Wood Mackenzie

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NSW domestic coal pricing study

Prepared for the Australian Energy Regulator

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1. Executive summary

On 22 December 2022, the New South Wales (NSW) parliament passed amending legislation to the *Energy and Utilities Administration Act (NSW) 1987* (the Act), effecting a price cap on thermal coal sold by coal suppliers (Coal Suppliers) to coal fired power stations (Power Stations).

The same day the NSW Premier, by written order, declared a coal market price emergency pursuant to the Act. On 23 December 2022, the *Coal Market Price Emergency (Directions for Coal Mines) Notice 2022* and the *Coal Market Price Emergency (Directions for Power Stations) Notice 2022* were made by the Minister based on the declared emergency. Both Directions were amended on 30 January 2023, and then revised Directions were made on 16 February 2023.

These notices require named Coal Suppliers and Power Stations to affect the cap on prices for coal sold by the Coal Suppliers for use in the Power Stations and prevent the on-selling of capped coal by Power Stations (Directions).

- A price cap of $125 per metric tonne (the cap) is enforced on coal suppliers. The cap is a delivered to the power station price for coal of a given energy content (5,500 kcal/kg). Coal suppliers listed in the Directions, who consider that they cannot supply coal at the cap, may apply to the Minister for a higher cap.

These Directions will see a number of Coal Suppliers undertake deliveries of domestic types of coal for the first time or in recent times to Power Stations and other Coal Suppliers obliged maintain their deliveries over the period of the Directions. For the most part these deliveries to the Power Stations will be via NSW Rail Infrastructure.

This report has been prepared to assist in defining the current structure of the NSW coal industry, describe how domestic supply is currently contracted and inform potential approaches to determining fair margin for coal producers.

There are two main end uses for coal:

- The first being where the coal is utilised for its carbon content to reduce metallic ores to elemental state for example in steel making. These coals are commonly called metallurgical or coking coals.

- The second is for the contained energy where the coal is burnt to produce heat for electricity generation – commonly termed thermal or steaming coal.

It should be noted that there is a wide variation in the quality of the coal produced in different areas which effects both its end use and acceptance in different markets.

NSW produced around 192 Mt of coal in 2022 of which 167 Mt (or 87%) was thermal coal. By far the bulk of this production was exported with 23 Mt sold domestically of which 20 Mt was thermal coal. The thermal coal produced in NSW is highly valued by importers for its high energy and low impurity and sets the benchmark price for thermal coals in the seaborne market.

Most of the thermal coal in NSW needs to be washed to remove impurities before shipping. Washing increases both the cost of production and the achieved price, along with lowering shipping costs as less waste material is transported. Low ash coals are prized in countries like Japan which where ash disposal is an issue due to land constraints.

Coals consumed for power generation domestically in NSW are of lower quality to those exported to the high value markets in Asia. This is due to the boiler design of the plants in NSW being tuned to accept unwashed material or the material left over after washing the export coal. In the past NSW's coal fired power stations contracted coal on a ‘cost plus’ basis where the miners were paid based on the production cost of the coal plus an amount to return the capital of investment. This arrangement suited the miners who could sell an otherwise unsaleable product.

This dynamic changed when new power plants in China and India opened throughout the last two decades. Both these countries have large domestic coal resources of inferior quality to NSW's export benchmark. And both have struggled to expand their domestic coal production to keep up with energy demand. As their boilers were designed for lower quality coal miners in NSW commenced selling unwashed or product rejected for export to these consumers.

Domestic supply in NSW is contracted for discrete periods. As these periods expired the miners were unwilling to offer cost plus pricing arrangements and instead sought to link the price to export prices – exposing NSW electricity production to external events – leading to the situation today where energy shortages outside of Australia have increased domestic coal prices.

