10 August 2021

Steel and Metallurgical Coal Expert Report

Prepared for West Cumbria Mining

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1. Metallurgical Coal Demand Outlook

1.1. The objective of this chapter of the report is to provide detailed analysis of the methodologies used and assumptions applied to derive Wood Mackenzie's long-term global and European coking coal demand forecasts. The section provides an outlook for BF-BOF-based and EAF steel production globally and in Europe to 2049 and assesses the impact of EAF steel production and new low-carbon steelmaking technologies on coking coal demand. The section also provides a downside scenario for coking demand in Europe, highlighting the implications for West Cumbria Mining.

Methodology

Wood Mackenzie Metals & Mining Research Overview

1.2. Wood Mackenzie produces commodity market reports, which provide in-depth analysis and forecasts of global and regional metals market fundamentals. The primary deliverables are:

- Short-term monthly reports
- Long-term quarterly or bi-annual outlooks, including up to 30 years of supply, demand and price forecasts
- Monthly updates, covering a two-year period
- Web-based data tools with detailed information

1.3. Wood Mackenzie employs several different data sources and methodologies to produce its markets forecasts. These outlooks are created using proprietary supply data, which are built up by asset and include future projects. We also use our own demand research, coupled with detailed trade data, to complete our country balances and stock build-up or draw-down. From this point, we assess the global market balance and derive price forecasts based on the expected market surplus or deficit.

1.4. Wood Mackenzie's research analysts conduct extensive and detailed research into their respective focus areas.

Internal data sources: We use several internal data sources to compile our views on commodity markets, including.

- **Macroeconomics** – Wood Mackenzie has a global team of economists which provides our base view on GDP, IP, inflation and foreign exchange rates. They also produce datasets on other macro drivers, such as automotive and housing construction. These views are shared with all teams in Wood Mackenzie to ensure a consistent view across commodities.
- **Supply** – We provide a robust view of existing and future commodity production, including mines, smelters and refineries.
- **Energy** - Where relevant, our metals markets team exchange forecasts and data with Wood Mackenzie's various energy teams to form a consistent view on overlapping issues. Examples of this could be energy intensive smelting projects, power projects to fuel these smelters or other demand issues affecting both energy and metal markets.
- **Costs** – Our research uses our propriety databases and costing models which have been developed over many years of industry research and analysis.

External data sources: The primary external data sources used by Wood Mackenzie to compile metals and mining asset reports are shown below.

- **General and industry-specific media and databases –** Our analysts regularly review general media and a wide variety of industry-specific publications and databases including the World Steel Association (WSA), Platts, the Argus Media group, GTT and Clarkson Research Services.

- **Interviews with metals & mining companies and other industry contacts –** We interact with industry participants in all regions and countries. Meetings are also held with contacts in the relevant government and regulatory organisations.
- **Company annual reports and other company documents –** We regularly review key company annual reports, investor presentations and SEC or other stock exchange (e.g. ASX, SEDAR) filings

Steel Demand Modelling

1.5. Our steel analysis uses a combination of bottom-up and top-down approaches to form our view on demand. The forecasts are supported by Wood Mackenzie's key macroeconomic assumptions, including GDP and IP, as well as discussion of our assumptions on key demand drivers such as automotive production, housing construction and other relevant macro factors.

1.6. We use the bottom-up approach for the key areas of global steel demand, namely the US, Europe, Japan, Brazil, Russia, India and China. For these regions, we developed sector-by-sector steel demand models. We divide steel demand into three sectors – construction, automotive and other. For the US, India and China we further model machinery, household appliances and shipbuilding. Growth for each sector is forecast using sector drivers. For example, for the automotive sector, we estimate average vehicle weight and steel intensity. We make assumptions on expected changes to weight and material preferences. We combine these estimates with our internal automotive production forecasts to derive end-use steel consumption.

1.7. Alternatively, for locations where statistics are scarce, we may use an econometric model on certain steel consuming sectors or sub-sectors and use a growth driver of best fit to determine the forecast. For example, we have found a strong relationship between household appliances growth and residential, commercial and agriculture energy demand (available from Wood Mackenzie's energy markets team). For smaller steel consuming countries, we use a top-down approach, where we utilise steel intensity to GDP and per capita steel consumption models.

Steel Supply Modelling

1.8. Our steel supply analysis is based on our historical production and capacity data. We also develop steel capacity forecasts by plant. We derive crude steel production from our steel demand forecasts plus or minus steel trade (adjusted for yield loss). We estimate steel production by blast furnace, electric arc furnace or open-hearth furnace, based on our detailed steel plant capacity database, capacity utilisation assumptions and historical data. We make assumptions on how preferred production routes will change, taking into account cost competitiveness, scrap availability, environmental legislation and evolution of technologies, among other factors.

1.9. Consumption of steelmaking raw materials (iron ore, coke, metallurgical coal) are derived from our steel production forecasts. For example, using our proprietary assumptions on coke rates, pulverised coal (PCI) rates, and coal share by quality type (hard coking, semi-soft, and PCI coal), we develop a long-term forecast of metallurgical coal demand by quality type.

Steelmaking Overview

1.10. Steel is produced via two main routes: the blast furnace-basic oxygen furnace (BF-BOF) route and electric arc furnace (EAF) route. Variations and combinations of production routes also exist.

Blast Furnace-Basic Oxygen Furnace

1.11. Coking coal is used to make metallurgical coke, which is a key raw material in steelmaking through the BF-BOF route. Coking coal is most often charged into the top of a coke oven and heated at around 1,100°C for 18 hours. This carbonisation process removes impurities, like coal tar and coal gas, to produce coke. The red-hot coke is pushed from the side of each oven and quenched with either water or inert gas, before being transferred by conveyor to the blast furnaces.

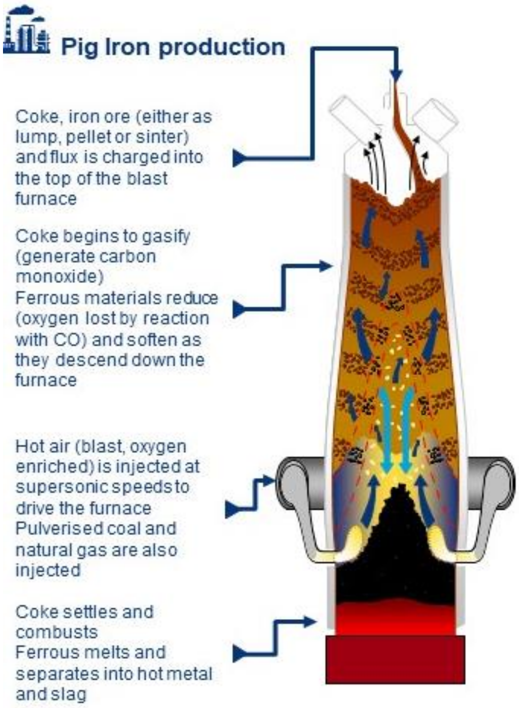
1.12. Coke, iron ore and limestone are fed (or charged) into the top of a blast furnace. A hot air blast of temperatures ~1,000°C is injected at the bottom of the furnace through nozzles called tuyeres. As the coke burns, temperatures higher than 2,000°C are reached and this heat creates molten metal (iron). The molten metal collects at the bottom of the furnace and the limestone combines with impurities to form slag. As the slag is less dense than molten metal, it floats on top of the metal and can be removed.

1.13. In the basic oxygen furnace, hot metal is poured into refractory-lined charging ladles, where unwanted elements such as sulphur are removed. Scrap metal is charged into steelmaking vessels and the liquid iron is then added to the vessel. Using a water-cooled lance, high purity oxygen is blown onto the surface of the liquid iron at very high pressure. Lime is added to the process, which forms a slag and removes the unwanted elements from the liquid steel.

1.14. When the oxygen blowing process is complete, the steel is tapped into ladles, where the desired steel chemistry is achieved through careful addition of alloying elements and close control of the deoxidation process to ensure a high level of steel purity.

1.15. BF-BOF-based production accounted for 73% of global steel production in 2020.

Figure 1.1: Blast furnace steel production process



Source: Wood Mackenzie

Electric Arc Furnace (EAF)

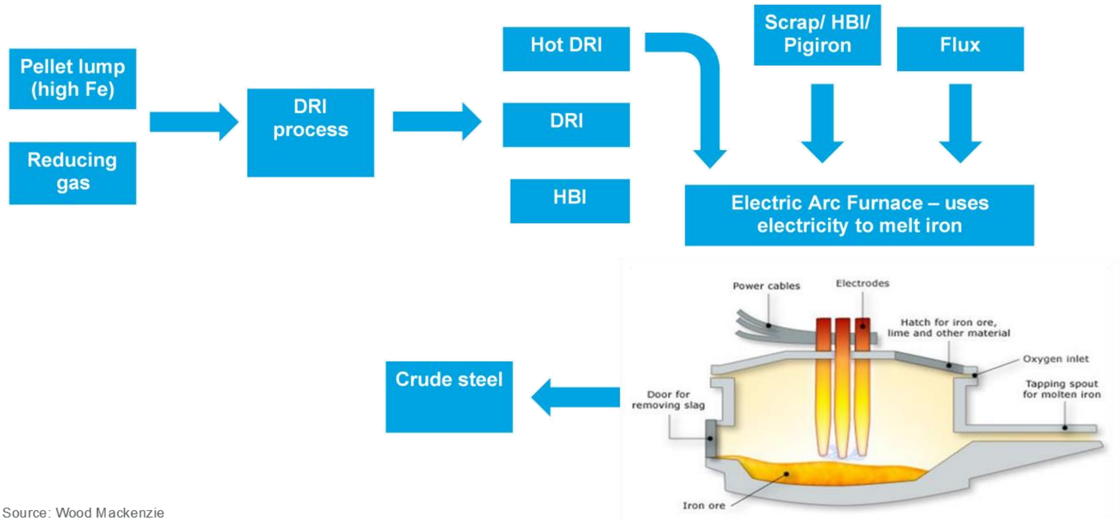
1.16. Electric arc furnaces (EAFs) produce molten steel using electrical currents to melt scrap, direct reduced iron (DRI) (or sponge iron), hot briquetted iron (HBI) and cooled hot metal, which is known as pig iron. DRI is produced from the direct reduction of iron ore using reduced gas, usually from natural gas or coal. Fed with iron ore pellets or lump, the DRI furnace is heated to just below iron's melting point to reduce iron ore in a solid state. Feedstock is restricted to high-grade pellets and lump because the DRI furnace does not reach hot enough smelting temperatures to remove additional impurities.

1.17. In the steelmaking process, the EAF consists of a circular bath with a movable roof, through which graphite electrodes can be raised or lowered. At the start of the process, the electrodes are withdrawn and the roof swung clear. The steel metallics are charged into the furnace from a large steel basket. When charging is complete, the roof is swung back into position and the electrodes lowered into the furnace. When the electric current is passed through the charge, an arc is created, and the heat generated melts the metallic feed. Lime and fluorspar are added as fluxes and oxygen is blown into the melt. As a result, impurities in the metal combine to form a liquid slag. Samples of the steel are analysed for quality and then the furnace is tapped rapidly into a ladle. Final adjustments to precise customer specification can be made by adding alloys during tapping or, subsequently, in a secondary steel making unit.

1.18. EAFs use a very small amount of coal in the process – 12 kg/t of steel. European EAFs currently produce about 63 Mt of crude steel; coal needed for this process would represent about 0.8 Mtpa. Coal used in EAFs does not require coking properties, therefore thermal coal can be used.

1.19. EAFs are generally smaller in scale than blast furnaces, however, their carbon emissions are approximately one-fourth as much. EAF production accounted for 27% of global steel production in 2020.

Figure 1.2: Overview of electric arc furnace (EAF) steel production



Source: Wood Mackenzie

Global and European Metallurgical Coal Demand Outlook

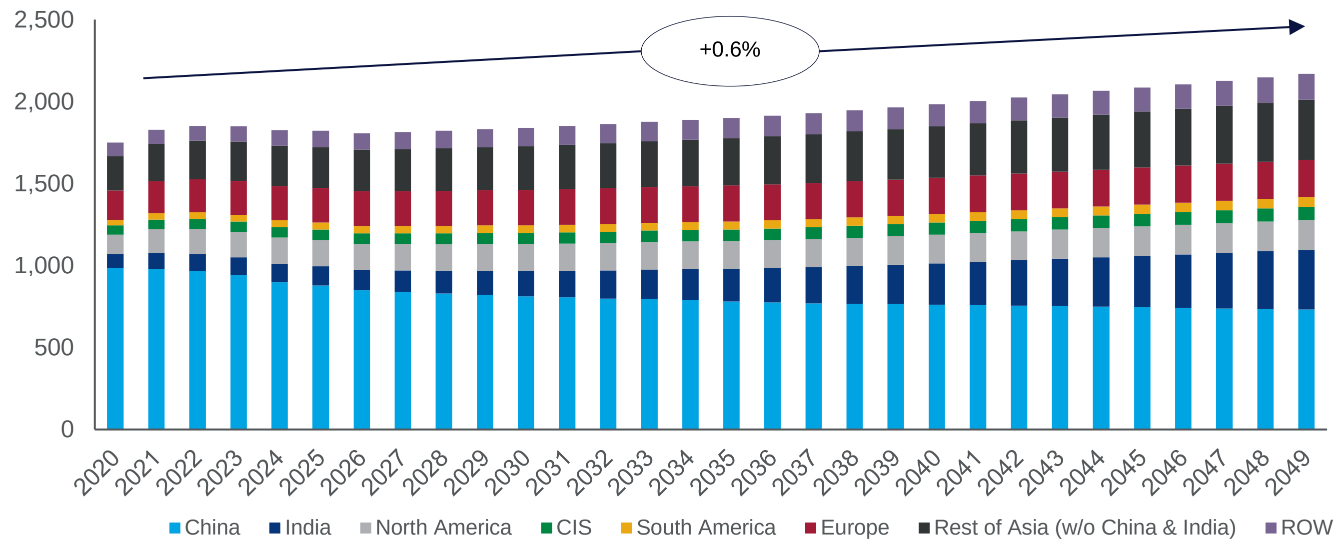
1.20. The following section outlines the key assumptions underpinning Wood Mackenzie's global and European metallurgical coal demand forecasts, including the outlook for steel demand, crude steel production and displacement of BF-BOF-based steel production for EAF steel production. All forecasts are shown to 2049, which will be the final year of production for West Cumbria Mining.

1.21. The chart below (Figure 1.3) shows forecast global steel demand to 2049. Global finished steel demand is forecast to continue to rise over the next 20-30 years, albeit at a slower rate than historical levels, as Chinese consumption peaks. China accounts for over half of global steel consumption and its economy is shifting from being driven by investment and industrial production to being led by consumption and services. A slowdown in urbanisation, an ageing population and declining total population will contribute to a long-term contraction in Chinese steel demand. Consumption in the property sector will decline the most, followed by infrastructure, while auto sector consumption will grow in the 2020-2049 period.

1.22. The vast growth aspirations of the Indian economy are central to the global steel demand outlook in the next 20-30 years. Urbanisation and electrification for a massive and growing population will result in steel demand increasing by more than fourfold, to over 360 Mt by 2049. In the Rest of Asia, steel demand growth is forecast to increase at a Compound Annual Growth Rate (CAGR) of 1.9% to 2049. Southeast Asia, in particular, is focusing on infrastructure development for improving connectivity to propel investments and manufacturing competitiveness. Additionally, rising income levels and a majority working-age middle-class population will support the demand for low-cost housing, automobiles and consumer durables.

1.23. Europe is a mature steel consuming region and demand is expected to grow at a more modest pace in the next 20 to 30 years. Finished steel consumption in Europe is forecast to increase from 195 Mt in 2021 to 227 Mt in 2049, equivalent to a CAGR of 0.5%.

Figure 1.3: Global apparent finished steel demand, 2020-2049 (Mt)



Source: Wood Mackenzie

1.24. Wood Mackenzie derives country crude steel production from our steel demand forecasts by adjusting for country-level net steel trade (adjusted for yield loss). The following chart (Figure 1.4) shows forecast global crude steel production to 2049. Global steel production will grow steadily in the long term, in line with finished steel demand.

