growing Role of Minerals and Metals for a Low Carbon Future June 2017

Looking at the various materials needed, it is important to understand whether there are alternative materials which can reduce cost, reduce stress to the supply chain while improving performance for these green technologies. The aspect that is also key is to look at the recyclability of these materials, economics of recycling and technology available for recycling as shown in *Table 5*.

a) Copper - Its incredible ability to conduct electricity without a better alternative makes copper an attractive mineral. The tricky part when sourcing the material is finding areas where the metal is concentrated in large enough amounts that are close to the surface, so to make it economically viable while overcoming technological challenges
b) Aluminium – currently there are no limitations to supply, however, the operation to turn aluminium ore to aluminium alloy is very energy intensive.
c) Cobalt - A material that is dominated by the controversial? mines of the Democratic Republic of the Congo, which is very efficient to be used in batteries. There are no replacement products at this stage
d) Nickel - As batteries are moving away from relying on cobalt from Nickel: Magnesium: Cobalt (NMC) with ratio of 6-2-2 (known as NMC 622) to ratio of 8-1-1 (known as NMC 811), the demand of nickel will significantly increase.
e) Lithium - A key component in the electrolysis for rechargeable batteries. These minerals are extracted either through evaporation form brine under a lake, or extracted from spodumene which is a hard rock resource.
f) Neodymium (known as rare earth materials) - Best material for magnets, which is a silvery metal when combined with iron and boron makes a strong magnet. The challenge is that it is very much controlled by a single country as 85% of the neodymium comes out of China. There are other mines in the world, which tend to send their deposits to China to process.
g) Silver - Remains an irreplaceable component in solar PV.

Apart from the challenges on extraction, there are also challenges when it comes to smelting and turning the raw materials into alloys. Just looking at the battery supply chain as stated in *Figure 27*, as the key makers of battery components are based in Asia, the raw minerals flow into Asia to be transformed into a final product, which in itself consumes a lot of energy, while also rely heavily on coal- powered energy supply during metals refining.

