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The First Metallurgical Coal Grade To Be Impacted by Decarbonisation

Replacement of Pulverised Coal Injection With Hydrogen Likely To Accelerate

Executive Summary

Much of the long-term opportunity for green hydrogen in steelmaking is via its use in direct reduced iron (DRI) processes. However, the replacement of pulverised coal injection (PCI) coal with hydrogen in blast furnaces looks like being an early decarbonising application.

Lower-cost PCI coal is injected into blast furnaces to reduce coking coal consumption. Essentially high-quality thermal coal, PCI coal can be sold into either the metallurgical or thermal coal markets.

Wood Mackenzie sees PCI coal coming under particularly high pressure under a 2˚C scenario with demand falling 50%. However, Wood Mackenzie's scenario depends on a high roll-out of as yet unproven carbon capture and storage (CCS) technology. In the event that such a CCS uptake does not occur, emissions reductions via other methods would need to be increased to remain in line with 2˚C and PCI coal consumption would need to drop even further.

German conglomerate Thyssenkrupp began the first industrial-scale test of PCI coal replacement with hydrogen in November 2019. The replacement of PCI coal with hydrogen remains a key, early emissions reduction pathway for the company.

Australian steelmaker BlueScope's initial measures to reduce carbon emissions are focused on blast furnace improvements. The company is planning to replace blast furnace PCI coal consumption with coke oven gas, which contains 60% hydrogen. Following this, coke oven gas will be complemented with green hydrogen to reduce PCI coal use further – the company has plans to work with the Commonwealth Scientific and Industrial Research Organisation (CSIRO) and Shell on pilot hydrogen production projects for this purpose.

Lower grades of metallurgical coal, such as PCI coal, have a challenged future.

BHP has highlighted lower grades of metallurgical coal, such as PCI coal, have a challenged future. The company has noted that the first widespread use for hydrogen in steelmaking is likely to be in the replacement of PCI coal in blast

furnaces. Holding on to its hard coking coal assets, BHP has started divesting mines that produce lower-quality metallurgical coal including PCI coal.

BHP announced an agreement to sell its 80% holding in the BHP Mitsui Coal joint venture – which produces PCI coal along with lower-quality coking coal – to Stanmore in November 2021

Further, BHP appears to be planning to sell at least one of its mine holdings within its BHP Mitsubishi Alliance (BMA) joint venture. The most likely to be sold are the Blackwater mine, producing lower-quality coking as well as thermal coal, and the Daunia mine, producing lower-quality coking coal and PCI coal.

As with BHP, Rio's first priority when it comes to reducing its Scope 3 emissions is blast furnace optimisation. Rio Tinto has highlighted that reducing carbon emissions from blast furnaces will involve the use of higher-grade iron ore and the replacement of PCI coal with hydrogen, echoing the view that PCI coal is facing an increasingly challenged future as steelmakers and iron ore suppliers come under mounting pressure to reduce emissions.

Russia supplies Europe with almost all of its low-sulphur PCI coal. The EU ban on Russian coal imports – to take effect from August 2022 – will clearly have a major impact on this trade. Australia is the only other major supplier of PCI coal but is unlikely to be able to make up for lost Russian supplies. This is reflected in Australian PCI coal prices which S&P recorded as high as US$645/tonne in March 2022.

Other than Russia, Australia is the only other major supplier of PCI coal.

At this stage of the global energy transition, high coal prices – as well as energy security concerns – are only likely to accelerate a transition towards alternative technology, including the replacement of PCI coal with hydrogen. In an April 2022 research note, Moody's highlighted that an extended period of high coal prices would accelerate the long-term decline in coal demand, as alternative technology looks even more favourable.

Introduction

Major steelmakers increasingly are committing to reach net zero emissions by 2050. Modelled scenarios aligned with this target by the likes of the International Energy Agency (IEA)[1] and Bloomberg New Energy Finance (BNEF)[2] foresee a significantly greater role for low- and zero-emissions steelmaking processes such as scrap steel recycling and direct reduced iron (DRI), which can use green hydrogen instead of

[1] IEA. Net Zero by 2050: A Roadmap for the Global Energy Sector. May 2021.
[2] BNEF. Decarbonizing Steel: A Net-Zero Pathway. 1 December 2021.

the metallurgical coal consumed by the currently-dominant blast furnace technology.