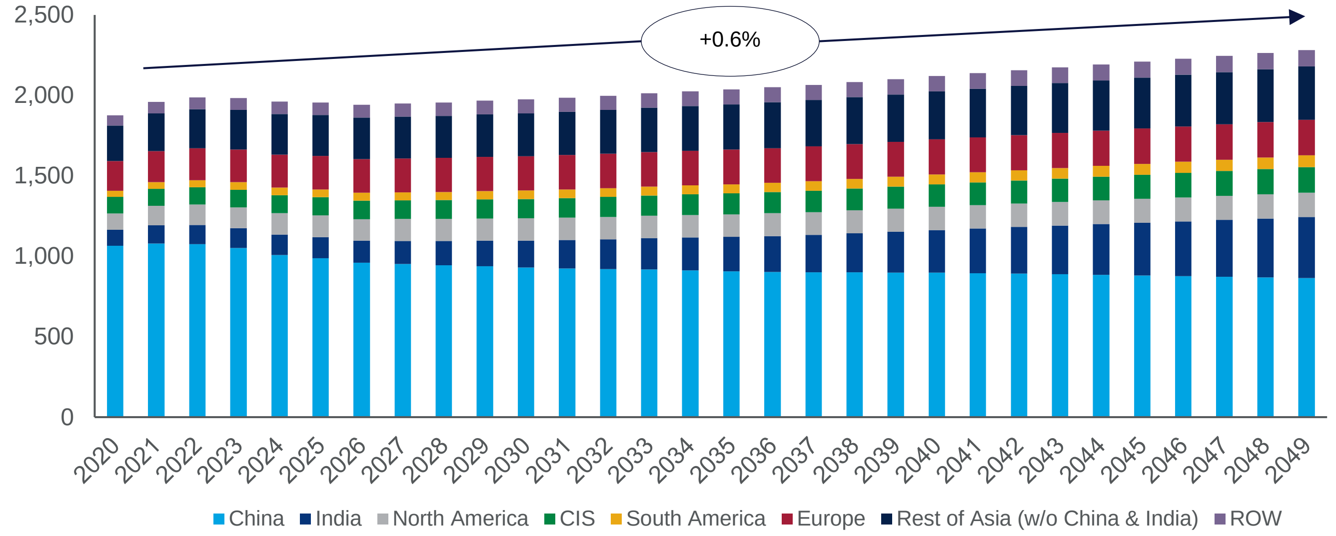
1.25. China's domestic steel demand was robust in the first half of the year, indicating that 2021 will be another growth year for Chinese steel production. Nonetheless, we believe that Chinese crude steel production is peaking. We expect it to start a gradual decline from 2022, highly leveraged by retreating property sector demand.

1.26. Indian crude steel production is expected to grow at a healthy average of 6% p.a. to 2025 and 5% p.a. thereafter, reaching 379 Mt by 2049. In the medium term, we expect significant capacity additions by integrated steelmakers. Additions totaling 18 Mtpa are expected to come onstream by 2025. Downside risks to our forecast manifest from India's ability to reach these significant goals, historically marred by political stagnation, land availability and economic slowdowns.

1.27. Southeast Asia (e.g. Malaysia, Philippines, Thailand, Vietnam) has exhibited continued steel production growth amid increasing demand. However, crude steel production is still sub-optimal, with 58% utilisation and finished steel imports catering to more than half of steel demand. The government has started levying safeguard duties to support domestic production and reduce import dependence. Despite the overcapacity, we expect nearly 40 Mt of capacity additions by 2030.

1.28. Steel production in Europe is forecast to grow gradually in the future, in line with finished steel demand. European crude steel production is forecast to increase at a CAGR of 0.5% in the 2021-2049 period, reaching 220 Mt. Italy is forecast to account for a large proportion of the region's growth, increasing by almost 8 Mt over the period. In the UK, crude steel production is forecast to remain broadly flat at 7.0-7.5 Mtpa.

Figure 1.4: Global crude steel production, 2020-2049 (Mt)



Source: Wood Mackenzie

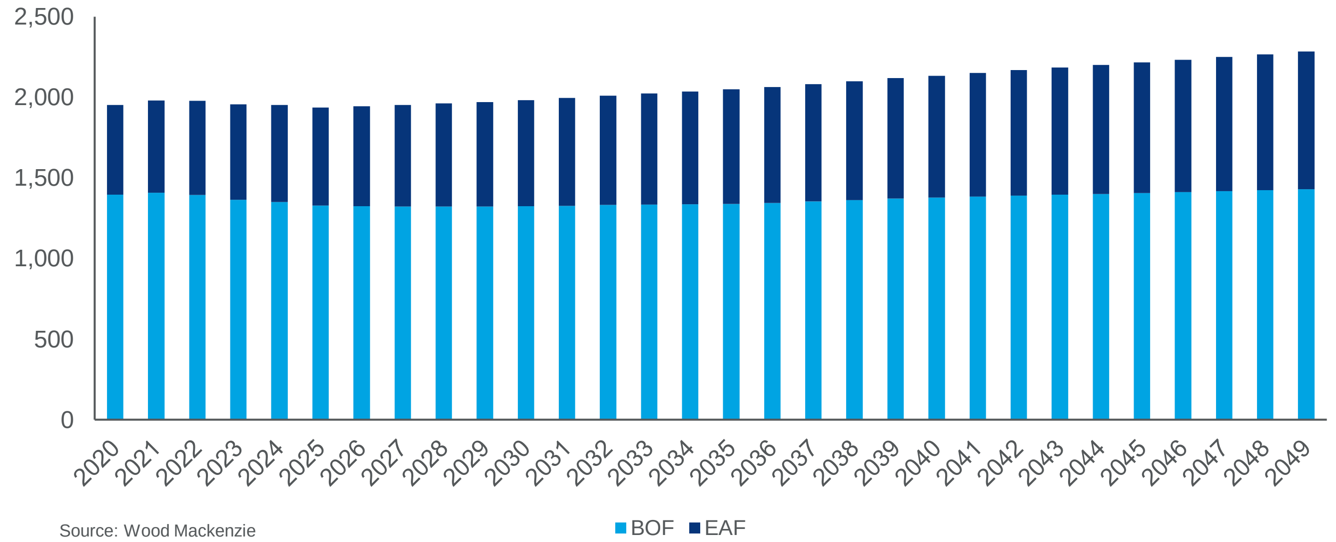
1.29. The following chart (Figure 1.5) shows global crude steel production by process to 2049. At a global level, BF-BOF-based steel production will remain the dominant production process, but its share is forecast to fall from 73% in 2020 to 62% in 2049.

1.30. In China, following the trend of steel demand, we expect BF-BOF production to peak in 2022 and gradually fall thereafter. By 2049, BOF crude steel and hot metal will have fallen to 702 Mt and 684 Mt, respectively, which is around 74% of their 2020 levels. However, despite higher preference for EAF production in capacity additions, scrap availability and lower cost-competitiveness of the BF-BOF route will maintain dominance in China with a share of 81% in 2049, down from the current share of 89%.

1.31. In India, the BF-BOF route will remain dominant in the long term, because the country's plentiful iron ore reserves, the cost-competitiveness of the BF-BOF route, and domestic scrap availability issues will remain key in deterring the growth of EAF technology. With the global shift to cleaner steelmaking technologies, major Indian steelmakers are now slowly considering investing in new EAF-based steel capacity. However, we believe that BF-BOF-based steel production will remain the dominant process in the future, increasing to 72% in 2049 from current levels of 47%.

1.32. In the rest of the world, carbon emission reduction targets, set publicly by a growing number of countries, dictate that hard-to-abate industries cannot hide behind the extra efforts and costs to decarbonise. Higher scrap use, operational efficiencies and switching to EAFs will be a focus of company strategies.

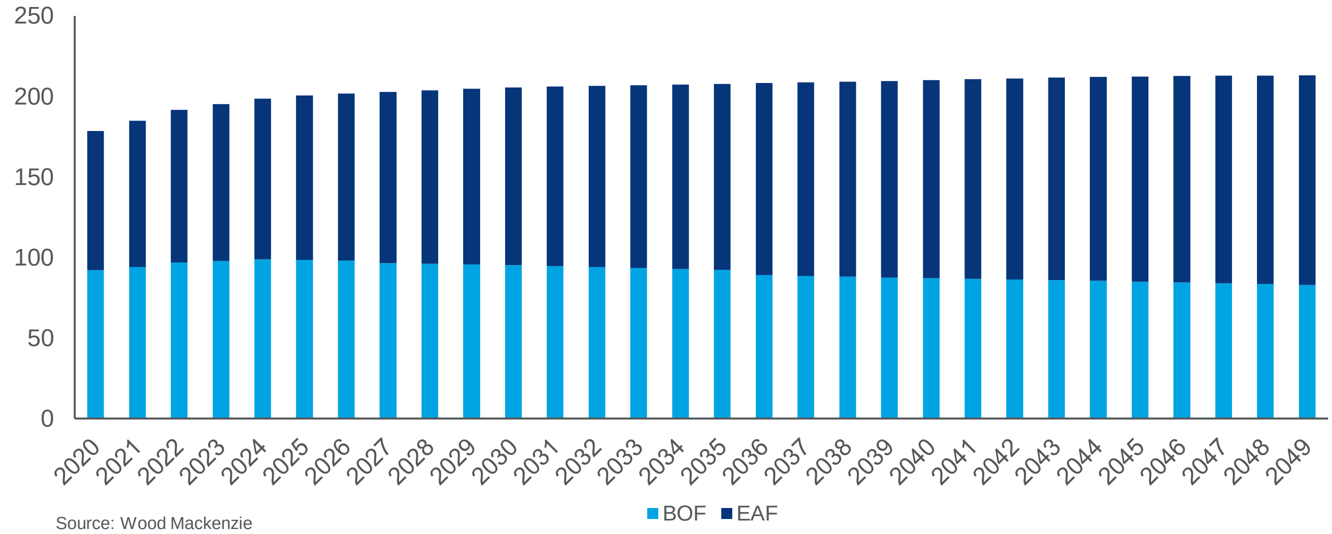
Figure 1.5: Global crude steel production by process, 2020-2049 (Mt)



Source: Wood Mackenzie

1.33. The following chart (Figure 1.6) shows European crude steel production by process to 2049. In Europe, EAF production accounts for a significantly higher proportion of the region's steel production than the global average at 47% in 2020. EAF production in the region is forecast to rise over time, as steelmakers replace BF-BOF-based capacity with EAFs to reduce emissions. By 2049, EAF steel production is forecast to account for 60% of European crude steel production. Despite the increased penetration of EAF production in Europe, BF-BOF steel production is forecast to decline only marginally in the long term, from 99 Mt in 2021 to 88 Mt in 2049. The "Decarbonisation of the European Steel Industry" section below provides more detailed analysis around the long-term outlook for the European steel industry.

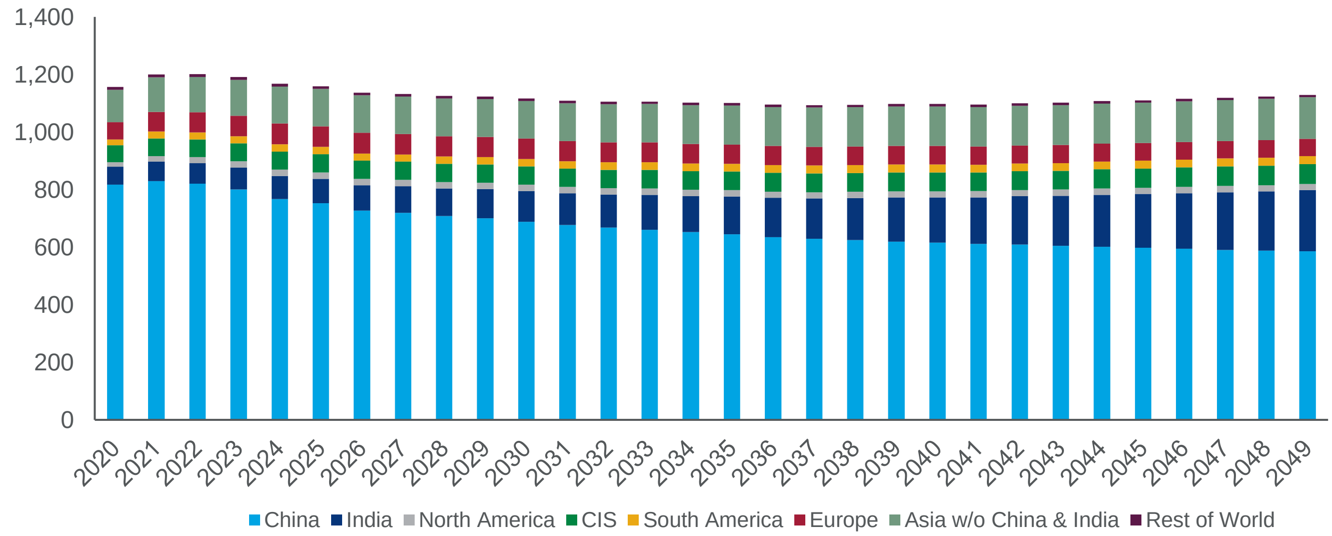
Figure 1.6: European crude steel production by process, 2020-2049 (Mt)



Source: Wood Mackenzie
N.B. Europe includes EU27, UK, Bosnia & Herzegovina, Serrbia and Turkey

1.34. The following chart (Figure 1.7) shows global metallurgical coal demand to 2049, which has been derived from our BF-BOF steel production forecasts. Global metallurgical coal demand is forecast to decline steadily due to the structural fall in Chinese hot metal production, as well as declining coke rates. In search of low-cost emissions reduction options, we expect steel mills will seek blast furnace efficiencies by maximising raw materials quality. The use of high-quality iron ore (high Fe and low gangue contents) can reduce the coke requirements of the blast furnace, allowing lower fuel rates and emissions. Fuel rate reductions, including coke rate improvements, are assumed to occur in all regions over the forecast period, as mills strive to use less coke and injection coals in BF production. Global metallurgical coal demand will peak at 1.201 bn t in 2022 and decline to 1.129 bn t in 2049.

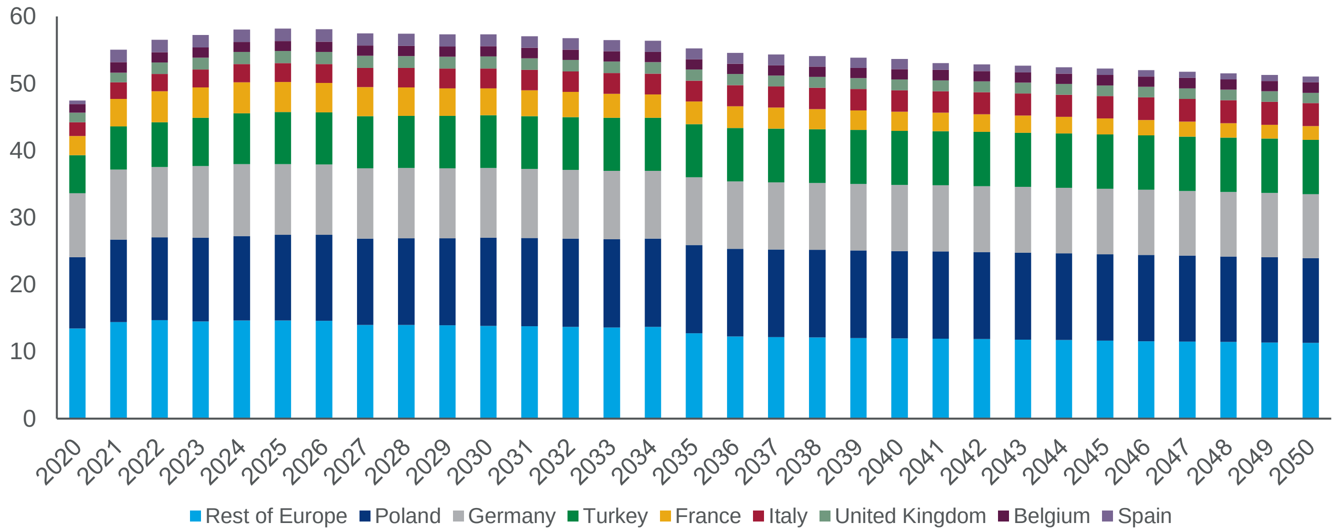
Figure 1.7: Global metallurgical coal demand, 2020-2049 (Mt)



Source: Wood Mackenzie

1.35. The following chart (Figure 1.8) shows forecast European metallurgical coal demand to 2049. While BF-BOF production in Europe is forecast to decline marginally in the next 20-30 years, the region will remain a significant metallurgical coal market. European metallurgical coal demand is forecast to remain between 50-55 Mtpa in the 2021-2049 period. In the UK, metallurgical coal demand is forecast to hold at ~1.5 Mtpa, as BF-BOF-based steel production flat-lines over the period.