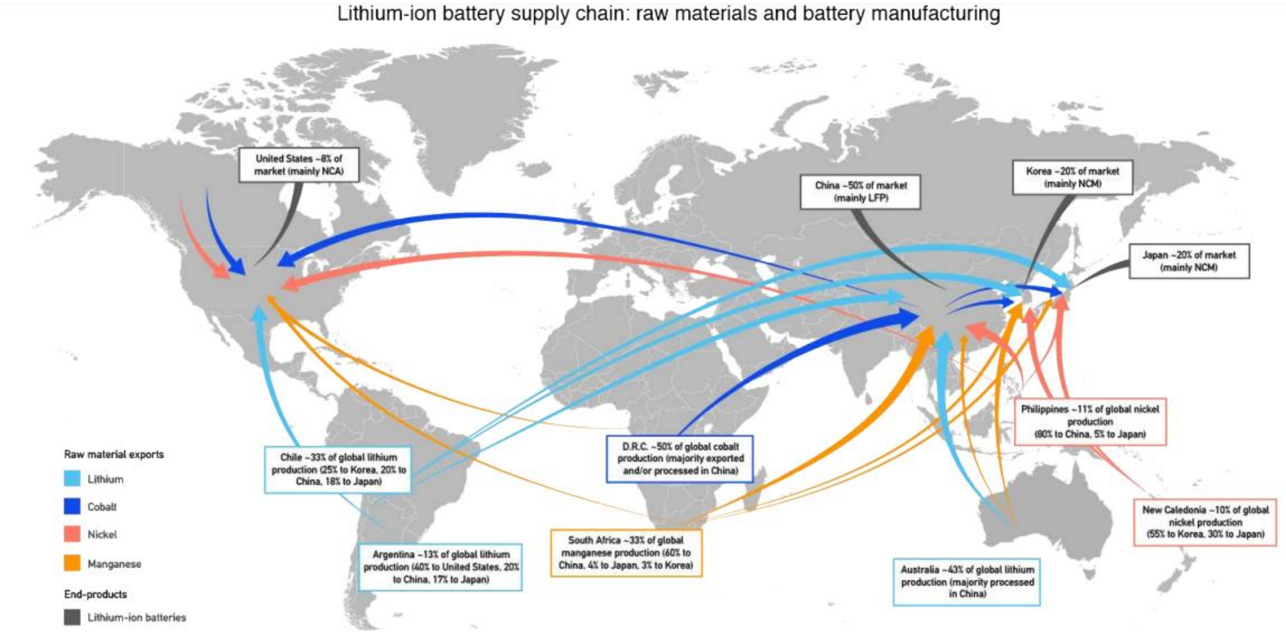

*Figure 27 Overview of Lithium-ion battery supply chain[55]*

## Recycling

To reduce price volatility, while meeting the demand, there has been some efforts in place to recycle these materials to give it a 2nd life. Recycling will become more efficient; this might help reduce the impact of metal reserve shortages. Currently, older NMC 111 batteries are entering the recycling market. Referring to *Figure 28,* Cobalt has the most potential for recycling as it is the most expensive component and as it makes up 30% of the cost of a battery. A study showed that cobalt prices need to be above $30,000/pound to make recycling viable, prices are currently around $34,000/pound. Prices of cobalt will need to remain above this threshold, so cobalt miners will need to be careful to not oversupply the market, causing a price fall. A potential dramatic scenario could be the following: if battery demand is less than expected due to poor consumer adoption of electric cars despite regulatory pressure, overzealous cobalt miners could be faced with flooding the market with their extra cobalt supplies, damaging the trading price. This would damage the capacity and profitability of recycling older batteries. Damaging sale of new batteries, as owners cling on to their older batteries waiting for scrap prices to rise. On the other hand, cobalt prices could increase steadily based on the back of a healthy increase in battery demand from car manufacturers facing increased EV demand. This would encourage recycling older batteries due to more profitability and would increase sale of new batteries and cars.

[55] Dominish, E., Florin, N. and Teske, S., 2019, Responsible Minerals Sourcing for Renewable Energy. Report prepared for Earthworks by the Institute for Sustainable Futures, University of Technology Sydney that are based on Comtrade data available at: https://comtrade.un.org/data/

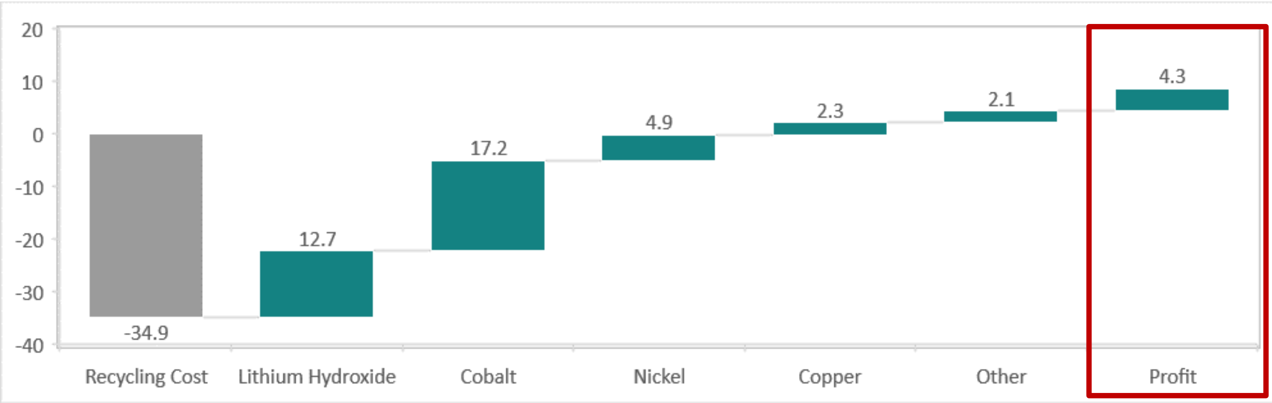

*Figure 28 Economics of recycling an NMC 111 battery in China at the commodity prices of November 2018 in $/ kWh*[56]

[56] BNEF Lithium-Ion Battery Recycling: 2 million tons by 2030, published on January 2019