However, major steelmakers are often primarily focused on reducing emissions from existing blast furnace operations. This is also true of iron ore miners looking to reduce Scope 3 emissions – the emissions that occur when their mining products are processed downstream along the value chain by their steelmaking customers.

Most of the long-term opportunity for green hydrogen in steelmaking is via its use in DRI processes.

One of the options of achieving this is to replace the use of pulverised coal injection (PCI) coal in blast furnaces with hydrogen. Most of the long-term opportunity for green hydrogen in steelmaking is via its use in DRI processes, though the replacement of PCI coal with hydrogen looks like being an early decarbonising application.

Coking Coal and Pulverised Coal Injection (PCI) Coal

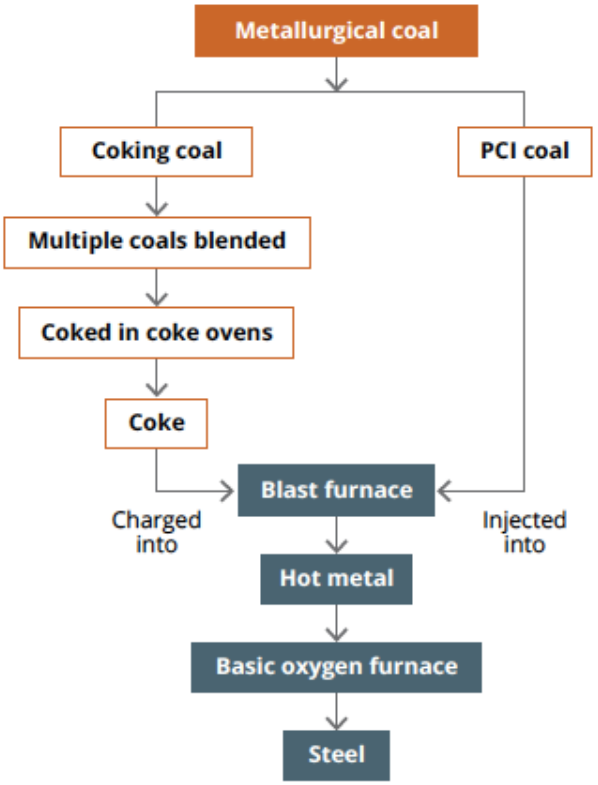
Australia is the world's largest exporter of metallurgical coal, which is used in blast furnace-basic oxygen furnace (BF-BOF) processes to produce steel – 70% of the world's steel is produced via this method.

Metallurgical coals fall broadly into two types (Figure 1). Coking coal is heated in the absence of oxygen in a coke oven to produce coke, which is then charged into blast furnaces as the key fuel and reactant. Coking coal can be further divided into hard coking coal (HCC), semi-hard coking coal (SHCC) and semi-soft coking coal (SSCC). HCC and SHCC have better coking properties making them desirable for blast furnace steelmaking. HCC has the best coking properties and consequently attracts a price premium. SSCC produces lower-quality coke so is used in smaller volumes to reduce overall coking coal costs. SSCC can also be sold into the thermal coal market.

Pulverised coal injection (PCI) coal, due to its lower cost, is injected into blast furnaces to reduce coke consumption. Depending on the calorific value (energy content), one kilo of PCI can replace 0.7 to 0.9kg of coke.[3] PCI coal is essentially a high-quality thermal coal and it can be sold into either the metallurgical or thermal coal markets.[4]

[3] Minerals Council of Australia. Australian Metallurgical Coal: Quality Sought Around the World.
[4] Commodity Insights. Market Demand Study: Australian Metallurgical Coal – Report to the Minerals Council of Australia. 12 October 2018.

Figure 1: Overview of Metallurgical Coal Use in Steelmaking



Source: Minerals Council of Australia.