Figure 1.8: European metallurgical coal demand, 2020-2049 (Mt)



Source: Wood Mackenzie

Decarbonisation of the European Steel Industry

1.36. Net zero emissions targets by 2050 have been set publicly by a growing number of countries, including the European Union and the United Kingdom, and, as a result, hard-to-abate industries cannot hide behind the extra efforts and costs to decarbonise. In Europe, steelmakers' CO2 costs are expected to rise over the coming decades, due to increased regulation on emissions. Furthermore, investors have become increasingly interested in reducing CO2 exposure across their portfolios. As a result, European steelmakers have come under increased pressure to show willingness to bring down CO2 emissions, often with limited cost considerations.

1.37. This section assesses the future impact of increasing EAF steel production, new low-carbon steelmaking technologies and carbon capture and storage on European coking coal demand.

Conventional EAF production

1.38. The main competing route of BF-BOF-based steel production is via scrap or DRI-fed EAFs. The GHG emissions levels associated with EAF production are significantly lower than for BF-BOF-based production. While the typical emissions intensity of BF-BOF-based production is ~2 t CO2e per tonne of hot metal (thm), a typical EAF emissions intensity is currently about 0.5 t CO2e /thm and in some places (such as Brazil which has access to cheap renewable energy) the level is as low as 0.1 t CO2e /thm. While there is a drive to replaces blast furnaces in Europe with EAFs, there are a number of constraints to increasing EAF production:

1. **Scrap availability**: Scrap will play an important role in supporting the increase in EAF steel production. In Europe, there is limited scope for steel scrap availability to grow. Even at the highest rates of collection and recycling, scrap availability would still be well short of supplying all the steel industry's Fe metallics needs . The reason scrap cannot be the sole metallic are two-fold. Firstly, scrap is a function of historic demand – as European steel demand will continue to grow from now until 2049, future, higher levels of demand cannot be replaced by scrap from past, lower levels of demand. A one-to-one replacement is not possible. Secondly, recycling and collection rates are unlikely to exceed 90% even in mature

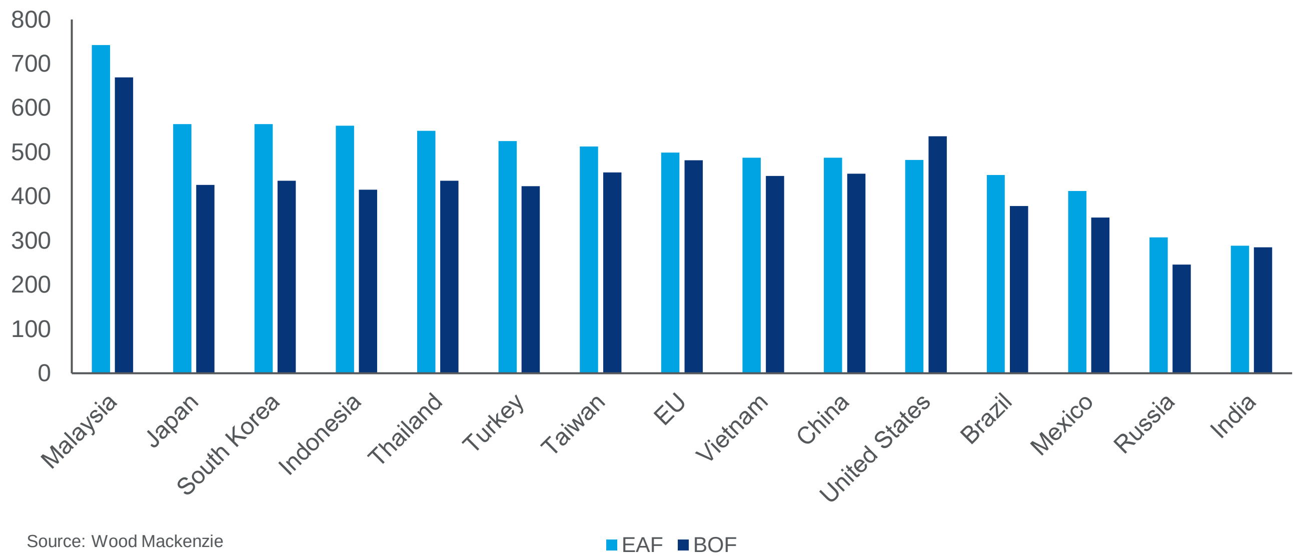
economies in Europe.

2. **Product quality**: It is very difficult, but not impossible, to produce high-quality steel from scrap instead of virgin iron ore (DRI or pig iron). Although steel is theoretically infinitely recyclable, in practice, impurities or residuals in the scrap build up with each reuse and must be controlled or removed during the steelmaking process. For instance, copper can easily be mixed in with steel scrap – the two metals are often found in construction and automotive applications. High levels of copper can make steel unworkable. The operational knowledge and ability to use scrap to produce high-end steel must be learned quickly. Lower-quality steel is often used in the construction sector rather than high-end sectors such as automotive or consumer durable goods.

3. **High capital costs**: The capital costs of replacing BF-BOF capacity with new EAF steel making facilities are very high. The typical capital intensity of a new EAF is US$500/t of capacity. Therefore, a 1 Mtpa capacity steel plant would require US$500 M of investment.

4. **Cost-competitiveness**: Historically, BOF production costs have been lower than EAF costs, but this gap has narrowed recently, primarily due to relatively low scrap prices (ex-China) and high iron ore prices. As seaborne iron ore prices decline in the coming years (as the majors increase supply and Chinese demand eases) and scrap prices moderate, we forecast the spread between EAF and BOF costs will widen again and maintain this gap on a long-term basis. When comparing 2021 crude steel production costs by country, EAF is higher cost than traditional BOFs, on average in most countries.

Figure 1.9: EAF vs BOF production costs, 2021 (US$/t)



Source: Wood Mackenzie

1.39. There is no doubt that EAF steel capacity will replace some BF-BOF capacity in Europe in the next 20-30 years. However, a number of constraints will limit EAF growth. Therefore, BF-BOF production in the region will only decline marginally over time. EAF steel production in Europe is forecast to increase at a CAGR of 1.3% in the 2021-2049 period and its share of crude steel production will grow from 47% in 2020 to 60% in 2049.

Emerging Low-Carbon Steel Technologies

1.40. As steelmakers decarbonise, higher scrap use, operational efficiencies and switching to EAFs will be a focus of company strategies, but will only take the transition so far. Hydrogen-based steel offers the most compelling long-term solution that could eventually lead to widespread replacement of coal and coke in steelmaking.

1.41. Currently, the only large-scale, commercial, non-blast furnace, iron-making route is DRI, which is produced by reducing iron ore in a shaft furnace using natural gas or coal. The iron ore is not melted, as in a blast furnace, so DRI is a solid iron product (often called sponge iron) with a higher gangue content than hot metal. Because of the higher level of impurities, DRI is most often made using higher-quality iron ore pellets, then combined with scrap in an EAF to produce liquid steel. As the conventional DRI process uses carbon monoxide and hydrogen from coal (around 800 kg to 1,000 kg of non-coking coal) or natural gas as the reducing agent on the iron ore, CO2 and H2O are released as by-products once the oxygen molecules are removed from the iron oxide.

1.42. Hydrogen-based DRI is the most likely source of future 'green' virgin iron. Hydrogen is already used to reduce iron ore in the DRI process: methane is typically split into its carbon and hydrogen constituents, which then directly reduce the iron ore. Green hydrogen refers to the process of using renewable energy in electrolysis to split the hydrogen and oxygen atoms from water. Using hydrogen DRI in combination with green energy to power the electric arc furnaces would result in emission-free steel production. The hydrogen-based DRI technology is the subject of experiments by a range of European steelmakers, most notably the Hybrit project in Sweden, led by a consortium including SSAB, Vattenfall and LKAB.

1.43. At present, there are only a handful of hydrogen DRI projects in Europe, all of which are small-scale, and most of these will not be operational within the next ten years:

- **Hybrit (JV of SSAB, LKAB and Vattenfall)**: The Hybrit joint venture was formed in 2016. In June 2018, construction of the pilot plant started in Luleå, Sweden. The plant has a proposed 2.3 Mtpa of DRI capacity and Wood Mackenzie expects it to be operational by 2027.
- **ArcelorMittal (Spain)**: The company is investing ~ €1bn in green steel projects in northern Spain, with support from the Spanish government. As part of this investment, development of a hydrogen DRI unit is planned at their Gijon plant by 2025. The unit has planned capacity of 2.3 Mtpa of DRI which is planned for use across ArcelorMittal's Gijon and Sestao works.
- **ArcelorMittal (Germany)**: The company's hydrogen DRI projects are planned to be located in Bremen, Hamburg and Eisenhüttenstadt in Germany. Wood Mackenzie expects the Bremen site to be operational by 2026, with capacity of 2.1 Mtpa of DRI. The Eisenhüttenstadt plant is expected to be operational by 2030, with capacity of 1.4 Mtpa of DRI.
- **Salzgitter**: The company's SALCOS project has planned capacity of 1.5 Mtpa of DRI in Germany. The green hydrogen will come from their project in partnership with Avacon (a subsidiary of E.ON) and Linde – WindH2 and Spitfires GrInHy2.0 project. The plant is expected to be in operation around 2025.
- **H2 Green Steel**: The project is the largest hydrogen DRI project in development, with a planned capacity of 5.0 Mtpa. As with Hybrit the proposed location is in Luleå. Financing and permitting is not yet in place and as such Wood Mackenzie does not currently include this project in our base case. Should the project proceed a startup date of 2030 is more likely than the company proposed date of 2024.

1.44. Wood Mackenzie expects 9.1 Mt of H-DRI capacity in the EU prior to 2030. At 80% utilisation and a 10% yield loss from metallics to crude steel production, that represents 6.5 Mt of crude steel produced using H-DRI. Production of 6.5 Mt is 4% of total EU crude steel production in 2029.

1.45. While technically feasible, there are numerous hurdles to overcome to make widespread green hydrogen use a reality. Green hydrogen must be produced using electrolysers, which split distilled water into hydrogen and oxygen. To produce a sufficient quantity of green hydrogen to decarbonise the steel sector would require hundreds of gigawatts of electrolyser capacity. At the end of 2020, there were only about 250 MW of electrolysers in existence globally, meaning over a 1,000-fold expansion would be required, specifically dedicated to steel production. Announced growth in electrolyser capacity is very significant – a 2025 pipeline of around 6 GW to 11 GW exists today, with a total pipeline of 84 GW – but, the enormous scalability challenge will take time to overcome.

1.46. Additionally, to allow decarbonisation, the electrolysers must be powered using green electricity. Standalone power units are possible, but ultimately, the energy transition will need to be much more mature – including decarbonised electricity grids – to guarantee the widespread availability of cheap green hydrogen, wherever needed. A massive increase in hydrogen production will also need a transformation of transport infrastructure, whether in gaseous form or as ammonia.

1.47. We believe that hydrogen will be critical in the energy transition for steel, but deployment of green hydrogen infrastructure will be a slow process. Also, the steel sector will have to compete with other sectors for use of hydrogen, such as transport, other industrial processes, and power generation.

1.48. The development timeframe for hydrogen DRI projects is long at approximately 10 years from project scoping to commercial production given the significant technical challenges faced. Therefore, a large number of projects would need to be in development today in order for hydrogen DRI to have a material impact on European BF-BOF production within the next 20 years.

1.49. As a result, in our base case, we consider there to only be a modest role for hydrogen in steelmaking in the 2021-2049 timeframe. We have included the Hybrit project's likely impact on demand in Sweden and

Finland, and the ArcelorMittal project in Spain, but these are the only countries where specific projects have been included.

1.50. Another new technology that has captured some interest in the steel industry is Molten Oxide Electrolysis (MOE). The MOE process involves electrolytic reduction of molten iron ore, heated to over 1,500°C. The process is being developed by Boston Metals, a pre-production company that was founded in 2012. The technology currently remains unproven outside of a laboratory setting and is many years from commercial production. As a result, we do not include the integration of the technology in our base case steel production forecasts.

Carbon Capture and Storage (CCS)

1.51. Achieving a low-carbon future requires not just carbon avoidance, but also carbon removal, especially through carbon capture and storage (CCS). The world has been experimenting with CCS for many decades, yet the roll-out has been very slow. In 2019, the world emitted around 33 gigatonnes (Gt) of CO_2. The current CCS projects in operation are capturing just a fraction of that, about 40 Mt of CO_2 annually. This low presence is due to both technical barriers and a lack of commercial incentive. CCS can be applied in power generation, natural-gas processing, refining, cement, hydrogen reforming, chemicals and metals smelting, as well as other industries.

1.52. There are three main processes relevant to the steel industry, each with their own complexities:

1. **Pre-combustion**: A gas mix of hydrogen and carbon monoxide (CO) is processed converting the CO into CO_2. The CO_2 is then removed using solvents.
2. **Post-combustion**: Sulphur and nitrogen-based gases and any trace metals need to be removed. The residual flue gas is then heated and treated with solvents, releasing CO_2.
3. **Oxy-combustion**: Enriching the fuel-burning process with oxygen gives a higher concentration of CO_2 in the flue gas.

1.53. The carbon is stored in the many depleted oil and gas fields, with the CO_2 transported by pipeline. The Global CCS Institute believes that there is almost 400 years' worth of storage capacity at today's level of annual emissions – more than enough to meet the Paris climate targets. Geological stability is critical among the environmental criteria for carbon storage to work. There are also long-shot contenders for storage – such as low-grade coal seams and saline reservoirs.

1.54. The concept of CCS has been understood for a long time, but has not been significantly developed primarily because it is very expensive. Wood Mackenzie believes that 68 CCS projects have started and terminated, primarily because of the high costs. Costs vary significantly, because no project is the same, and much of the technology is proprietary. Instead, we look at 'cost of CO_2 avoided' – the carbon price that makes a project economic. We estimate that a minimum carbon price of US$100/t is needed for most applications in the steel industry, about two times today's traded price in Europe. It is clear that costs need to come down for development to accelerate. R&D will help, as will, in time, scale and a modular, standardised approach. But CCS also needs fiscal support – as with tax credits in the US recently – and it also needs access to low-cost financing, so investors can generate an adequate return on equity.

1.55. As well as costs, there are some technical restraints regarding CCS in steelmaking. An integrated iron and steel mill has multiple flue gas stacks (hot blast stove, lime kiln, cogeneration plant) as well as units producing combustible gases (coke oven, blast furnace, basic oxygen furnace). These streams contain different concentrations of CO_2 and therefore a decision needs to be made from which location/s to directly capture the CO2.

1.56. At present, such a high level of capture efficiency is not considered to be practically possible. BF gas emissions are "dirty". The carbon is mixed with other gasses and is very difficult to separate. ArcelorMittal thinks it can reduce emissions by 30% via its Smart Carbon project. Smart Carbon is a project where a carbalyst® plant captures carbon from blast furnace top gas and converts it to ethanol for use as a biofuel. Smart Carbon is expensive – adding about 30% to current steel production costs. As capture rates increase, the cost rises exponentially with climbing difficulty.

1.57. A further challenge is having a feasible carbon storage location. A proven storage method is the use of sedimentary basins (old oil and gas fields); but these are not always situated close to steel production sites, so transportation becomes an issue. Other options for carbon storage are to use unminable coal seams (which are logistically complex) and saline reservoirs (the use of which is relatively unproven).

1.58. While major steelmakers including Tata Steel and ArcelorMittal have announced plans to invest in CCS, its use in steelmaking is negligible at present. Nonetheless, CCS is a proven technology that has been in existence for decades. Costs are expected to decline going forward, which will support a large increase in its use in steelmaking in the future.

1.59. We expect that steelmakers will continue to invest in CCS, which will support the continuation of BF-BOF steel production in Europe.