## Responsible Sourcing

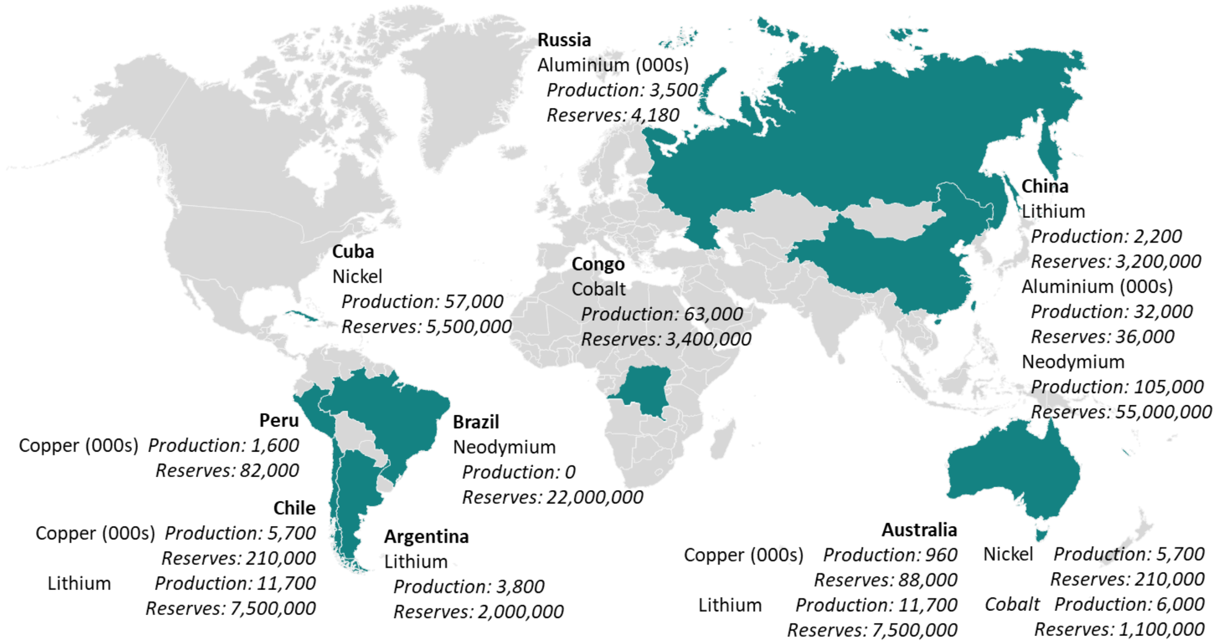


*Figure 29 Metals production and reserves globally*[57]

Looking at the current balance of production and reserves as well as where the majority of reserves are today as seen on *Figure 29*, the key materials are concentrated in few emerging countries where the employment and environmental regulations are still evolving. This creates conflicts in minerals sourcing like the ones we have seen in the Democratic Republic of Congo on Cobalt artisan miners. Apart from these issues, there are also bribery and corruption and health & safety concerns.

While all of metals critical to the renewable value change pose some sustainable sourcing challenges, those that have reserves concentrated in countries with particularly acute environmental and human rights challenges, such as lithium and cobalt, are worthy of deeper examination.

As much as we will like to have an ideal mining operation, as investors and companies that are buying the finished products, there is a need to strike a balance between security of supply and responsible mining. To put this into context, we will discuss the few points to look at when accessing materials companies.

[57] Carmignac, United States Geological Survey (USGS) December 2016

## Case Study 1: Lithium Mining in Chile

**Paul Bugala, Independent Mining Investment and Sustainability Analyst**

Lithium mining in Chile is concentrated in the country's largest salt flat, Slara de Atacama. While the area where lithium mining takes place is a very arid and dry zone surrounded by the Andes Mountains, it shares a complex hydrogeologic system with neighbouring lagoons that are of high importance to biodiversity and to native peoples. In fact, the lagoons are protected by the Ramsar Convention on Wetlands[58]. Issues of water management and human rights due diligence have posed significant challenges to lithium development in the areas. For example, in December 2019 a Chilean court rejected a $25 million remediation plan proposed by lithium producer SQM and in July 2020 the same court asked the mining company to revise and resubmit its insufficient water management plan[59].