PCI Coal in Australia

Total metallurgical coal exports from Australia in 2021 are estimated at 167 million tonnes (Mt) by the Australian Government.[5] PCI coal has historically made up about 15%-20% of Australian metallurgical coal exports. In 2019, Australia exported 183Mt of metallurgical coal, representing 61% of the global seaborne metallurgical coal market. Of this, 123Mt was HCC, 29Mt was SSCC and 31Mt was PCI, coal accounting for 63% of the global seaborne PCI market.[6]

Given that PCI coal can be sold interchangeably in the thermal or metallurgical coal markets, Australian thermal coal mine developers often suggest that a percentage of their proposed product will be sold as PCI coal. This is despite there being no certainty that any product from a proposed mine will be sold into the metallurgical coal market.

Thermal coal mine developers are incentivised to state this for two reasons. First, with an increasing number of banks and other financial institutions ending their

[5] Office of the Chief Economist. Resources and Energy Quarterly. March 2022.
[6] Minerals Council of Australia. Australian Metallurgical Coal: Quality Sought Around the World.

financing of thermal coal,[7] it is useful to thermal coal miners to suggest that new mine developments will produce metallurgical, as well as thermal, coal. Second, by maintaining that new mine projects will produce metallurgical coal, developers can suggest that such mines are less exposed to energy technology change. Low carbon steelmaking technology is not yet at the advanced stage of development as wind and solar power, which are now mature, low-cost alternatives to power generation using thermal coal.

Replacement of PCI Coal With Hydrogen

Major steelmakers are working on the use of hydrogen in steelmaking. However, many steelmakers are prioritising the reduction of emissions at existing blast furnaces rather than immediately shifting production to DRI processes. As such, an early use of hydrogen in steelmaking will be in the replacement of PCI coal. This is not a route to full decarbonisation – the replacement of PCI coal with green hydrogen reduces blast furnace carbon emissions only by 20%.[8]

Wood Mackenzie sees PCI coal coming under particularly high pressure under a 2˚C scenario with demand falling 50%.[9] However, Wood Mackenzie's scenario is dependent on a high roll-out of as yet unproven carbon capture and storage (CCS) technology. In the event that such a CCS uptake does not occur, emissions reductions via other methods would need to be increased to remain in line with 2˚C and PCI coal consumption would need to drop even further.

The replacement of PCI coal with green hydrogen reduces blast furnace carbon emissions only by 20%.

Numerous companies around the world see the replacement of PCI with hydrogen as a key early step on their emissions reduction pathway.

Thyssenkrupp

German conglomerate Thyssenkrupp began the first industrial-scale test of PCI coal replacement with hydrogen in November 2019.[10] The company's initial plan was to gradually expand hydrogen use until it fully replaced PCI coal in one blast furnace before expanding its use to three other blast furnaces by 2022.[11] Its timetable has been pushed back by COVID-19 but the replacement of PCI coal with hydrogen remains a key, early emissions reduction pathway for Thyssenkrupp . Beyond the replacement of PCI coal with hydrogen, Thyssenkrupp plans to shift towards

[7] IEEFA. Finance is leaving thermal coal.
[8] McKinsey & Company. Decarbonization challenge for steel: Hydrogen as a solution in Europe. April 2020.
[9] Wood Mackenzie. Steel sector emissions must fall 75% under 2˚C scenario. 10 August 2021.
[10] Argus Media. Thyssenkrupp tests hydrogen as PCI replacement. 13 November 2019.
[11] Thyssenkrupp. Green steel: Review of phase 1 of the injection trials. 2 February 2021.

steelmaking via hydrogen-based DRI with the first blast furnace to be replaced by a new DRI plant in 2025 and the second in 2030.[12]

BlueScope

Australian steelmaker BlueScope has started assessing the use of green hydrogen in DRI processes with an agreement with iron ore supplier Rio Tinto to investigate direct reduction at the company's Port Kembla steelworks.[13] However, in the short to medium term, BlueScope remains committed to blast furnace technology. The company is planning to invest A$1 billion on a project to reline its No. 6 blast furnace at Port Kembla.[14]

As a result, BlueScope's initial measures to reduce carbon emissions are focused on blast furnace improvements. The company is planning to replace blast furnace PCI coal consumption with coke oven gas, which contains 60% hydrogen. Following this, coke oven gas will be complemented with green hydrogen to reduce PCI coal use further – the company has plans to work with the Commonwealth Scientific and Industrial Research Organisation (CSIRO) on a pilot hydrogen electrolyser for this purpose.[15]

BlueScope is also exploring green hydrogen production and use at Port Kembla with Shell. The partnership will investigate the construction of a 10MW green hydrogen electrolyser with a view to using the hydrogen in BlueScope's blast furnace.[16] The agreement also allows for BlueScope and Shell to collaborate with other companies on a larger hydrogen hub concept for increased hydrogen production and consumption in the longer term.