Assumptions Comparison to the UK's Sixth Carbon Budget

1.60. Wood Mackenzie has reviewed the assumptions underpinning the decarbonisation pathway of the UK steel industry in the UK's Sixth Carbon Budget and compared them to our own assumptions to forecast UK steel production in the next 20-30 years.

1.61. On page 128, the UK's Sixth Carbon Budget Report states that "CCS is applied to… half of the UK's integrated steelwork capacity." (by 2035). Wood Mackenzie's base case forecast assumes that CCS is applied to between 30-40% of UK steel production by 2035.

1.62. The main assumptions underpinning Wood Mackenzie's base case forecast are:

- Steel mills in the UK are able to reduce carbon emissions through efficiency improvements (without the use of hydrogen) by 6% over the 2021-2035 period.
- Without the use of CCS, UK blast furnaces emit 8.6 Mt CO_2e in 2035, while EAFs emit 0.6 Mt CO_2e.
- The use of CCS reduces emissions by 2.8-3.7 Mt CO_2e in 2035, equivalent to 30-40% of steel emissions.
- UK BF-BOF-based steel production remains broadly stable at ~5 Mtpa in the 2021-2035 period.

1.63. The Report also states that "*CCS (carbon capture and storage) reduces manufacturing emissions in the Balanced Net Zero pathway by 6MtCO_2e per year in 2035, increasing to 9MtCO_2e by 2045*". Wood Mackenzie assumes that CCS reduces steelmaking emissions by between 2.8-3.7 Mt CO_2e in 2035 and between 2.5-3.3 Mt CO_2e in 2045.

1.64. Wood Mackenzie's assumptions around CCS usage in UK steelmaking are more conservative than those used in the Sixth Carbon Policy Report. Indeed, even assuming a lower usage of CCS in steelmaking, BF-BOF production in the UK is forecast to remain broadly stable over the long term.

Conclusions

1.65. The period to 2049 will see enormous progress on global decarbonisation and the steel sector will not be immune to this change. However, the reliance on high-temperature smelting to provide most of the iron used to make steel means it is a hard-to abate sector that will rely on new technologies for deep decarbonisation. Given the scalability and cost challenges, long project lead times and the lack of projects in development, our assessment that the impact of "green steel" is likely to be limited and cautious approach should be taken is both robust and realistic. Accordingly, we have directly limited the impact on coking coal from hydrogen DRI to a few European countries in the period to 2049. We also expect the availability of inexpensive and ample green hydrogen will have a more widespread impact on PCI coal usage, as hydrogen co-firing grows globally, post 2035. PCI coals are not coking coals but are used by steelmakers as a coke replacement in BF production to provide energy and lower costs.

1.66. The key assumptions regarding decarbonisation routes in our base case steel production forecast are as follows:

• Co-injection of H2 with PCI occurs in all major steelmaking countries from in the mid to late 2030s, gaining momentum into the 2040s. Injection swaps in Europe begin in the late 2020s to early 2030s. Depending on green hydrogen availability, hydrogen injection shares range from 10% to 100% by 2049.

1.67. We consider hydrogen replacement of PCI is likely to occur at a faster pace than hydrogen DRI. Capex to inject hydrogen is much lower and can still provide tangible emissions savings. A project to replace PCI with grey hydrogen (hydrogen derived from methane) and ultimately green hydrogen is making headway at

Duisburg, Germany and we expect its technical feasibility will be confirmed in 2022 under a full-tuyere injection testing phase. Using the current EU carbon prices of around US$50/t as an incentive to swap using grey hydrogen – which have been seen in Europe this year – we consider the use of green hydrogen to be uncompetitive. Prices for green hydrogen need to drop to the US$1/kg range and carbon prices rise over US$100/t to incentivise a switch from a pure economics standpoint. We expect green hydrogen prices to continue to decline over the decade in Europe, as the market develops in Germany specifically. It suggests that some PCI replacement is likely in Europe this decade and into the early 2030s.

• Greater scrap availability globally will allow EAFs to cover most of the net new steel demand to 2049. This is the primary decarbonisation strategy employed.

1.68. Scrap will play an increasing role in steel production under our base case. Given the lower energy intensity of scrap, its greater use in BF-BOF and EAF steelmaking is inevitable. However, its use will be constrained by a lack of availability, as well as quality restrictions. In our base case, global scrap use grows from 636 Mt in 2021 to 778 Mt by 2040 and over 900 Mt in 2049. Despite the growth in scrap rates, we expect scrap to provide only 36% of metallics demand in the steel sector by 2049, up from 29% in 2021. Steel demand and metallics (Fe) demand will reach 2.3 Bt and 2.5 Bt respectively by 2049. This means that virgin iron will be required to meet over 1.6 Btpa by 2049, slightly up on the 1.5 Bt produced today. There is potential for scrap availability to be higher, but there are significant challenges to increase recycling and collection rates, which are unlikely to exceed 90% even in mature economies in Europe. In addition, there are technical limits to the use of scrap in the production of high-quality steel products, which cannot tolerate feedstock impurities (e.g. for use in the automotive sector).

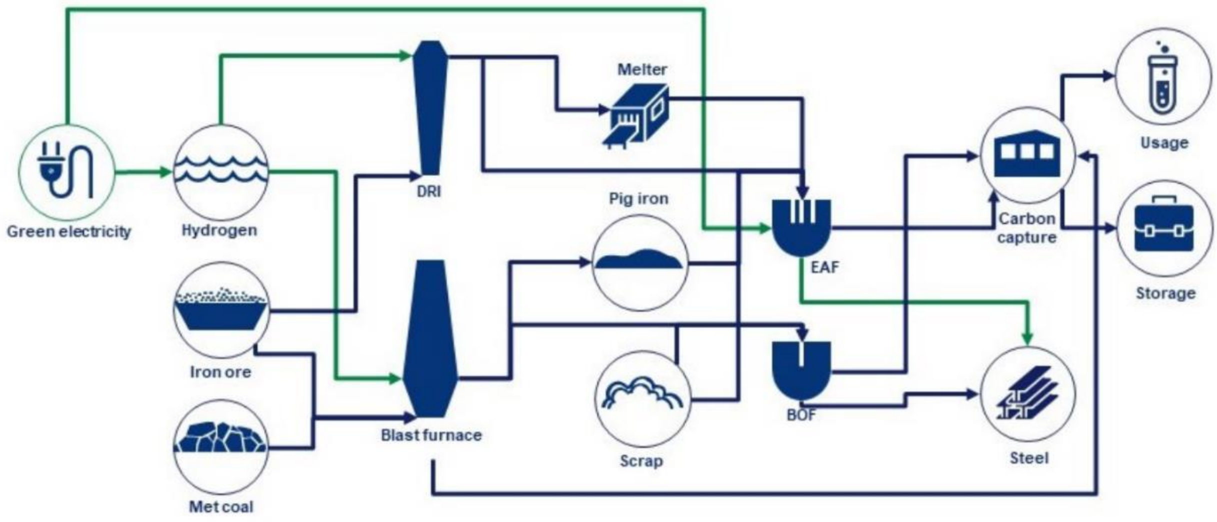
• Hydrogen-based DRI production is limited to specific projects in three EU countries in our base case.

1.69. While technically feasible, there are numerous hurdles to overcome to make widespread green hydrogen use a reality. Green hydrogen must be produced using electrolysers which split distilled water into hydrogen and oxygen. To produce a sufficient quantity of green hydrogen to decarbonise the steel sector would require hundreds of gigawatts of electrolyser capacity. At the end of 2020, there was only about 250 MW of electrolyser in existence, meaning over a 1,000-fold expansion would be required, specifically dedicated to steel production.

1.70. Despite the calls to decarbonise, the global steel industry’s response remains slow in its approach to net zero carbon emissions. Decarbonisation of the broader electricity system, proper carbon pricing incentives, favourable government policy, electrolyser scalability and cost challenges are a few of the hurdles which need to be cleared to make this option a reality. These constraints along with the huge investment required to build DRI and EAF facilities, scrap availability and hydrogen transport infrastructure weigh heavily on any shift away from fossil fuel derived steel. Europe leads all current efforts in the move towards green steel and the advancement of green hydrogen markets, but tangible results are unlikely within the next 20-30 years, beyond PCI replacement.

1.71. There is no holy grail for emission-free steelmaking and European steelmakers are exploring several options. Ultimately, we expect the majors to adopt a hybrid-style set-up, with DRI, EAF, BF and BOF facilities on the same site, and the ability to switch the steelmaking route between the lowest cost option, taking into account the cost of carbon, scrap, iron ore, coke and others at any given time. CCS will play a role in the coming years. BF-BOF production in Europe will decline in the next 20-30 years, albeit marginally, and the region will remain a significant coking coal market. European metallurgical coal demand is forecast to remain between 50-55 Mtpa in the 2021-2049 period, which provides a large target market for West Cumbia Mining’s product.

Figure 1.10: Idealised hybrid steelmaking process



Source: Wood Mackenzie

Metallurgical Coal Demand Scenario Analysis

1.72. In this section, we explore an alternative scenario, beyond our base case, whereby the steel industry successfully follows a two-degree warming pathway – called the Wood Mackenzie Accelerated Energy Transition 2.0 scenario (AET 2.0).

1.73. We have explored the varying options to BF-BOF steel production as well as the new technologies slowly being adopted by the steel industry. In our base case we have the underlying assumption that scrap use, incorporation of EAFs and operational efficiencies will form the bulk of decarbonisation strategies at most mills during the period to 2040.

1.74. In the AET2.0 scenario, steel demand remains unchanged from the base case view. However, it is assumed that carbon emissions from the steel sector must fall by 47% by 2040. For this to happen, steel production methods must change in the following ways:

- **Scrap use in steelmaking needs to nearly double**
- **Direct Reduced Iron production and use must double**
- **Global average Electric Arc Furnace emissions intensity must fall by 40%**
- **BF-BOF emissions intensity needs to fall by 15%**
- **30% of the residual carbon emissions must be captured and stored or used (around 325 Mtpa)**

1.75. The following charts (Figures 1.11 and 1.12) illustrate the outlook for global hot metal production and metallurgical coal demand to 2040 under this scenario.

Figure 1.11: Global hot metal production, 2021-2040 (Mt)

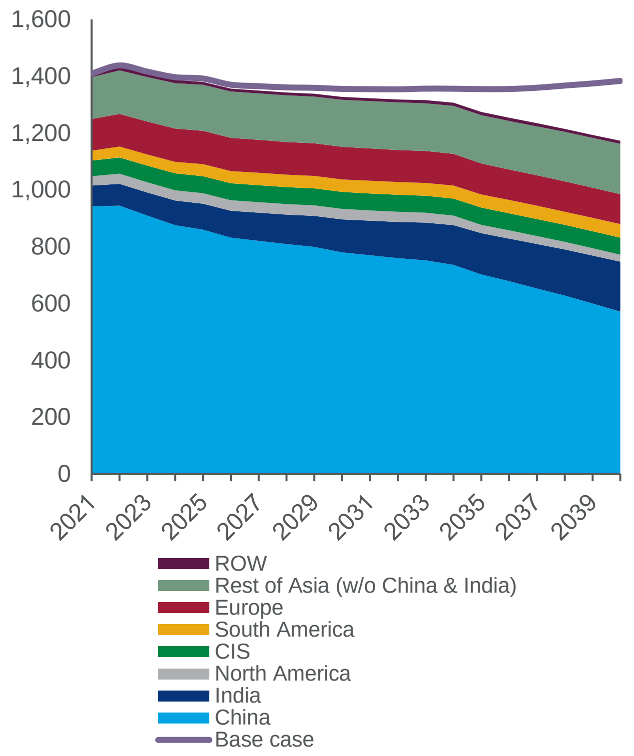
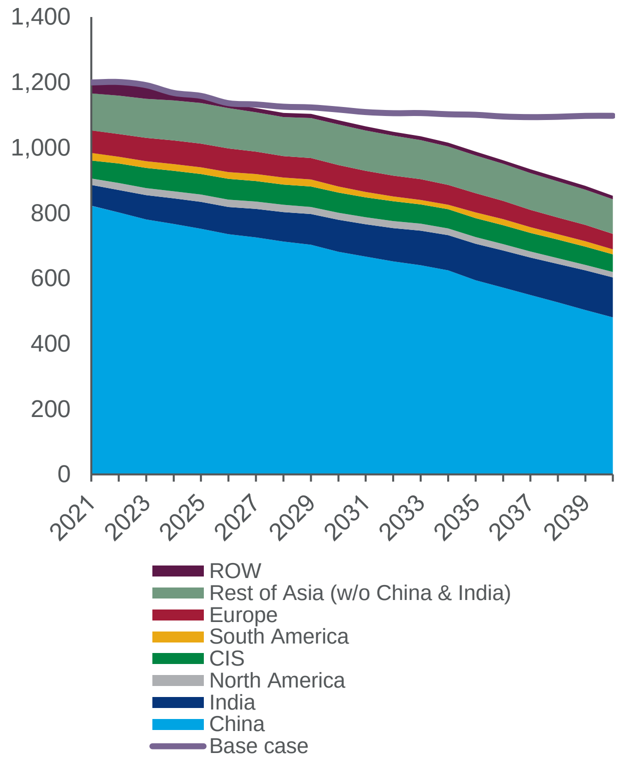


Figure 1.12: Global met. coal demand, 2021-2040 (Mt)



Source: Wood Mackenzie

1.76. The steel industry achieving a two-degree warming pathway has would have significant implications for metallurgical coal demand.

- Overall global hot metal production would be 286 Mt lower than our base case by 2040 as significant scrap-based EAF and hydrogen DRI-EAF production displaces BF-BOF production.
- Total metallurgical coal demand would be 245 Mtpa lower in 2040 compared with our base case. Most of the demand decline occurs from the late 2030’s onwards.
- In Europe, total metallurgical coal demand would fall from 85 Mt in 2021 to 60 Mt in 2040, a fall of ~30%. Most of the decline fall occurs between 2030 and 2040.

1.77. Under the AET 2.0 scenario, the reduction in European metallurgical coal demand is significant at ~25 Mt. However, even under this extreme scenario, Europe remains a large metallurgical coal market by 2040 at 60 Mt; therefore, there would still be a large target market for West Cumbria Mining’s coal.

1.78. It is important to emphasise that the AET 2.0 scenario diverges a long way from our base case outlook. The challenges to successfully decarbonise are immense and overcoming them will entail huge capital outlay, technical collaboration and development. Furthermore, steel will be heavily reliant on external factors – most significantly the decarbonisation of the power grid.

2. Competitive Analysis

2.1. The objective of this chapter is to assess the competitive position of the Woodhouse mine. We provide analysis of the quality of the coking coal that will be produced by West Cumbria Mining and compare the operating costs of the mine to competing suppliers in the global seaborne metallurgical coal market. We assess the extent to which production of coking coal at Woodhouse will displace supply from existing international suppliers and analyse whether the development of the mine could potentially delay the penetration of EAF steel production and other emerging steelmaking technologies in Europe.

Coal Quality Analysis

Key Coking Coal Quality Parameters

2.2. In the international coal market, metallurgical coals are typically categorised by their coking properties, in particular, the strength of the coke the coals produce. Only a limited range of coals – specifically bituminous coals that exhibit plasticity and swelling – produce good quality cokes.

2.3. The common metallurgical coal classifications in the international market are:

- **Hard Coking Coals (HCC)** are essential for the production of a strong coke when using coke ovens and generally have the ability to make a strong (or hard) coke when coked on their own. These coals are often classified based on volatile matter content (high, medium, and low) and are typically blended with a number of other coking coals to produce high-quality coke. HCC are the highest priced coals on the market, given their relative scarcity and prized value-in-use[1] .

- **Semi-Soft Coking Coals (SSCC)** do not produce a strong coke when coked alone. They have weak coking properties and are commonly added to the coke oven blend to reduce the overall cost of the coke. There is a limit to the proportion of semi-soft coking coal that can be added without coal pre-treatment prior to coking.

- **Pulverized Coal Injection (PCI) Coals** are used for direct injection into the blast furnace. They fall into two categories: 1. High volatile matter (HV), low rank bituminous coals (including semi-soft coking coals) and 2. semi-anthracite. Higher rank coals such as semi-anthracites, with high energy and high fixed carbon contents, are the most efficient in this application and have significantly increased their share of the PCI market.