In an attempt to identify and address these challenges, German auto manufacturers Volkswagen and Daimler have engaged GIZ, the German Development Bank, to study best practices for addressing water management and human rights issues faced by companies operating in Chile's Atacama region including Antofagasta, Albemarle and SQM[60]. So far, the research has found that dialogue between stakeholders, which includes a neighbouring population of about 10,000 mostly indigenous peoples, is deeply insufficient with the exception of a joint water monitoring project between Albemarle and a local indigenous council. The GIZ research also proposes the implementation of a regional Water Risk and Action Framework based on best practices. Implementation of the GIZ guidance will start in 2021 and runs for three years.

## Case Study 2: Cobalt Mining in the Democratic Republic of the Congo (DRC)

**Paul Bugala, Independent Mining Investment and Sustainability Analyst**

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[58] World Wildlife Foundation. "Flamingo paradise becomes largest Andean Ramsar wetland." September 22, 2009. https://www.wwfca.org/?174641/Flamingo-paradise-becomes

[59] Reuters. "Chile judge calls for water study on 'fragile' lithium-rich Atacama salt flat." July 27, 2020. https://www.reuters.com/article/us-chile-lithium/chile-judge-calls-for-water-study-on-fragile-lithium-rich-atacama-salt-flat-idUSKCN24S12A

[60] Reuters. "Germany's Volkswagen and Daimler push for more 'sustainable' Chile lithium." February 11, 2020. https://www.reuters.com/article/us-chile-lithium-exclusive/exclusive-germanys-volkswagen-and-daimler-push-for-more-sustainable-chile-lithium-idUSKBN20524Z

In 2019, the DRC continued to be the world's leading source of mined cobalt, supplying approximately 70% of global cobalt production from mines concentrated in the country's North Kivu province.[61] A third of the country's cobalt originates from artisanal mines where child labour and unsafe conditions are common and the use of mercury and other toxic materials goes on without adequate regulation[62].

The challenges posed by cobalt, tin and tantalum mining in the DRC have long been the subject of international concern. In fact, Section 1502 of the Dodd-Frank Act requires disclosure of the supply chains of productions using these three metals key to battery and other electronics manufacture. As the royalty and tax proceeds from development of cobalt in the DRC and many other resources worldwide are too often squandered or misused, another part of the Dodd-Frank Act, Section 1504, requires the disclose of natural resource related payments by extractive industries firms. While this law has yet to be implemented in the U.S., companion laws in place in Canada, the EU, UK and Norway have resulted in the disclosure of more than $1 trillion in payments between extractives companies and governments[63].

Despite this international attention, the cobalt producing provinces of North and South Kivu are still effectively run by more than 130 armed groups which engage in war crimes, including ethnic massacres, rape, forced recruitment of children, and pillage[64]. Proceeds from cobalt mining represent a very significant portion of the money used by these armed groups to terrorize the people of eastern DRC.

While transparency provided by Dodd-Frank, Section 1502 has led to some accountability, and the International Criminal Court (ICC) has sentenced a rebel leader responsible for decades of human rights violations in the Kivus to 30 years in prison[65], the situation in the DRC remains dire. Growth in the demand for cobalt threatens to exacerbate this situation unless mines in the DRC come under the control of a more regulated entity or alternatives are found.

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[61] U.S. Geological Service. " Cobalt Data Sheet - Mineral Commodity Summaries 2020." January 2020. https://pubs.usgs.gov/periodicals/mcs2020/mcs2020-cobalt.pdf
[62] The Financial Times. "Congo, Child Labor and Your Car." July 6, 2019. https://www.ft.com/content/c6909812-9ce4-11e9-9c06-a4640c9feebb
[63] Natural Resource Governance Institute. Resource Projects Payment Database. Accessed 30 October 2020. http://www.resourceprojects.org/projects?tab=0&
[64] Human Rights Watch. "World Report 2020: Democratic Republic of Congo." 2019. https://www.hrw.org/world-report/2020/country-chapters/democratic-republic-congo
[65] Ibid.

## Policies, Programs and Performance

**Paul Bugala, Independent Mining Investment and Sustainability Analyst**

Mining companies that take the obligation to manage ESG risks and opportunities seriously should implement sustainability management systems that feature a combination of best practice policies, the programs necessary to implement those policies, and the performance disclose systems necessary to determine whether their programs are achieving the goals set forth in strong policies.