Considering our instructions, Wood Mackenzie has reviewed its historical data on NSW domestic coal production, costs and prices and has determined that it is appropriate to conduct the Fair Margin analysis for the period inclusive of calendar years 2016 through to 2021. This period is believed to extend across a time span representative of a typical commodity price cycle, commonly thought of as 6-7 years, albeit it excludes the most recent 15 months of the cycle where coal prices are likely to have reached their near-term peak. The last 15 months of this cycle are viewed as being exceptionally unusual and warranting exclusion from the Fair Margin analysis.

Wood Mackenzie recommends that the level of Fair Margin be set such that domestic coal suppliers are compensated enough to provide a fair return to their investors without providing them with abnormally high or super profits. By excluding the period post-2021, most of this risk is already removed. A significant portion of the residual risk can be removed by targeting a Fair Margin close to what the industry achieved as a whole during the analysis period as we believe that the margins the industry made during that time were high enough to encourage businesses to stay in operation without promoting large-scale, unsustainable development.

Wood Mackenzie recommends that the Fair Margin analysis be conducted using costs and pricing data based in real 2023 terms, to help ensure the data being used is comparable and reflective of the business environment faced during the term of the directions. As such, the analysis completed as part of this project has been done using real 2023 terms.

In determining a Fair Margin, Wood Mackenzie suggests basing it in dollar per tonne terms rather than percentages. A common margin based on percentages has the benefit of providing each producer with a return commensurate with their own unique cost structure that would more easily deliver a common rate of return on investment across the industry but provides little incentive for each producer to operate efficiently. Rather, a margin based on dollar per tonne terms is both easier to understand and apply and provides a much stronger incentive for producers to operate efficiently, in turn, likely saving on costs associated with these directions.

Following the instruction that the fair margin is consistently defined as a sector-wide benchmark applied equally across all firms, Wood Mackenzie recommends that all producers supplying domestic coal to NSW during the 2016-2021 period be included in the determination of the Fair Margin. This would help ensure equality and alignment of Fair Margin across the industry with historical norms (i.e., industry compensation under a Fair Margin is aligned, in aggregate, with the past) but will result in some individual producers receiving lower or higher margins compared to the situation without application of a Fair Margin.

Following the recommended approach and based on the analysis conducted over the review period, Wood Mackenzie recommends that a Fair Margin of A$21.7/t for 5,500 kcal/kg (NAR) coal be applied to each suppliers' costs.

Anecdotal (albeit dated) examples of mines supplying domestic coal in Australia via cost plus contracts suggests long established miners received between 3% and 7% premiums on their cash operating costs with the higher percentage going to captive mines unable to access the more profitable export markets and lower margins going to mines focused on exporting and who could sell low cost 'reject' material to the domestic market. These examples are from the period where coal miners were able to access much lower cost capital and when expected returns were also materially lower. They are not expected to be relevant to today's environment.

2. Coal market fundamentals

Coal is a widely distributed natural resource that is produced in many countries worldwide. The largest resources are found in the USA, Russia, China, and Australia. Most coal (80% of global production in 2022) is used in the country in which it is mined. China, the USA, and India in particular – the world's three largest coal producers – consume the majority of their coal domestically. Only 19% of global coal production is expected to be traded on the seaborne market in 2023. The remaining 1% represents landborne trade, including trade within Europe, into China from its neighbours, and between Canada and the USA. Despite being a relatively small proportion of global coal production, the seaborne coal market is important for the Australian coal industry, which is strongly dependent on exports.

Coal mining is not a uniform process, with methods of coal extraction dependent on local geographies, position of the coal seam, geological properties of the surrounding material and capital available for infrastructure. Open pit (also known as open cut or surface mining) involves the use of trucks and shovels or draglines. The volume of rock that must be removed to reach the subterranean coal seam is a key component of surface mining costs. Underground mining involves the use of longwalls or bord and pillar and is typically more expensive than surface mining. Mining in Australia is a mix of open pit and surface mining although the bulk of thermal coal production in NSW is via surface mining. Miners will generate a life of mine plan that includes an estimation of cost of production – typically on an annual basis. This plan will take into account the overall strip ratio and coal quality and will be based around the characteristics of the geography and geology of the deposit. For multi pit operations there is some flexibility in terms of managing costs and some mines will have flexibility in regarding the coal quality produced at the wash plant. When prices are low some miners will 'high grade' (i.e., take lower strip ratio or higher quality coal) the operation to maintain margin. This practice can increase the overall life of mine cost structure of the mining lease and in extreme cases sterilise coal reserves.