2.4. The following diagram and table (Figure/Table 2.1) outlines the key quality parameters of metallurgical coal. Globally, seaborne coals have broad quality ranges. Some parameters such as sulphur have fixed maximum percentages, while phosphorous (a contaminant) is accepted in Chinese mills at higher levels than by Japanese steelmakers. Product usage is determined chiefly by the customers' plant parameters and the other coals being used in the blend. In addition to the CSN and CSR tests, a wide number of other standardised tests are undertaken on coking coals and coke.

2.5. It is rare for steelmakers and coke producers to charge a single coking coal into a coke oven. Most companies blend high-volatile coals with low-volatile coals and target a blend volatile matter in the mid 20s%. A single coal will not possess all of the properties required to produce coke suitable to meet blast furnace specifications for properties, including ash, sulphur, phosphorus, CSR, etc. Low-volatile coals provide most of the coke strength, while high-volatile coals allow good blending and porosity to the coke.

[1] Different types and qualities of metallurgical coal will be priced depending on their characteristics. That is, depending on how the coal performs in a blast furnace in terms of its impact on productivity, energy consumption and the quality of steel produced. The discounts or premiums received for metallurgical coal products are referred to as "value-in-use" adjustments.

Figure 2.1: Key coking coal parameters

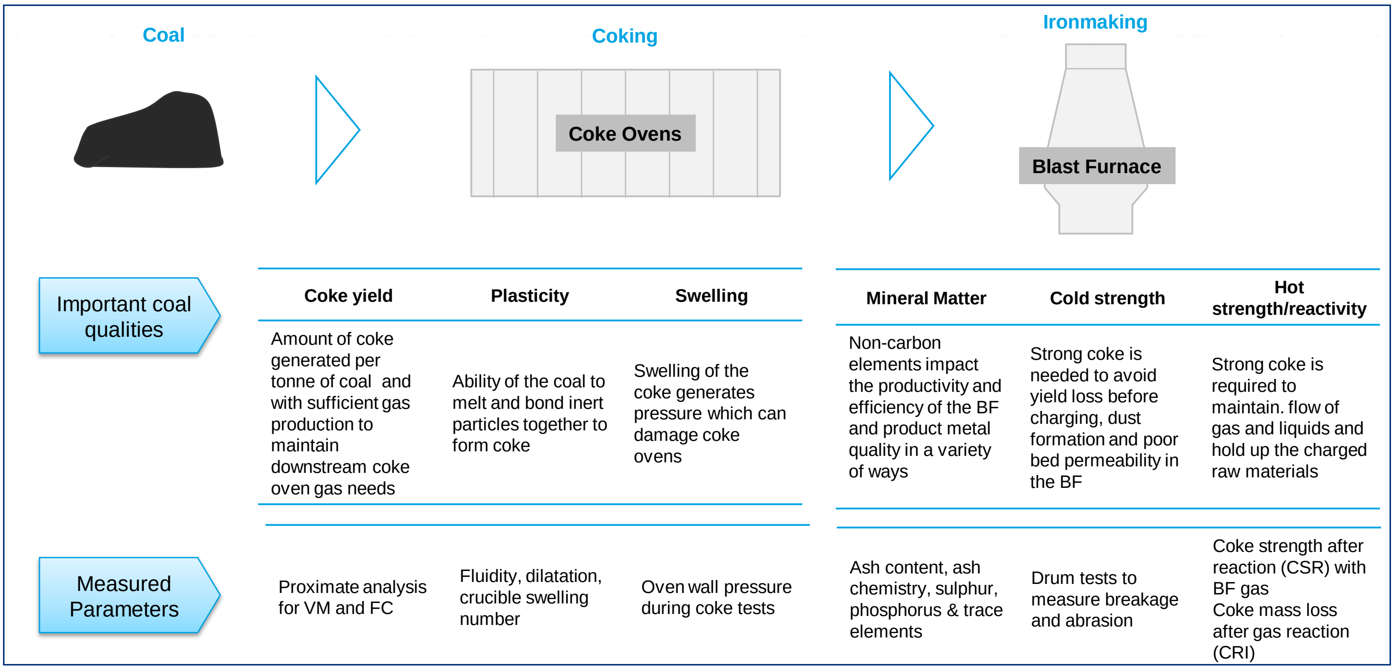


Table 2.1: Key metallurgical coal quality parameters

Parameter	Definition	Significance
Total (TM) and inherent (IM) moisture	TM is the moisture in the coal as sampled and removable under standard conditions and comprises both inherent and free moisture; IM is the moisture bound within the coal pores or chemically attached to the organic coal matter.	Moisture is a costly dilutant, as it consumes heat from the furnace during combustion, and increases freight costs; high moisture levels often results in handling problems.
Volatile matter (VM)	VM is the gaseous component of the coal (excluding moisture) that is released when the coal is heated; it is mainly comprised of methane and other light hydrocarbons.	Volatile content divisions comprise the most fundamental market groups in coking coal. Volatile content indicates the rank of a coal, which varies from peat to anthracite.
Ash	Ash is the inorganic residue remaining after coal has been combusted. Ash is comprised of mineral matter either bound within the coal matrix or of insufficient thickness to economically extract during the mining process. Ash can be removed by washing the coal and lowering the mining yield, however washing high-ash coals significantly adds to costs.	Coals with a low ash content are preferred. The typical seaborne coals have ash contents between 9% and 10%. US coals are lower in ash, usually in the 7% to 8% range, than Australian coals.
Fixed carbon (FC)	FC is the solid residue (excluding ash) remaining after the volatile matter has been released.	FC content gives a rough estimate of coke yield.
Total sulphur (TS)	TS comprises both an organic component that is part of the carbonaceous material, and an inorganic component that is part of the mineral matter; forms sulphur oxides during coal combustion.	Sulphur is an unwanted contaminant, which makes steel brittle. Sulphur in coke should not exceed 0.7%, However, it can be removed in the hot metal side of the blast furnace.
Phosphorous (P)	Phosphorous is contained in ash usually in the form of P_2O_5.	Phosphorous is a contaminant that can causes steel to weaken. It is very difficult to remove.
Hardgrove Grindability Index (HGI)	HGI is a measure of hardness that indicates a coal's relative grindability or ease of pulverization.	Low HGI (hard) coals are more difficult to grind, increasing milling costs. High HGI (soft) coals usually generate excess fines, resulting in handling and higher moisture.
Crucible swell number (CSN)	The CSN is a measure of the coal's ability to swell when heated and is measured as a number between 0 and 9 with 9 being the most reactive.	CSN indicates the reactivity of the coal and its ability to form coke. Hard coking coals have CSN greater than or equal to 7.
Coke strength after reaction (CSR)	The CSR test measures the physical strength of the coke.	CSR is a widely utilised test for seaborne metallurgical coals.
Petrography and reflectance	Petrography is the study of the maceral content of a coal sample. Reflectance is a measurement of the ability of vitrinite to reflect light.	Petrographic analysis is the quantification of the original plant material of the coal. Vitrinite reflectance is a more precise measurement of rank than volatile matter.

Source: Wood Mackenzie

Product Review

2.6. The quality specifications of the coking coal product has been provided by West Cumbria Mining and the key values detailed below (Table 2.2). The product coal quality presents a high-volatile coking coal, which is a well-established product in seaborne trade, especially in the Atlantic market.

Table 2.2: West Cumbria Mining coal quality versus US HV HCC

Specification	Parameter (unit of measurement)	WCM	HVA	HVB
Proximate analysis	Ash (%)	<5	6-10	6-10
	VM (%)	32.0	29-34	34-38
	FC (%)	>61	-	-
	Sulphur (%)	<1.5	0.6-1.3	0.6-1.4
	Phos (%)	<0.005	0.04-0.05	-
Coking & coke properties	CSN	8	7-9	7-9
	Fluidity	30,000	30,000	25,000
	CSR	30-40	50-55	40-50
Rank	Ro. Max (%)	1.02	1.0-1.12	0.90-0.99
Ash analysis	SiO_2	36	49-54	
	Al_2O_3	29	24-29	
	Fe_2O_3	17	6-17	
	CaO	6.5	1.5-1.3	

Source: West Cumbria Mining, Wood Mackenzie

2.7. High-volatile hard coking coals are mainly produced and exported from the Appalachian basin in the eastern US. The products are typified by coal rank around 1.0, with VM between 29 and 38%. Key parameters that denote attractiveness for pricing are extremely high fluidity and usually low ash content (below the typical level of 9-10% for seaborne-traded coking coals). The high fluidity allows the coal to liquefy and act as a binder in a coke blend. The high VM content lowers the yield of solid coke, but provides output gas and liquids, which are captured or processed onsite for sale or recycled at the mill.

2.8. The further categorisation of US high-volatile coal into premium HVA and lower quality HVB is based on maximum reflectance values. High-volatile coals with reflectance values of 1.0 or higher are A coals, while those between 0.90 and 1.0 are B coals. Most coals with reflectance under 0.90 are considered thermal coals, although the exact lower limit varies and can sometimes be as low as 0.85. High Vol A (i.e. high fluidity, low ash and good ash chemistry) are occasionally priced at parity, or even at a premium, to the benchmark Australian LV HCC on an FOB basis.

2.9. Other high-volatile coals in several countries (notably from the Kuzbass and South Yakutiya basins in the Central and Far East of Russia) mostly have lower fluidity and higher ash content, or are only available in small tonnages (such as New Zealand). These coals are largely marketed in Asia. One of the leading traded HV HCC brands in the Asian market is Kestrel, from Queensland, Australia, with sales focused on Japan, South Korea and India. The Gregory brand is sold by Sojitz (34% VM, fluidity of ~7,500 ddpm).

2.10. West Cumbria Mining's coking coal exhibits almost all of the key parameters used to designate HVA quality. Key observations of the coal quality include:

- **Coal type**: The West Cumbria Mining product is equivalent and appropriately benchmarked to US HVA.
- **Ash**: The West Cumbria ash content is below 5%, which is about half of the typical ash content of seaborne traded coals and well under the typical ash content of US HVA coals.
- **Volatile matter**: The VM content of 32% is within the expected range for a high volatile A coal. Volatile matter is an indication of rank.
- **Fluidity**: At 30,000 ddpm, the maximum fluidity is comparable to US HVA coking coals. This is one of the most important quality characteristics of the West Cumbria product. High-volatile coals with strong fluidity in the blend allows steel companies greater flexibility to select other coals to include. It allows the coals to blend better into a good coke. The most common

equipment used to measure fluidity are only able to measure up to 30,000 ddpm (i.e. it is at the top of the range).

- **CSN**: The CSN is the most basic test to determine a coal's ability to form coke. The test values range between 0 and 10, with hard coking coals having values between 7 and 10. West Cumbria has a CSN at 8, which is a good value for hard coking coals.
- **CSR**: CSR is coke strength after reaction and higher numbers indicate the coal would make a strong coke. The CSR of West Cumbria Mining's coal is estimated to be in the range of 30 to 40..
- **Sulphur:** At <1.5%, the sulphur content is higher than the normal spec at coke plants. Using this coal in the blend would require adjusting the overall sulphur content by including other coals with lower sulphur levels. Since most European mills use a portion of Australian coals, which average 0.5% to 0.6% sulphur in the blend, we believe these mills can use West Cumbria Coal in their blends.
- **Phosphorus**: The phosphorus is extremely low, which will help offset the higher sulphur in marketing and price discussions.
- **Ash chemistry**: This is acceptable, with low elements which contribute to coke degradation (Fe2O3, and CaO,).

2.11. The West Cumbria Mining coking coal can be benchmarked against US HV hard coking coal. Currently these coals only represent approximately 26 Mt (approximately 9%) of the seaborne export market, but are well known within the logical European target market for West Cumbria Mining. The coking coal produced by West Cumbria Mining is expected to be a highly marketable product within the European steel market.

2.12. We view the expected sulphur content of West Cumbria Mining's product at <1.5% to be marketable to European steel mills. We believe the typical sulphur spec for steel mills in the region are <1.0%. Therefore, the company would be required to pay a penalty for exceeding that mark. However, most companies use a significant amount of Australian coal in their blends, which have sulphur contents ranging between 0.5% and 0.6%. So, cokemakers should be able to maintain an acceptable overall sulphur level in their blend to produce good-quality coke. The penalty on sulphur would be somewhat balanced by a premium for having extremely low ash and phosphorus content.

Operating Cost Analysis

2.13. This section benchmarks the Woodhouse mine's cash costs relative to competing seaborne metallurgical coal producers. Cash cost curves have been prepared using technical mining cost data provided by West Cumbria Mining combined with Wood Mackenzie's estimates for the other seaborne coal producers.

Costs Methodology

2.14. Wood Mackenzie's *Coal Supply Service* delivers in-depth, independent commercial research and analysis on the global coal industry. We develop capital and operating cash expenditure forecasts associated with our view of reserves and production for an asset or group of assets:

- Capital Costs: These include, exploration and acquisition costs, mining development works, mining equipment, coal handling facilities, coal preparation plants, general infrastructure, transport infrastructure, sustaining capex, any 'other' capital costs, and closure or final rehabilitation costs.
- Operating Cash Costs: These include, mining, coal preparation, product coal transport, port and demurrage charges, overheads and any 'other' charges. Additionally, they include any tariffs paid to other assets for transportation and/or processing production.
- Royalties and levies: These include, coal royalties and leases, export levies, mine safety levies, health levies, environmental taxes, industry research levies.

2.15. The combination of operating cash costs plus royalty & levies is termed the Total Cash Cost. For seaborne exports, the total cash costs are estimated on a Free on Board (FOB Port) basis, the normal point of sale. Costs are modelled based on local currencies.

2.16. The Total Cash Costs have been estimated in current-year terms, using public domain information including; geological reports, reported statistics on production, labour and input costs, and company reports (see 'Research Sources" section). The estimates have been validated, when possible, with visits to operations, and discussions with industry participants.

2.17. The estimates are internally comparable, in that the methodology utilised to produce them is consistent for all operations. However, because the estimates are based only on public information and our analysis, and do not represent private knowledge of an operation's actual costs, there may be deviations from actual costs. In instances where confidential information is held by Wood Mackenzie, it has not been used to produce the published estimates.

Cash Costs Benchmarking

2.18. The following table shows the expected cash cost components for the Woodhouse mine, as provided by West Cumbria Mining. The year 2029 has been selected for the cost benchmarking, which is the first year that the Woodhouse mine will be operating at full production. The mine's direct cash costs at the mine (C1 cash costs) are estimated at US$67.4/t in 2029, while total cash costs are estimated at US$69.6/t (Table 2.3).

Table 2.3: Woodhouse Cash Costs, nominal, 2029 (US$/t)

Component	Value
Mining	40.7
Coal Preparation	5.8
Transport	10.1
Port	4.5
Overheads	6.2
C1 Cash Cost	**67.4**
Royalties	2.2
Total cash cost	**69.6**

Source: Wood Mackenzie

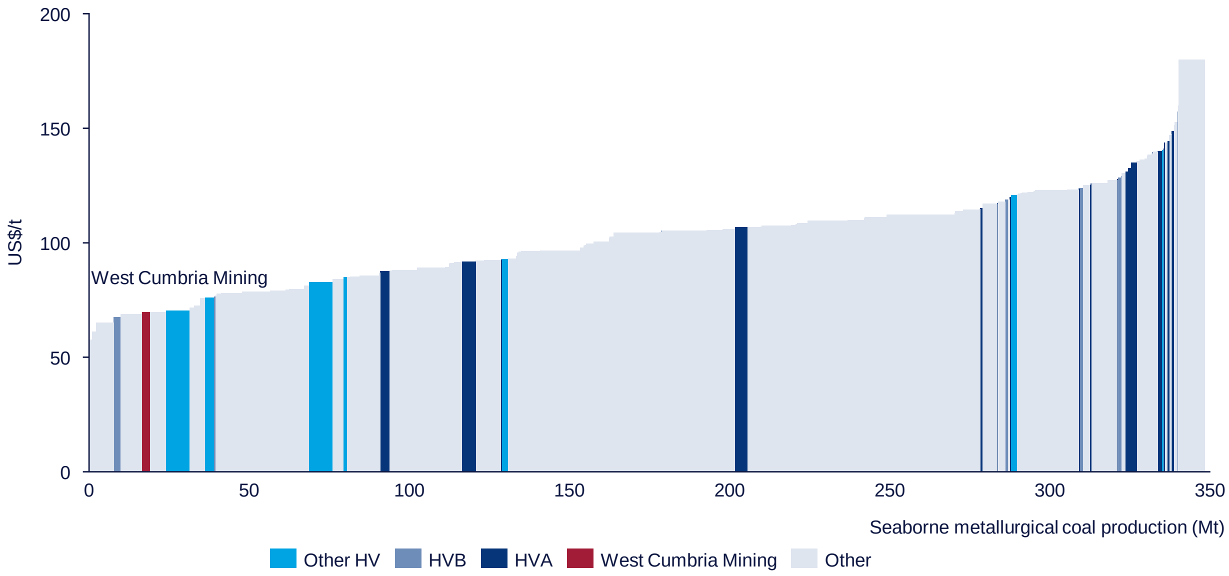
2.19. Wood Mackenzie's 2029 total cash costs (mining, coal preparation, transport, port charges, overheads, royalties) for export metallurgical coal production are shown in the figure below (Figure 2.2). Based on total cash costs of $69.6/t, the mine would occupy a position in the first quartile of global metallurgical production among low-cost producers in Russia and Australia.