In the context of greenhouse gas (GHG) emissions management, a best practice policy would constitute a commitment to reduce GHG emissions on an absolute basis consistent with the IPCC’s 1.5°C guidance. The programs would include emissions monitoring and collections through Scope One, Two and Three throughout the company's supply chain. The performance disclosure would include full supply chain emissions disclosures provided on an annual basis for all geographies and majority owned properties. A very similar model could be applied to water management.

With regards to human rights, a policy, program and performance model would include the following elements. Policies requiring compliance with the United Nations Universal Declaration of Human Rights[66], the United Nations Guiding Principles on Business and Human Rights[67], and any other international standards relevant to their operations such the United Nations Declaration of the Rights of Indigenous Peoples[68]. The programs necessary to implement these policies may include evaluation and consultation capacities necessary to determine that the company has the Free, Prior and Informed Consent (FPIC) necessary to proceed with its operations with the necessary social license to operate. The performance disclosure aspects of a human rights system would include data collect through grievance mechanism systems and information necessary to indicate their resolution.

[66] https://www.ohchr.org/EN/UDHR/Pages/UDHRIndex.aspx
[67] https://www.ohchr.org/documents/publications/guidingprinciplesbusinesshr_en.pdf
[68] https://www.un.org/development/desa/indigenouspeoples/declaration-on-the-rights-of-indigenous-peoples.html

## Nature-related financial risks to the mining sector

**Nitin Sukh, Head of Natural Capital from Planet Tracker**

Given the broad range of impacts and dependencies on ecosystems services provided by natural capital, disruptions to biodiverse landscapes can trigger material nature related financial risks.

| Type of risk | Impact | Description |
|---|---|---|
| **Physical risk** | Disruption of operations | Years of ecosystem degradation has left many areas vulnerable to man-made natural disasters. Environmentally irresponsible mining can lead to the destabilisation of surrounding landscapes that otherwise buffer mining sites from physical environmental risks. |
| **Regulatory and legal risk** | Restricted access to land and resources | With increasing calls for governments to allocate more land for nature-based solutions and to secure buffer zones around wildlife habitats, mining companies may lose access to land located in or around ecologically sensitive areas. |
| | Litigation | Companies are frequently subject to litigation as a result of their exploitation of biological resources or their adverse impacts on ecosystems and the associated human health consequences. Litigation can lead to fines and penalties being levied on mining companies. |
| | Pricing and compensation regimes | Governments around the world are introducing new compensation regimes and market-based instruments to help address threats to ecosystems and biodiversity by putting a price on the environmental damage caused by companies. Such mechanisms will significantly increase costs for sectors and operators affected. |
| **Market & Transition risk** | Changing consumer preferences & transition risk | As consumers become increasingly aware of the environmental credentials of companies and their products there is evidence that buying habits are already changing. If this trend continues, sustainably extracted natural materials will eventually be a core requirement for market access in the sectors affected. Furthermore, as industries that require metals and minerals to produce green economy goods, mining company operations will come under increasing scrutiny for their ecological impacts. |
| | Purchaser requirements | Purchasers are introducing or enhancing sustainable procurement guidelines which present significant risks for suppliers that will struggle to comply. For example, the EU and the UK [69] are introducing stringent environment and social due diligence reporting protocols for companies involved in the trade and import of soft commodities through amendments in law. |
| | Reputational risk | Association with adverse impacts on biodiversity and ecosystems can result in severe damage to a company's brand and restrict its social license to operate. |
| | Financing risk | Risks outlined above may have an adverse impact on a company's cash flows reducing its credit quality and consequently increasing the cost of accessing new finance. Lenders are tightening environmental requirements for access to corporate loans, particularly signatories to the Equator Principles, and insurers are increasingly sensitive to risks associated with biodiversity loss and ecosystem degradation. |

[69] UK Government (2020) – Global Resources Initiative, Final Recommendation Report

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|---|---|---|
| | Systemic risks | Scientists suggest that with the current rate of deforestation, human-wildlife interaction and climate change, COVID-19 is just the tip of the zoonotic disease iceberg. Zoonotic outbreaks are biosecurity and nature-related financial risk events that are now pushing companies and countries into economic distress. |
| | Supply chain risk | Risks outlined above can have dramatic adverse consequences for downstream operators threatening security of supply chains or leading to increased costs. |