The global coal market can be divided into two major sub-markets – thermal and metallurgical – based on the properties and end-use of the coal. For the most part, the markets for thermal and metallurgical coal operate independently of each other, although some degree of substitution between thermal coals and lower ranked metallurgical coals is possible (e.g., pulverised coal injection coal, which can be sold as a low volatile thermal coal).

Thermal coal is used in combustion processes to produce steam for power generation, heating, and industrial applications such as cement manufacture. Thermal coals are chiefly classified by their energy content which is the main determinant of pricing with the following sub-divisions being typical in the coal market:

- **Anthracite** Specific energy > 6,900 kcal/kg (gar)
- **Bituminous** Specific energy 5,400 – 6,900 kcal/kg (gar) – NSW produces bituminous coal
- **Sub-bituminous** Specific energy 4,500 – 5,400 kcal/kg (gar)
- **Low rank and Lignite**[1] Specific energy < 4,500 kcal/kg (gar)

However, the geological process of coal formation can result in varying quality across a basin - factors such as the original plant material, volcanic activity and post sedimentary process all combine to form the coal produced today. These factors result in variations such as overall carbon content, volatile matter, moisture, and ash which all directly affect the energy of a coal while sulphur (a contaminant) and the hardness (measured as HGI) affect the value in use and have a lesser effect on pricing and acceptance for different consumers[2]. Essentially this means some coals do not fit into the classifications above for example anthracites produced in Vietnam have such high ash content that on an energy basis they would be classified as a bituminous coal, similarly some domestic coals produced in NSW have bituminous characteristics but energy contents similar to sub-bituminous coals.

[1] The term low rank coal is a market based category developed by Wood Mackenzie to capture the difference in pricing between the pricing of sub-bituminous coal (e.g., Envirocoal at ~ 4,900 kcal/kg gar) and the step down to coals such as Ecocoal (4,100 kcal/kg gar). True lignite is technically less than 3,500kcal/kg gar and very little is currently traded on the seaborne market however the naming convention is widely understood – especially when reviewing custom import and export statistics. For the purposes of this report, Wood Mackenzie combines Low Rank Coal and Lignite on a volume basis for the charts however refer to Low Rank Coal when referring to this specific product.

[2] Coal fired power stations are typically designed for a specified range of coal types which are believed (at the time of planning the plant) to be the best available in terms of quantity and cost. In NSW plants were designed around higher ash lower energy coals locally available that were not of export quality but had low production costs and/ or were a byproduct in producing export coals.

Metallurgical coal is used in steel production. It is used either to produce coke, which is then fed into the top of a blast furnace along with iron ore; or for PCI (defined below), where the coal is injected directly into the base of a blast furnace. Metallurgical coal is classified based primarily on the strength of the coke it produces:

- **Hard coking coal (HCC)** Coal that forms high strength coke
- **Semi-soft coking coal (SSCC)** Coal that produces coke of a lower quality than hard or semi-hard coking coal
- **Pulverised coal injection (PCI)** Coal that is injected into a blast furnace to replace relatively more expensive coke

In 2023 thermal coal is expected to account for 76% of the total seaborne coal market, and for 54% of Australian exports.

The seaborne market for coal can also be divided into two sub-markets geographically, based around the Atlantic and Pacific Basins. The two markets are relatively segregated, primarily due to the relative cost of shipping between them. However, some inter-basin trade does occur, either due to quality considerations or when freight and price differentials allow exporters to compete in non-traditional markets.