2.20. Russia generally has low mining costs, but bears high cost of inland rail transportation. Russian third-party port charges can be high at Far East ports, given the recent focus on Asian markets. However, overall Russian costs have benefited from the weakened rouble against the USD.

2.21. Large open pit mines in Australia are also low cost, as can be highly productive underground longwall operations. Transport charges vary depending on infrastructure ownership and whether new facilities are being used.

2.22. US mining costs are generally high as a result of mining thin seams, with productivity impacted by a high degree of safety and environmental auditing. US transport costs are also generally high as well.

Figure 2.2: Global seaborne metallurgical coal total cash costs curve, FOB, nominal, 2029 (US$/t)



Source: Wood Mackenzie Dataset May 2021, West Cumbria Mining

2.23. The following chart (Figure 2.3) shows the 2029 global seaborne metallurgical coal cost curve on a CIF ARA basis (cost, insurance and freight at Amsterdam- Rotterdam- Antwerp), to assess West Cumbria Mining's cost-competitiveness to European customers. The West Cumbria Mining coal is assumed to be exported from the Redcar Bulk Terminal (RBT) port and shipped to the Netherlands at a freight charge of US$6.29/t. The mine is favourably located at the low end of the CIF ARA cost curve.

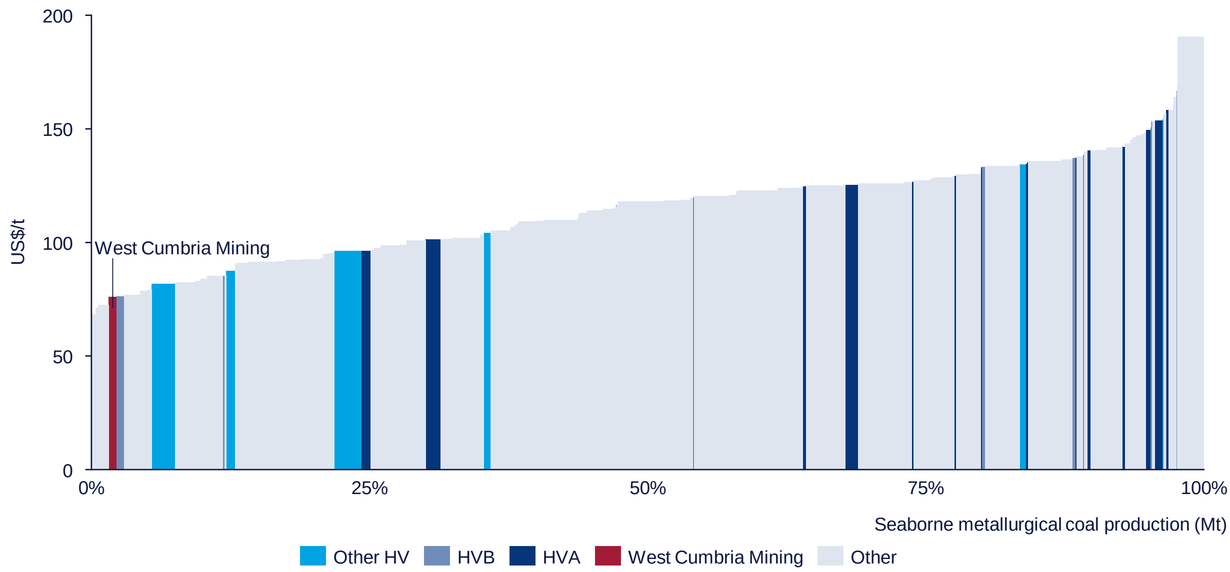
2.24. We also provide the same cost estimates for HV HCC and equivalent mines only, on a CIF ARA basis (Figure 2.4). Given the comparable coal qualities, US producers of HV HCC will be the main competitors for West Cumbria Mining.

2.25. US HV HCC producers are fragmented and generally fall within the third and fourth quartiles on the total seaborne metallurgical cost curve. Arch's Leer mine is the lowest-cost US HV producer, with significant export tonnage (approximately 2.9 Mt at an FOB operating cost of US$75/t).

2.26. Other HV HCC producers outside US, notably Russia and Australia, are lower cost.

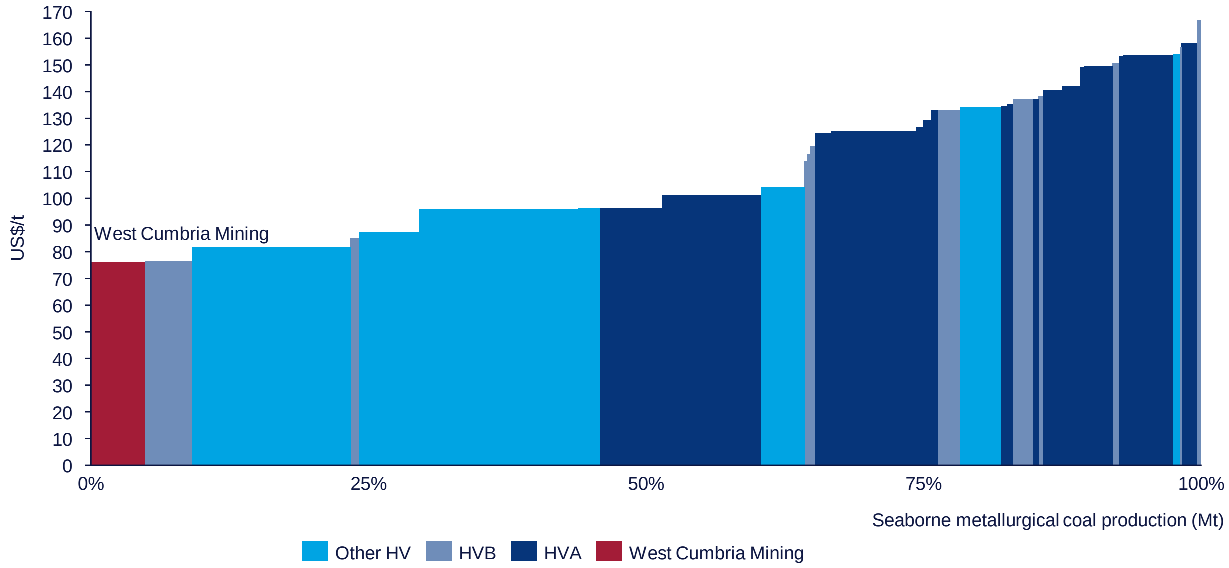
2.27. West Cumbria Mining compares favourably amongst competing suppliers of HV HCC, sitting at the low end of Wood Mackenzie's estimates for all US production, which ranges between ~US$75/t and up to US$165/t.

Figure 2.3: Global seaborne metallurgical coal total cash costs curve, CIF ARA, nominal, 2029 (US$/t)



Source: Wood Mackenzie Dataset May 2021, West Cumbria Mining

Figure 2.4: High volatile hard coking coal total cash costs curve, CIF ARA, nominal, 2029 (US$/t)



Source: Wood Mackenzie Dataset May 2021, West Cumbria Mining

Target Markets and Potential for Substitution

2.28. The main market for West Cumbria Mining coal consists of the integrated (BF-BOF) steel mills in Northern, Western, Southern Europe and Turkey. These countries are selected on the basis that they include the major steel mills, are reliant on imports, and the US is a known supplier of HV HCC. Some of the mills in the addressable markets have dedicated terminals for receiving cargoes, while others, e.g. within Germany, Belgium or Austria, rely more on vessels discharging at the Amsterdam, Rotterdam, and Antwerp (ARA) ports and then river barging to the mill. Key customers within this addressable market include Arcelor Mittal, with plants in France, Belgium, Spain and Germany and Tata Europe, with the mills at Port Talbot in the UK, and

Ijmuiden in the Netherlands.

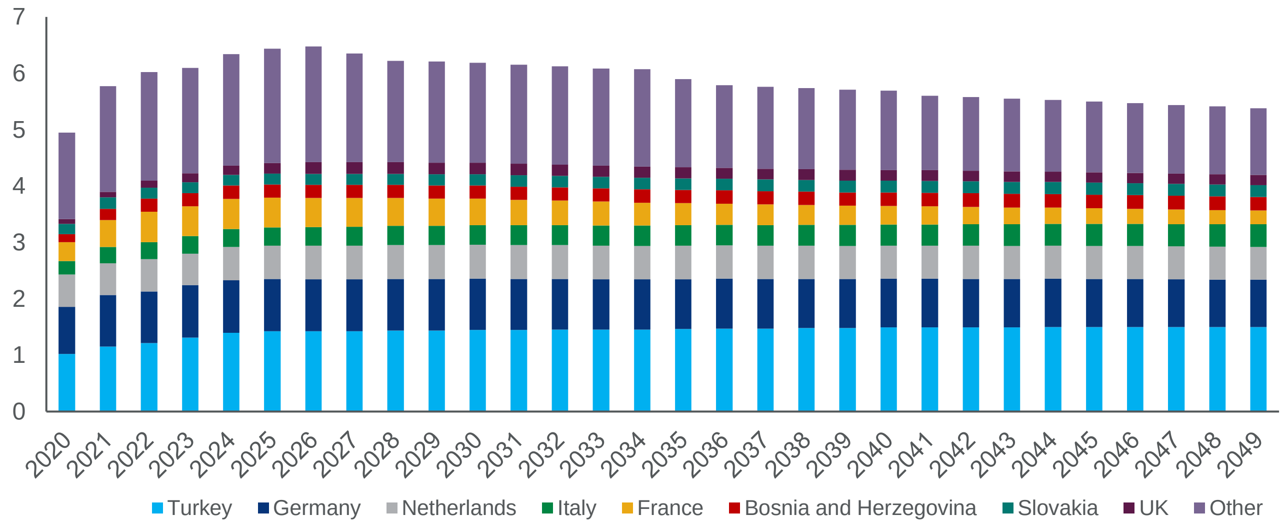
2.29. Steel mills in several other countries are considered as secondary targets, including Hungary, Czech Republic, Slovakia and Bosnia and Herzegovina. These countries are relatively small consumers/individual mills, with nearby domestic coking coal production (Czech Republic) and less accessible to the seaborne market. We expect coking coal production from the Czech Republic will end in 2023. However, offtake potential may still exist, if particular coal types offer value to the customer blend compared to their domestic or landborne options.

2.30. There are also other opportunities for West Cumbria Mining coal, including as feedstock into the specialist ferro-alloy market.

2.31. In order to refine the addressable market size for West Cumbria Mining, Wood Mackenzie has compiled estimates of the HV coking coal contribution in the addressable market countries, compiled primarily using trade statistics. The observed average is around 20%, however individual plant blend references are believed to range from zero to 25%. TKS and Salzgitter, with mills in Germany, have a very low volatile percentage blend and do not typically use high-volatile coals.

2.32. Wood Mackenzie estimates the HVA coking coal addressable market to be between 5-6 Mtpa over the 2021-2049 period. This is a competitive market, but given that most, if not all, of the current supply is coming from US producers, we consider that West Cumbria Mining is in a good strategic location to capture market share to allocate all of its saleable coal within the addressable market. Figure 2.5 shows Wood Mackenzie's estimate of the HVA demand for Europe, by country.

Figure 2.5: West Cumbria Mining's HVA coking coal addressable market, 2020-2049 (Mt)



Source: Wood Mackenzie

2.33. West Cumbria Mining's coal is expected to be marketable in Europe, given that there is significant demand for HVA HCC in the region. The likely role of the coal (as with all coking coal) is as a blend component and, therefore, West Cumbria Mining's coal would displace a proportion of the overall coking coal required by each steelmaker.

2.34. The Woodhouse mine is expected to be cost-competitive in the European market, benefiting from relatively low freight charges. As a result, West Cumbria Mining is expected to take market share from high-cost US HV HCC producers that currently supply the region. European seaborne coking coal demand is forecast at 53.9 Mt in 2029. Once at full production of 2.7 Mtpa, West Cumbria Mining is expected to obtain a 5% share of the European seaborne coking coal market.

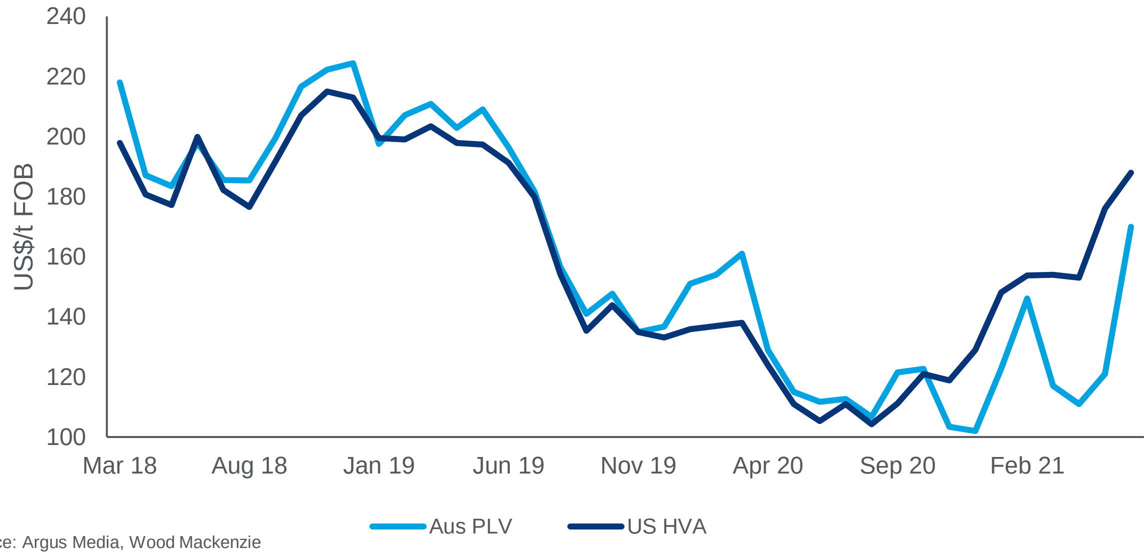
Impact of the Woodhouse Mine on the European Steel Industry

2.35. In this section, we analyse the potential impact of the Woodhouse mine development on the European steel industry, in particular, whether production of coking coal in the UK will slow down the transition towards a greater level of EAF steel production or other low-carbon steel production processes. The analysis focuses on the likelihood of Woodhouse significantly reducing coking coal procurement costs for European BF-BOF steelmakers and, therefore, increasing the cost-competitiveness of BF-BOF production relative to EAF production and other processes.

2.36. Low-volatile coal is considered the most important component of coking coal blends, due to its ability to provide strength to the coke. Furthermore, low-volatile coal has a higher carbon content than high-volatile coal and, therefore, produces more coke per tonne of feedstock. As a result, the price for low-volatile coal sets the international benchmark for traded coking coal. The primary benchmark is the FOB Australia premium, low-volatile hard coking (PLV HCC) spot price. All other coking coal types are priced at differentials relative to the benchmark PLV HCC price.