*Table 6 Nature related financial risks to the mining sector[70]*

## Engagement guidelines for investors

**Nitin Sukh, Head of Natural Capital from Planet Tracker**

| Questions | Notes |
|---|---|
| **What are the internal governance mechanisms to ensure environment and/or biodiversity related policies and standards are upheld?** | Investors, at a minimum, should ensure that the company has updated policies and governance mechanisms, like a board level committee, to ensure regular natural capital and biodiversity related due diligence is undertaken. |
| **How does the company ensure Environmental Impact Assessments (EIAs) meet the highest global standards?** | As best practice, Sustainable Development Goals (SDG) aligned investors must ensure that mining companies operating in countries ranked low on the Corruption Perception Index[71] and the Environmental Performance Index[72] should produce high quality EIAs that meet the laws and requirements of countries in which the investor is headquartered. |
| **How does the company ensure the stakeholder process undertaken to identify Go Vs. No-go zones are broad, thorough and verified?** | Companies should clearly identify *'Go' Vs. 'No-go' zones* by biodiversity richness and historical heritage by consulting grassroot environmental organisations, local communities, environment ministries, national biodiversity authorities and cultural organisations. Records of these consultations must be included in EIAs and audited by reputable third-party organisations. Investors can use online free geospatial tools, such as WWF sight, to verify whether the mining company is going to operate in a biodiversity hotspot and essential life support areas. |
| **Are Free and Prior Informed Consent (FPIC) documents publicly disclosed?** | Free and prior informed consent (FPIC) should be sought from communities and traditional stewards of the land irrespective of whether rights to the land have been given to them from legal institutions. |
| **Is the company meeting the basic environmental criteria outlined in the Equator Principals?** | Principle 4 of the Equator Principles recommends that companies must have the following environment related systems in place:[73]<br>• A real time data centric Environmental and Social Management System (EMS)<br>• Environmental and Social Management Policy and Plan (ESMP) – This should include a water and stringent hazardous waste management plan with a stated ambition of working towards full circularity.<br>• Ensure the mining company has a spent mine biodiversity rehabilitation plan |

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[70] Source: Planet Tracker research 2020
[71] Transparency International (2020) – Corruption Perception Index
[72] Yale University (2020) – Environmental Performance Index
[73] The Equator Principles Association (2020 ) – The Equator Principles

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|---|---|
| **Is the company a signatory or adherent to industry standard environmental guidelines? of** | Industry level guidelines have been drafted The Framework for Responsible Mining [74] and the Mining Principle of the International Council of Mining and Minerals. |
| **Are the mining operations eco- certified?** | Eco certifications can be sought from the Initiative for Responsible Mining Assurance or other environmental certification initiatives that are vetted by the Gold Standard and/or the ISEAL alliance?[75] |
| **How does the company report its environmental and social performance?** | • Audited sustainability report? - Sustainability reports should be GRI accredited and must be audited before being considered by SDG aligned asset managers.<br>• Audited integrated Report – Integrated reports should meet high auditing standards before consideration for equity investments from SDG aligned asset managers.<br>• United Nations Global Compact (UNGC) Communication of Progress report - Companies that are UN Global Compact signatories should be taking social and environmental issues into consideration anyway. Investors could check if the companies are UNGC signatories and whether their historical communications on progress (COP) indicate environmental concerns in project identification, execution and reporting.<br>• Environmental profit and loss accounting or other means of quantitatively integrating environment related performance in financial statements |
| **How robust are the company's environment and biodiversity related disclosures?** | • Has the company disclosed science-based targets and/or net zero targets?<br>• Does the company disclosure scope 1,2 & 3 GHG emissions, biodiversity impacts, water usage and wastewater treatment quantities and efficiency rates, non-GHG emissions, solid waste disposal and treatment data?<br>• Does the company have a timebound biodiversity offsetting plan when planning to change land use in a biodiverse region?<br>• Does the company purchase Gold Standard level verified voluntary carbon and biodiversity offsets? - If land use change of biodiverse habitat is unavoidable, the company must commit to timebound biodiversity offsetting or purchasing voluntary forest carbon offsets that represent verifiable social and environmental impact and are recognized by global standard setting organisations.<br>• What is the site reclamation plan/spent mine rehabilitation plan and how will it be funded?<br>• Is executive pay linked to environmental performance and if so, how material is it in the assessment of executive performance? |