The company is also studying the possibility of replacing PCI coal with charcoal produced from forestry or construction waste. Some steel producers in Brazil use biochar as a reductant and BlueScope is also planning biochar trials with the University of Wollongong.[17]

BHP

BHP does not have a measurable target to reduce total Scope 3 carbon emissions that occur when its customers use its iron ore and metallurgical coal in steelmaking processes. However, the company is looking at early opportunities to make Scope 3 reductions.

When it comes to driving down carbon emissions in the steel industry, BHP is clearly focussing on BF-BOF operations and does not consider that DRI will play a major part in that decarbonisation prior to 2050. BHP CEO Mike Henry stated in

[12] Thyssenkrupp. Charts on Q1 FY 2021/22: Facts & Figures. March 2022.
[13] BlueScope. BlueScope and Rio Tinto sign MOU for low-emissions steelmaking at PKSW. 29 October 2021.
[14] BlueScope. BlueScope delivers record underlying EBIT of $2.20Bn. 21 February 2022.
[15] Argus Media. Australia's BlueScope Steel seeks alternatives to coal. 18 August 2021.
[16] BlueScope. BlueScope and Shell join forces to develop renewable hydrogen projects in the Illawarra. 7 December 2021.
[17] BlueScope. BlueScope Investor Day. 20 September 2021.

October 2021 that hydrogen-based steelmaking via DRI may still be 20 to 30 years away – in contrast to many more positive views on the rate of steel technology transition – and that steel sector decarbonisation must remain focused on lower emissions from blast furnaces.[18] BHP considers that the majority of the world's steel will still be produced via the BF-BOF route in 2050.[19] This is perhaps not surprising given that BHP is the world's biggest producer of seaborne metallurgical coal.

However, the company has highlighted that lower grades of metallurgical coal such as PCI coal have a challenged future. BHP has noted that the first widespread use for hydrogen in steelmaking is likely to be in the replacement of PCI coal in blast furnaces.[20]

BHP is holding on to its hard coking coal-producing mines but seeking to sell the mines that produce lower quality metallurgical coal including PCI coal. BHP announced an agreement to sell its 80% holding in the BHP Mitsui Coal joint venture – which produces PCI coal along with lower-quality coking coal – to Stanmore in November 2021.[21]

BHP is seeking to sell the mines that produce lower quality metallurgical coal including PCI coal.

Furthermore, it now appears that BHP may be planning to sell at least one of its mine holdings within its BHP Mitsubishi Alliance (BMA) joint venture. BMA produces the type of hard coking coal that BHP believes will remain in demand for decades but two of the mines within the joint venture produce a lower quality coal. The most likely to be sold are the Blackwater mine, which produces lower-quality coking as well as thermal coal, and the Daunia mine, which produces lower-quality coking coal and PCI coal.[22]

Given BHP's views on the potential for hydrogen to replace PCI coal, it is perhaps not surprising that the Australian metallurgical coal mines that BHP is seeking to sell are those that produce PCI coal rather than hard coking coal.

Rio Tinto

As with BHP, Rio Tinto does not have a measurable target to reduce total Scope 3 carbon emissions. However, Rio Tinto seems to be more optimistic about

[18] S&P Global. Steelmakers must focus on decarbonising blast furnace use: BHP CEO. 7 October 2021.
[19] BHP. Pathways to decarbonisation episode two: steelmaking technology. 5 November 2020.
[20] BHP. Pathways to decarbonisation episode four: the promise and challenges of green hydrogen. 26 April 2021.
[21] BHP. BHP announces divestment of BMC interest. 8 November 2021.
[22] Australian Financial Review. BHP clears the way for more Queensland coal divestments. 12 April 2022.

hydrogen's potential to replace all forms of metallurgical coal in steelmaking. Rio sold its last remaining coal mines in 2018.[23]