2.37. The following chart (Figure 2.6) shows the trend in the Australian PLV HCC and US HVA prices in the last few years. Between March 2018 and September 2020, the HVA price was discounted to the Australian PLV HCC price by 3% (US$7/t) on average. Since October 2020, China has banned imports of Australian coal, and, given the resulting change in trade flows, the relativity has reversed with US HVA selling at a premium to Australian PLV HCC price. While the timing is uncertain, we expect China will recommence imports of high-quality coking coals from Australia over time, which will result in a return of the Australian PLV HCC premium over the US HVA price.

Figure 2.6: Australian premium, low-vol hard coking coal and US High Vol A coking coal prices, FOB, 2018-2021 (US$/t)



Source: Argus Media, Wood Mackenzie

2.38. The commissioning of the Woodhouse mine, which will produce HVA-quality coal, is expected to have minimal impact on the PLV HCC spot price. However, development of the mine would increase supply of low-cost HVA coal into the European market, which could lead to a larger HVA discount to the PLV HCC price.

2.39. Historically, the maximum discount of the US HVA price to the PLV HCC price has been valued at ~15%, outside of times of serious supply disruption (e.g. Australian cyclones). To assess the potential change in European BF-BOF steelmakers' costs as a result of the development of Woodhouse, we have assumed that the US HVA price would be discounted to the PLV HCC price by 15%, while the US HVB price would be discounted by 20%. While this is not Wood Mackenzie's base case forecast, the assumption is used to quantify the maximum impact on steelmakers' costs. The assumed discounts can be interpreted as a low-case scenario for US HVA and HVB prices relative to Wood Mackenzie's base case PLV HCC price forecast.

2.40. In terms of the pricing of the West Cumbria Mining's coal, Wood Mackenzie estimates that the product will achieve a net penalty of US$3.7/t relative to the US HVA price – the West Cumbria coal is expected to achieve a premium of US$4.0/t over US HVA for the low ash content, but would incur a penalty on the high sulphur content of US$7.7/t.

2.41. The following table (Table 2.4) shows a hypothetical coking coal blend for a European steelmaker. It's important to note that blends vary significantly between plants due to different blast furnace targets, while blends also change due to market conditions and coal availability. The coking coal blend shown comprises US HVA, US HVB, US low-vol, Australian tier-2 HCC, Australian low-vol coals and semi-soft/semi-hard coking coals. In this first case, the Woodhouse mine is not included in the coking coal blend. The table includes Wood Mackenzie's price forecasts for the coals in 2029 shown in Real terms, on an FOB and CIF ARA basis. The average price of the coking coals purchased is US$140.5/t.

Table 2.4: Hypothetical European steelmaker coking coal blend, excluding West Cumbria Mining coal

Coal type	Coal blend %	WM FOB price forecast, 2029 (US$/t)	Vessel charge (US$/t)	WM CIF Europe price forecast, 2029 (US$/t)
US HVA	14	136.0	9.0	145.0
US HVB	6	116.0	9.0	125.0
Australian Tier 2 HCC	25	120.0	12.8	132.8
US LV	15	138.0	9.0	147.0
Australian PLV/PMV	30	139.0	12.8	151.8
Other (Semi-soft, semi-hard)	10	107.0	12.8	119.8
Average coal price (US$/t)				**140.5**

Source: Wood Mackenzie

2.42. The following table (Table 2.5) shows a different coking coal blend, which includes 5% West Cumbria Mining coal and a lower proportion of US HVA coal at 9%. The proportions of all other coal types are the same as in the previous blend. In this scenario, coking coal production at Woodhouse results in a maximum reduction of the US HVA price from US$136/t to US$118/t and a maximum reduction in the US HVB price from US$116/t to US$111/t. As a result, the average price of the coking coals purchased is US$137.4/t, representing a fall of US$3.1/t, compared to the coking coal blend excluding West Cumbria Mining coal.

Table 2.5: Hypothetical European steelmaker coking coal blend with 5% West Cumbria Mining coal

Coal type	Coal blend %	WM FOB price forecast, 2029 (US$/t)	Vessel charge (US$/t)	WM CIF Europe price forecast, 2029 (US$/t)
US HVA	9	118.2	9.0	127.1
US HVB	6	111.2	9.0	120.2
WCM HV	***5***	***114.5***	***6.3***	***120.7***
Australian Tier 2 HCC	25	120.0	12.8	132.8
US LV	15	138.0	9.0	147.0
Australian PLV/PMV	30	139.0	12.8	151.8
Other (Semi-soft, semi-hard)	10	107.0	12.8	119.8
Average coal price (US$/t)				**137.4**

Source: Wood Mackenzie

n.b. The price of the West Cumbria Mining coal reflects a US$3.7/t discount to the HVA price. The HVA and HVB prices are assumed to be discounted to the PLC HCC price by 15% and 20% respectively following the development of the Woodhouse mine.

2.43. The following table (Table 2.6) shows an alternative coking coal blend that uses 20% West Cumbria Mining coal and no US HVA or HVB coal. The same price assumptions for West Cumbria Mining coal, US HVA and US HVB are used as in the 5% West Cumbria Mining blend. For this blend, the average price of the coking coals purchased is US$136.8/t, representing a fall of US$3.7/t from the coking coal blend excluding West Cumbria Mining coal.

Table 2.6: Hypothetical European steelmaker coking coal blend with 20% West Cumbria Mining coal

Coal type	Coal blend %	WM FOB price forecast, 2029 (US$/t)	Vessel charge (US$/t)	WM CIF Europe price forecast, 2029 (US$/t)
US HVA	0	118.2	9.0	127.1
US HVB	0	111.2	9.0	120.2
WCM HV	***20***	***114.5***	***6.3***	***120.7***
Australian Tier 2 HCC	25	120.0	12.8	132.8
US LV	15	138.0	9.0	147.0
Australian PLV/PMV	30	139.0	12.8	151.8
Other (Semi-soft, semi-hard)	10	107.0	12.8	119.8
Average coal price (US$/t)				**136.8**

Source: Wood Mackenzie

n.b. The price of the West Cumbria Mining coal reflects a US$3.7/t discount to the HVA price. The HVA and HVB prices are assumed to be discounted to the PLC HCC price by 15% and 20% respectively following the development of the Woodhouse mine.

2.44. The analysis above indicates that following the development of Woodhouse European steelmakers would achieve a maximum cost saving of between ~US$3-4/t on the average procurement cost of coking coal depending on the proportion of West Cumbria Mining coal purchased. Steelmakers use approximately 0.6 tonnes of coking coal per tonne of steel produced and, therefore, the maximum cost saving per tonne of steel would be between US$1.6-2.4/t.

2.45. As a result, the annual cost reduction tor a steel mill with 1.0 Mtpa capacity would be small, at US$1.6 M p.a. to US$2.4 M p.a. That level of cost saving alone is not significant enough to impact a steelmaker's decision to switch from BF-BOF steel production to another process. As a comparison, the capital expenditure to replace a BF-BOF steel mill with a hydrogen-based DRI with EAF capacity is ~US$1 Bn for 1 Mtpa capacity.

2.46. In summary, the cost reduction following the development of the Woodhouse mine would be negligible and likely to have no impact on the cost-competitiveness of BF-BOF steel production in Europe. Therefore, development of the mine will not slow down the transition towards EAF production or other low-carbon steel production processes in Europe in the future.

3. GHG Emissions Analysis

3.1. The objective of this chapter is to benchmark the greenhouse gas (GHG) emissions of West Cumbria Mining's Woodhouse mine against competing international metallurgical coal producers. GHG emissions are benchmarked on a mine site basis, as well as on a delivered Europe basis, to assess the difference in GHG emissions from producing metallurgical coal in the UK compared to importing from international suppliers (e.g. from the US, Russia or Australia). The change in global GHG emissions following the development of the Woodhouse mine is also assessed.

West Cumbria Mining Emissions

3.2. GHG emissions are defined as the seven greenhouse gases covered by the UNFCCC (United Nations Framework Convention on Climate Change) — carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF6), and nitrogen triflouride (NF3). All values in this report are presented in carbon dioxide equivalent (CO_2-e), which is a metric used to compare the emissions of the different greenhouse gases based upon their global warming potential (GWP). Global warming potential (GWP) factors are used to convert greenhouse gases to carbon dioxide equivalent

3.3. Emissions are classified in line with the Greenhouse Gas Protocol's Corporate Standard. This standard defines the three Scopes of emissions, as outlined in the table below.

Table 3.1: Emissions classification by scope

Scope	Name	Description
Scope 1	Direct GHG emissions	Direct GHG emissions occur from sources that are owned or controlled by the company, for example, emissions from combustion in owned or controlled boilers, furnaces, vehicles, mining equipment, etc.; emissions from chemical production in owned or controlled process equipment.
Scope 2	Electricity indirect GHG emissions	Scope 2 accounts for GHG emissions from the generation of purchased electricity consumed by the company. Purchased electricity is defined as electricity that is purchased or otherwise brought into the organizational boundary of the company. Scope 2 emissions physically occur at the facility where electricity is generated.
Scope 3	Other indirect GHG emissions	Scope 3 emissions are a consequence of the activities of the company but occur from sources not owned or controlled by the company. Some examples of Scope 3 activities are extraction and production of purchased materials; transportation of purchased fuels; transportation of products to end-users; and use of sold products and services.

Source: Greenhouse Gas Protocol's Corporate Standard

3.4. The mining, processing and transport of coal are highly mechanised, using fossil fuels in the form of direct combustion and indirectly through electricity consumption, predominately produced off site. The transportation of coal from mines to ports and end-users is dominated by fossil fuel combustion via trains, truck, and barge methods. Transport using electricity comes from rail and conveyor systems.

3.5. The largest emissions component from the coal emissions value chain arises from the liberation of methane during mining. Methane is vented or escapes into the atmosphere, when it is not captured for power generation or sold to third parties. The largest emitters of methane are generally underground mines. Deep seams retain their methane within the deposit; while shallower coal seams at surface mines have generally released most of their methane prior to mining. Methane content is variable between coal mining regions across the globe.

3.6. The choice of mining equipment drives where the scope of emissions resides. Surface mines can use electricity, diesel or a combination of the two to power major earthmoving equipment including shovels and draglines. Underground mines are dominated by electricity to power equipment. The energy mix in a country's electricity grid plays an important role in determining emissions from a mine. In general, the most energy intensive component of surface mining is prime earth or waste movement. The most energy intensive components of underground mines are longwalls/continuous miners along with ventilation and pumps.

3.7. The following table (Table 3.2) shows the emissions data provided by West Cumbria Mining for 2029, which is the first year that the Woodhouse mine will be operating at full production. Emissions are broken down into

Scope 1, Scope 2 and Scope 3 and two scenarios are shown – '*Likely Mitigated'* and '*Worst*' cases. Emissions are shown on an absolute basis (tonnes of CO_2e), as well as on an intensity basis (tonnes of CO_2e divided by tonnes of washed coal production). It's important to note that the emissions data provided by West Cumbria Mining has not been independently validated by Wood Mackenzie.

3.8. The *Likely Mitigated* case has an emissions intensity of 16.27 $kgCO_2e/t$, approximately 80% lower than the Worst case. In the *Likely Mitigated* case, emissions from mining operations and electricity consumption are significantly lower.

Table 3.2: West Cumbria Mining emissions estimates for Woodhouse, 2029

Scenario	Scope	Activity	Absolute Emissions (tonnes CO_2e)	Emissions Intensity ($kgCO_2e/t$)
Likely Mitigated Case	Scope 1	Fuel use on site from mining related equipment	0	0
		Capturable fugitive emissions from mining operations	25,996	9.35
		Company owned vehicles	0	0
		Land Use	-28	-0.01
	Scope 2	Electricity consumption	0	0.00
	Scope 3	Upstream distribution	285	0.10
		Rail distribution	17,241	6.20
		Waste	91	0.03
		Staff travel	1,650	0.59
		Purchased goods and services	0	0.00
	Total		**45,235**	**16.27**
Scenario	**Scope**	**Activity**	**Absolute Emissions (tonnes CO_2e)**	**Emissions Intensity ($kgCO_2e/t$)**
Worst Case	Scope 1	Fuel use on site from mining related equipment	1,005	0.36
		Capturable fugitive emissions from mining operations	191,783	68.99
		Company owned vehicles	24	0.01
		Land Use	-28	-0.01
	Scope 2	Electricity consumption	16,154	5.81
	Scope 3	Upstream distribution	291	0.10
		Rail distribution	17,241	6.20
		Waste	91	0.03
		Staff travel	1,841	0.66
		Purchased goods and services	0	0.00
	Total		**228,403**	**82.16**

Source: West Cumbria Mining

GHG Emissions Benchmarking

3.9. The Woodhouse mine's GHG emissions have been assessed relative to other global metallurgical coal mines using Wood Mackenzie's *Emissions Benchmarking Tool (EBT)*. The objective of the assessments presented in the EBT is to calculate the GHG emissions related to metallurgical coal operations, in line with the Greenhouse Gas Protocol. Wood Mackenzie employed a consistent methodology in the assessment of GHG emissions to enable the comparison of assets, companies, countries and regions on a like-for-like basis.

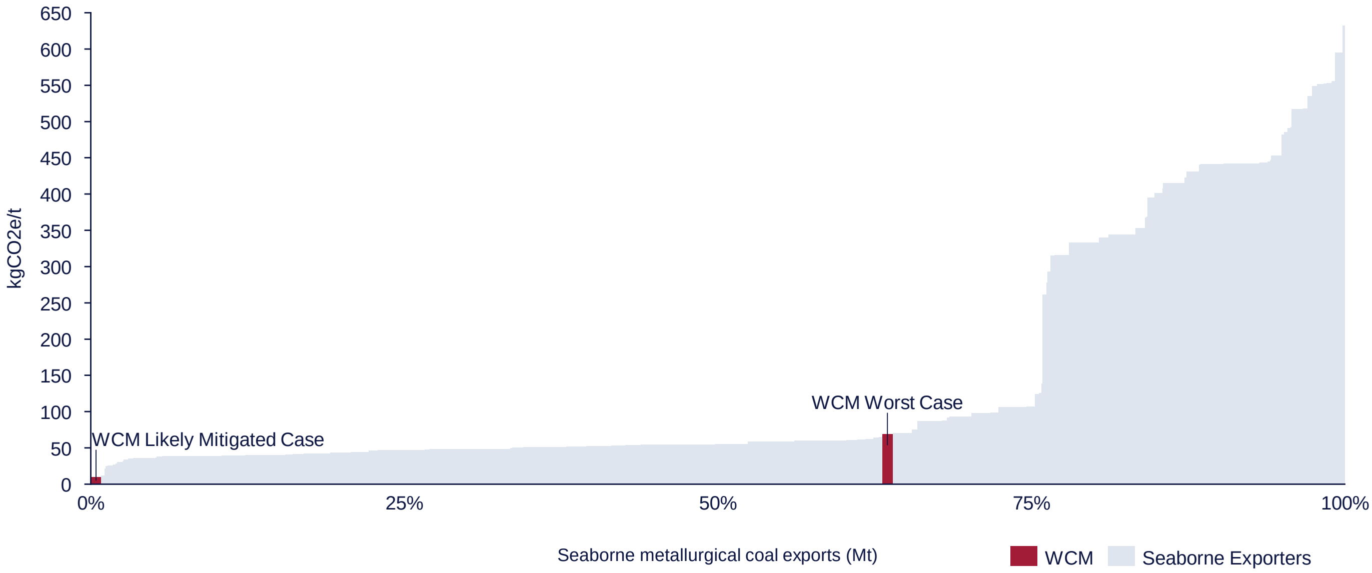
3.10. All companies' emissions assessments are undertaken at the asset level, using ownership and location to combine company- and country-level emissions. All mines' GHG emissions are shown on an unmitigated basis. A three-stage process is employed in the assessment of emissions, as outlined below.