*Table 7 Engagement guidelines for investors[76]*

[74] The Framework for Responsible Mining (2005) – A guide to evolving standards
[75] Initiative for Responsible Mining Assurance (2020)
[76] Source: Planet Tracker research 2020

## Conclusion

This paper has looked to examine the effect of green energy and green mobility technologies' supply chains on the climate and natural capital. This is of particular relevance for investors such as Carmignac because we have a fiduciary duty to invest our clients' money for both financial return and environmental and societal good, for current and future generations. As such, it is our duty to understand and support the industries that enable green technologies to prosper , but we consider it to be irresponsible to only invest in the pure play green companies and exclude enabling companies such as mining companies, despite higher CO2 or past controversies. Furthermore, we believe that it is by engaging with mining companies on these issues leads to heightened awareness and remediation of environmental or societal concerns.

This paper has demonstrated the range of alternative elements that must be considered when producing green technologies. As a result, it is important to design renewable energy systems and green mobility solutions that consider the available supply of its metals and materials and the potential challenges of ESG-related factors involved with its procurement and production. Indeed, it is increasingly evident that the green transition will not be possible without minerals and supporting sectors and whilst there is a lot of innovation in the minerals industry, such as new companies expanding the recycling and reuse of rare minerals to extend the lifetime of products and stretch out reserves, we must remain prudent to how reliant we are on such resources. It is important to note that in this paper we have taken a conservative approach regarding the materials and metals requirements for the future renewable energy systems and have not included support systems and supplementary parts such as cables, substations and vessels for offshore wind installations- these must also be taken into consideration for a full appraisal.

To achieve our green ambitions and the mitigation of climate change to achieve 1.5 degrees, we will need to mine. However, a more measured and environmentally positive approach is needed when obtaining and utilising our rare minerals. As a result of taking a more holistic view of green technologies, we will be able to weigh up the environmental benefits versus damages and help ensure that our green technologies are truly green.

## Contributors & Profile

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*Justin Kew is an ESG Analyst at Carmignac. Justin joined Carmignac in 2019. He started his career in 2007 as an Associate at J.P. Morgan London, before moving to Schroders as Client Portfolio Manager on Quantitative Global Equity. In 2015, he was appointed Sustainable Investment & Product Manager at J.P Morgan and in 2017, he joined Fidelity International, where he was Senior ESG analyst, responsible for integrating ESG data in the investment analysis and portfolio management process while designing investment processes for clients. Justin holds a Master's degree in Electrical & Electronics Engineering from the University of Sheffield. He's a CFA Charter holder since 2012.*

**Nitin Sukh**

**Head of Natural Capital, Planet Tracker**

*Nitin is an ecological economist and development banker specialising in environmental finance and green economic growth. He established the responsible banking and public policy divisions at Yes Bank where he co-developed India's first green bond. More recently he has consulted to organisations such as ShareAction and Ecosphere+.*

**Paul Bugala**

**Independent Mining Investment and Sustainability Analyst**

*Paul Bugala has worked for more than 15 years as an oil and mining investment and sustainability analyst at Calvert Investments, Oxfam and as a consultant. He has also taught a sustainable finance course in the MBA program at the George Washington University School of Business. Paul is on the advisory board of the American University Center for Environmental Policy and is a member of Amnesty International USA's Business and Human Rights Group. He was appointed by two Secretaries of the Department of the Interior to the U.S. Extractive Industries Transparency Initiative (US EITI) Federal Advisory Committee, on which he served from its formation in 2012 until its end in 2017. Previous to his work with the oil and mining industries, Paul was a technology industry analyst at IDC Research.*

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*Andrew Howell is Director of Corporate Research with the Alliance, focusing on topics including extractive industries, decarbonization and capital markets development. For 17 years, Andrew was an equity research analyst and strategist with Citi, where he led the frontier markets research effort, traveling* *regularly to Africa, the Middle East, Eastern Europe and South Asia. He has also worked in private equity and as a management consultant and financial analyst in Russia. Andrew holds degrees from the University of Pennsylvania and INSEAD, is a CFA Charterholder and holds the FSA (SASB Fundamentals of Sustainability Analysis) credential.*

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