Rio Tinto chief technical officer Mark Davies has stated that the company is developing a project to produce DRI using hydrogen at its Canadian iron ore business – Iron Ore Company of Canada (IOC).[24] In addition, Rio Tinto has signed a Memorandum of Understanding with BlueScope to investigate the use of Rio's lower-grade Pilbara iron ore in DRI-based steelmaking using hydrogen.[25]

However, in common with BHP, Rio's priority when it comes to reducing its Scope 3 emissions is blast furnace optimisation. Rio Tinto has highlighted that the reduction of carbon emissions from blast furnaces will involve the use of higher-grade iron ore and the replacement of PCI coal with hydrogen,[26] echoing the view that PCI coal is facing an increasingly challenged future as steelmakers and iron ore suppliers come under increasing pressure to reduce emissions.

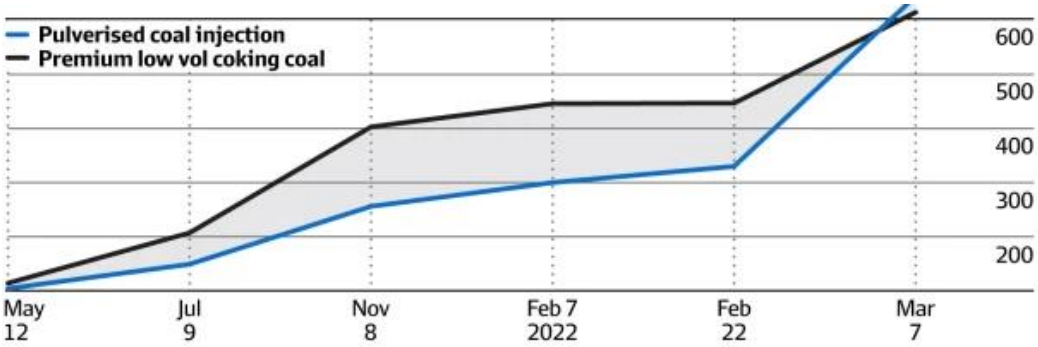
Russian Coal Ban Could Accelerate PCI's Replacement

Russia supplies Europe with almost all of its low-sulphur PCI coal.[27] The EU ban on Russian coal imports – to take effect from August 2022[28] – will clearly have a major impact on this trade. Australia is the only other major supplier of PCI coal but is unlikely to be able to make up for lost Russian supplies.

This is being reflected in Australian PCI coal prices which were recorded as high as US$645/t in March 2022 by S&P.[29] This price spike meant that PCI coal was briefly priced higher than premium-quality hard coking coal (Figure 2). PCI coal is more usually priced 20%-30% lower than hard coking coal. Even after coming off this extreme high, PCI coal was still at a very high US$365/t in early April 2022 by S&P Global Platts.

[23] Rio Tinto. Rio Tinto completes sale of remaining coal assets. 1 August 2018.
[24] Australian Financial Review. Greening the Pilbara is no easy feat: Rio Tinto. 24 November 2021.
[25] BlueScope. BlueScope and Rio Tinto sign MOU for low-emissions steelmaking at PKSW. 29 October 2021.
[26] Rio Tinto. Investor Seminar 2021. 20 October 2021.
[27] Mining.com. Chart: Bulk commodities most affected by Russia-Ukraine conflict. 15 February 2022.
[28] Reuters. EU's full ban on Russian coal to be pushed back to mid-August – sources. 8 April 2022.
[29] Australian Financial Review. BHP sold this QLD mine because it didn't have a future. Then Russia invaded Ukraine. 8 March 2022.

Figure 2: PCI Price Spike Following Russian Invasion of Ukraine (US$/tonne)



Source: S&P Global Platts, Australian Financial Review.

At this stage of the global energy transition, high coal prices – as well as energy security concerns – are only likely to accelerate a transition towards alternative technology, including the replacement of PCI coal with hydrogen. The current high (but declining) cost of producing green hydrogen will seem less of an issue in a very high PCI coal cost environment. In an April 2022 research note, Moody's highlighted that an extended period of high coal prices would accelerate the long-term decline in coal demand as it would make alternative technology look even more favourable.[30]

[30] Moody's. High coal prices drive earnings, but would hit affordability and demand if sustained. 11 April 2022.

About IEEFA

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