Figure 3.1: Wood Mackenzie's emissions assessment process

1. Definition & Planning	2. Execution	3.Reconciliation
Map Emissions: Identify the main emissions sources for each section of the value chain **Identify Drivers**: Identify drivers of emissions for each section of value chain (e.g. fuel consumption, power consumption) **Map Data**: Highlight data sources in existing models and gaps **Formulate**: Put together formula to calculate emissions	**Research:** undertake bespoke research for populate data gaps and populate, retaining Scope notation **Compile**: Combine bespoke data with existing data and common factors to be used across commodities **Model Emissions**: Apply standardised assessment formulae to full dataset	**Reconcile:** compare results with company sustainability reports **Liaise**: contact with key companies regarding emissions assessment to understand where differences arise **Revise**: Integrate revisions to underlying drivers into input data

3.11. The following chart (Figure 3.2) shows Woodhouse's position on the global seaborne metallurgical coal Scope 1 emissions curve in 2029, which is shown on a CO_2e per tonne of washed coal basis (t CO2e/t). The X-axis shows the seaborne metallurgical coal production volume (on a percentage basis) and the Y-axis shows each mine's emissions intensities. The position of West Cumbria Mining's two emissions scenarios are highlighted. Under the *Likely Mitigated* case, the Woodhouse mine is located at the low end of the Scope 1 emissions curve. Woodhouse is located in the third quartile of the Scope 1 emissions curve in the *Worst* case. However, the emissions intensity is significantly lower than the group of underground mines at the top of the curve, which exhibit Scope 1 emissions intensities of between 300 and 630 $kgCO_2e/t$.

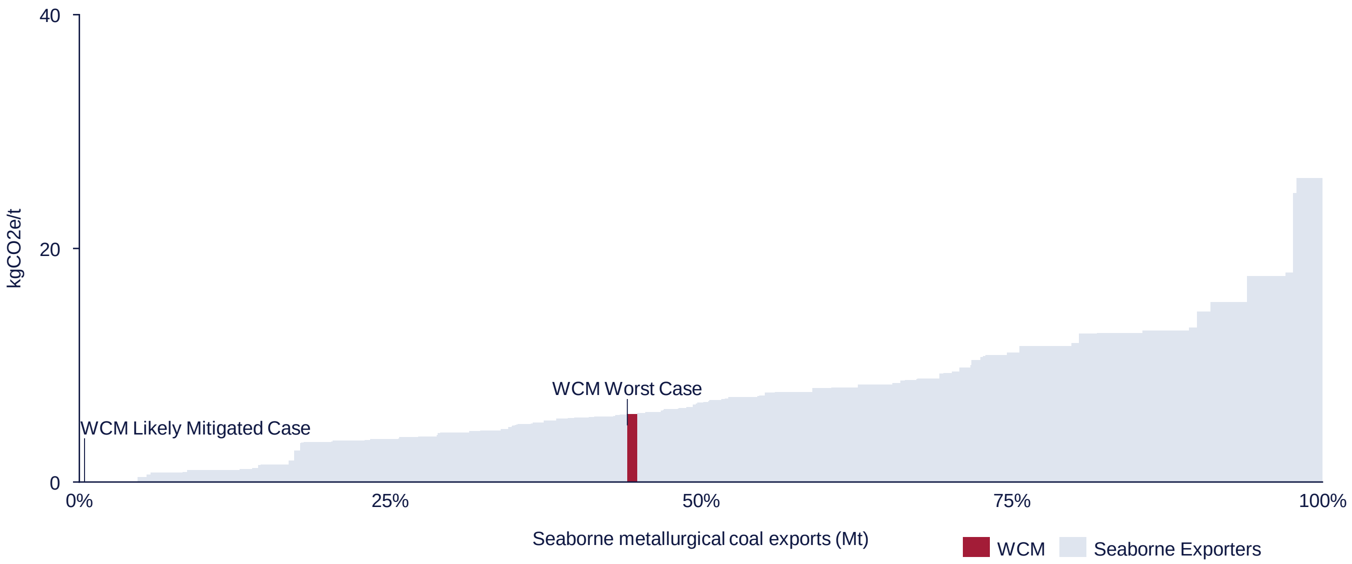
Figure 3.2: Global seaborne metallurgical coal Scope 1 emissions, 2029 (kg CO2e /t)



Source: Wood Mackenzie's Emissions Benchmarking Tool, West Cumbria Mining

3.12. The following chart (Figure 3.3) shows Woodhouse's position on the global seaborne metallurgical coal Scope 2 emissions curve in 2029. Under the Worst Case Scenario, Woodhouse is located favourably in the second quartile of the emissions curve. Under the *Likely Mitigated* case, the Woodhouse mine's Scope 2 emissions are zero. In this scenario, West Cumbria Mining assumes that all purchased electricity will be bought using a green tariff to ensure that they are from zero-emission renewable energy sources such as wind and solar.

Figure 3.3: Global seaborne metallurgical coal Scope 2 emissions, 2029 (kg CO2e /t)

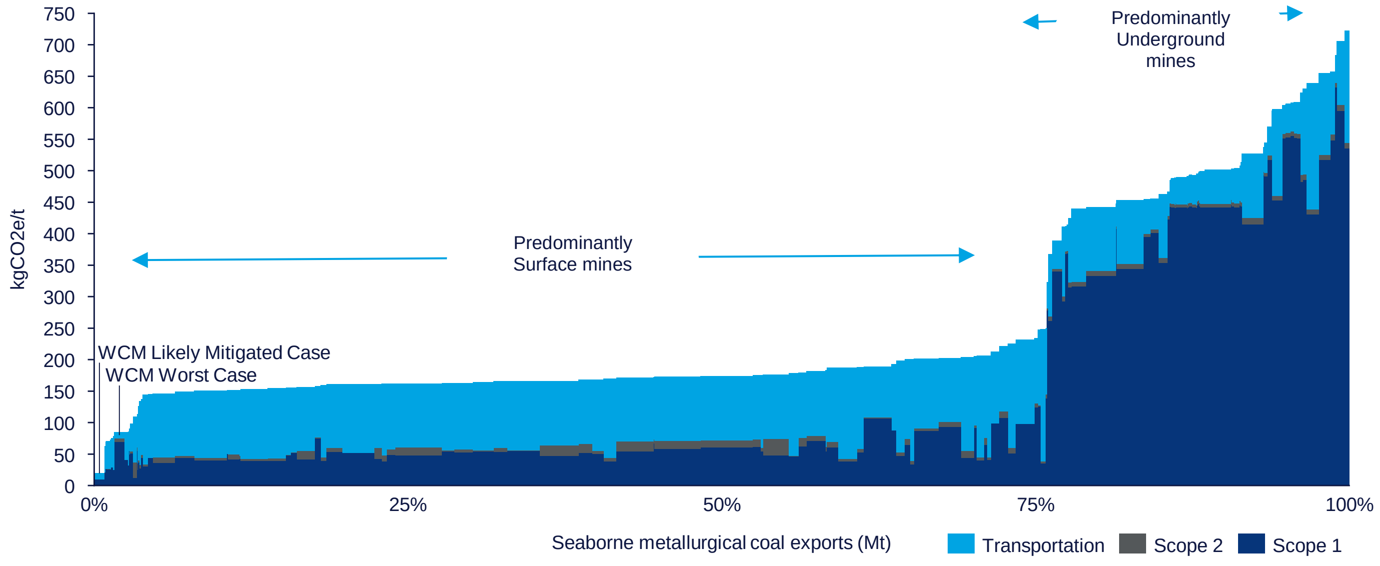


Source: Wood Mackenzie's Emissions Benchmarking Tool, West Cumbria Mining

3.13. The following chart (Figure 3.4) shows the global seaborne metallurgical coal Scope 1+2 + transportation emissions curve in 2029 on a delivered Europe basis. For all seaborne metallurgical coal producers, we calculated the transport emissions for delivery to Europe (Rotterdam), which includes trains, truck, barge and ocean freight. Ocean freight emissions were calculated for each mine taking into account the shipping distance and utilizing assumptions on bunker fuel consumption and vessel size. The purpose of this chart is to compare the difference in GHG emissions of producing metallurgical coal in the UK to supply the continental market with importing metallurgical coal from overseas. Under the two scenarios for the Woodhouse mine, emissions associated with coal transportation by rail and ocean freight to Rotterdam have been estimated. The rail emissions have been provided by West Cumbria Mining, while Wood Mackenzie has estimated ocean freight emissions following the same methodology used for all other mines. Woodhouse's total transportation emissions intensity is estimated at 9.78 kg CO_2e / t, including 6.20 kg CO_2e / t for rail to Redcar and 3.58 kg CO_2e / t for ocean freight to Rotterdam.

3.14. The chart shows that there are significant emissions associated with the transportation of coal from international suppliers through ocean freight. Under both scenarios, the Woodhouse mine is located at the low end of the emissions curve, supported by the low emissions from coal transportation. The UK currently imports metallurgical coal, primarily from the US, Russia and Australia, and the emissions associated with importing from these countries would be significantly higher than producing coal in the UK for the local market.

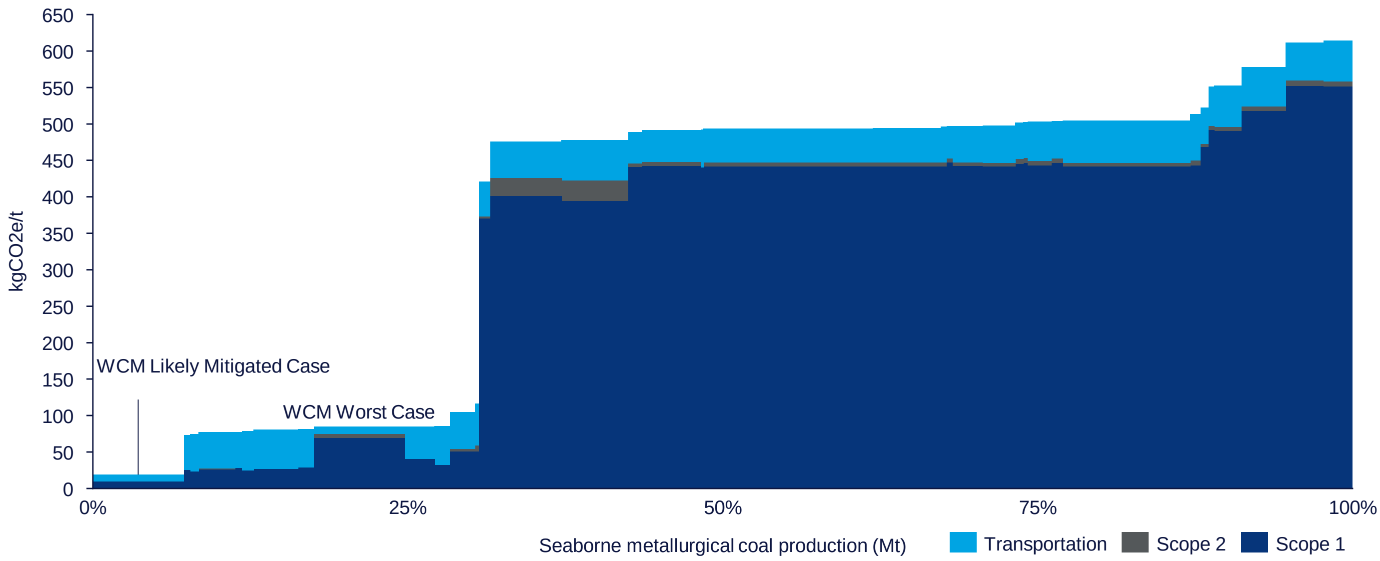
Figure 3.4: Global seaborne metallurgical coal Scope 1+2 + transportation emissions, delivered Europe, 2029 (kg CO_2e /t)



Source: Wood Mackenzie's Emissions Benchmarking Tool, West Cumbria Mining

3.15. As outlined in Chapter 2, the main competitors for West Cumbria Mining will be US producers of HVA coking coal, given their comparable coal qualities. The following chart (Figure 3.5) shows the Scope 1+2 + transportation emissions delivered to Europe for US HVA coal producers relative to West Cumbria Mining. Under both scenarios, Woodhouse's emissions intensities are significantly lower than HVA coking coal imported from the US.

Figure 3.5: US Producers of High-Vol A coking coal Scope 1+2 + transportation emissions, delivered Europe, 2029 (kg CO_2e /t)

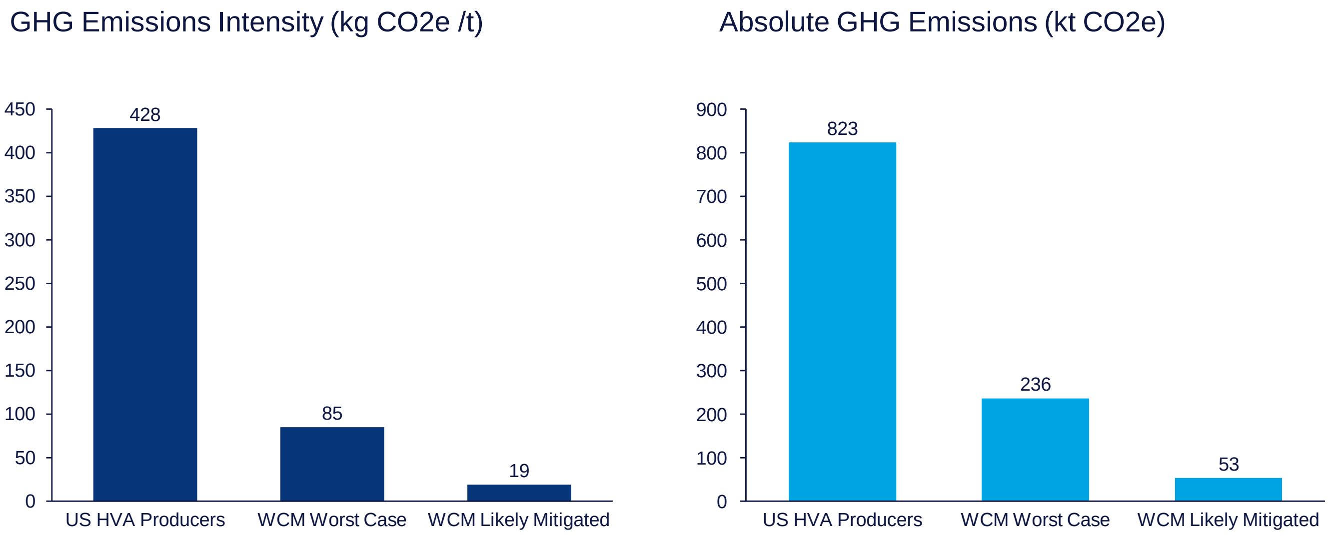


Source: Wood Mackenzie's Emissions Benchmarking Tool, West Cumbria Mining

3.16. Our competitive analysis above indicated that West Cumbria Mining is expected to take market share from high-cost US HVA HCC producers, currently suppling the European market. The following chart (Figure 3.6) compares the emissions intensities and absolute emissions of West Cumbria Mining and the US HVA production that the Woodhouse mine is expected to displace. The emissions shown for US operations are a weighted average of all US mines producing HVA quality coal.

3.17. The West Cumbria Mining *Likely Mitigated* and *Worst* cases (on a delivered Europe basis) have GHG emissions intensities in 2029 at 19 kg CO_2e / t and 85 kg CO_2e / t, respectively, which is significantly lower than average US HVA production at 428 kg CO_2e / t. Similarly, West Cumbria Mining's absolute emissions are much lower at 53 kt CO_2e in the *Likely Mitigated* case and 236 kt CO_2e in the *Worst* case, compared to 823 kt CO_2e for average US HVA production. The analysis indicates that the development of the Woodhouse mine would displace a volume of higher GHG emitting US coking coal production, therefore, leading to a global reduction in GHG emissions of between 587-770 kt CO_2e per annum.

Figure 3.6: Comparison of West Cumbria Mining Scope 1+2 + transportation emissions versus average US High vol A production, delivered Europe, 2029 (kg CO_2e /t)



Source: Wood Mackenzie's Emissions Benchmarking Tool, West Cumbria Mining

3.18. Under the two scenarios for the Woodhouse mine provided by West Cumbria Mining, the emissions intensities are very low, on a mine-site basis, relative to competing seaborne metallurgical coal suppliers. On a delivered Europe basis, there are also significant emissions associated with the transportation of coal from international suppliers, in particular through ocean freight. As a result, the emissions associated with producing metallurgical coal in the UK to supply the domestic market are expected to be much lower than importing coal from overseas, including US producers of HVA coal, the main competitors of West Cumbria Mining. Furthermore, development of the Woodhouse mine will displace high-cost US producers of HVA coal, which have much higher emissions than West Cumbria Mining. Therefore, the development of the mine is expected to lead to a reduction in global GHG emissions of between 587-770 kt CO_2e per annum.

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