Pacific Basin trade currently accounts for 86% of the seaborne market, with Indonesia and Australia being the largest suppliers. The developed Asian economies of Japan, South Korea, and Taiwan (JKT) have traditionally been the principal Pacific Basin importers, however demand from these markets has declined in recent years. Previously the most significant driver of growth in the region, China's demand for imported coal is expected to peak in 2025 as it focuses inward on domestic production and maintains its protectionist policies. Demand growth will instead be concentrated in the developing economies of India and Southeast Asia (SEA)[3]. In the Atlantic Basin, South Africa and Colombia are the largest producers, primarily supplying coal into the European market. Russia was also a large exporter in European markets but its exports to the EU have ceased as a result of EU sanctions following the invasion of Ukraine. Wood Mackenzie expects Russia's exports to be redirected to Asia, particularly China and India, although eastbound rail capacity constraints will limit upside in the near term. Europe's search for alternative coal imports is boosted by gas supply uncertainty, also a Russian export, and has resulted in coal prices spiking to unprecedented levels in 2022. There is potential for coal exported from Australia to be redirected to the European market for the duration of the trade restrictions.

The total volume of coal traded on the seaborne market is forecast to increase from 1,293 Mt in 2023 to a peak of 1,314 Mt in 2025 before falling to 855 Mt by 2040 (overall -1.4% CAGR). Wood Mackenzie forecasts thermal coal will fall from 75% of seaborne trade in 2022 to 59% by 2050 as the metallurgical coal market grows and thermal coal demand starts to decline.

[3] SEA countries with seaborne coal demand are Cambodia, Indonesia, Malaysia, Myanmar, Philippines, Singapore, Thailand, and Vietnam.

3. The Australian Coal Industry

3.1 Reserves

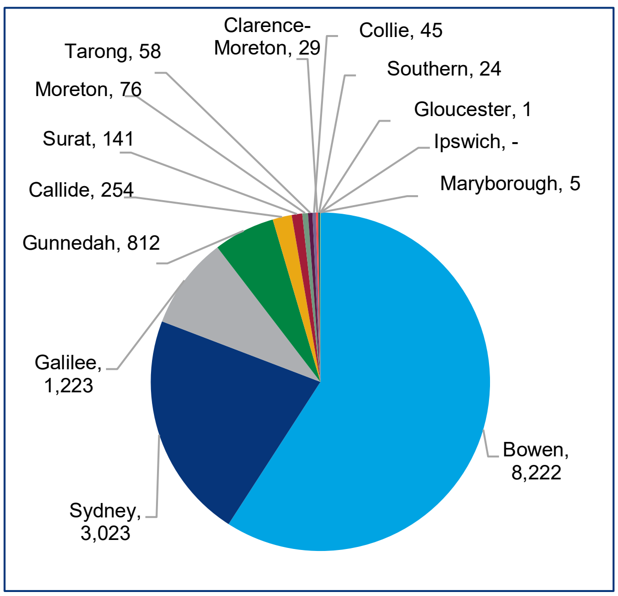
Wood Mackenzie's marketable reserves are defined as the total forecast future marketable[4] coal production over the life of each identified operating mine and Highly Probable, Probable and Possible project.

Coal production areas are often classified by the geological basin in which they were formed[5]. Figure 1 shows Australian marketable coal reserves by basin. Queensland holds majority of reserves in Australia. In New South Wales the Sydney Basin dominates the state's marketable reserves - the only other coal producing basins in the state are the Gunnedah and Gloucester basins with a significantly lower share.

Glencore has the largest marketable reserves in Australia at 1,789 Mt in 2023, followed by BHP at 1,454 Mt, Bravus at 1,223 Mt and Mitsubishi Corporation at 1,176 Mt. In 2023, metallurgical coal is estimated to account for just about half of Australia's marketable reserves at 6,819 Mt. Of this, 69% will consist of HCC, 12% of SSCC and 19% of PCI. Australia's thermal coal reserves are estimated to be 7,093 Mt, 58% of which is made up of bituminous coal, 38% bituminous HA and 4% sub-bituminous.

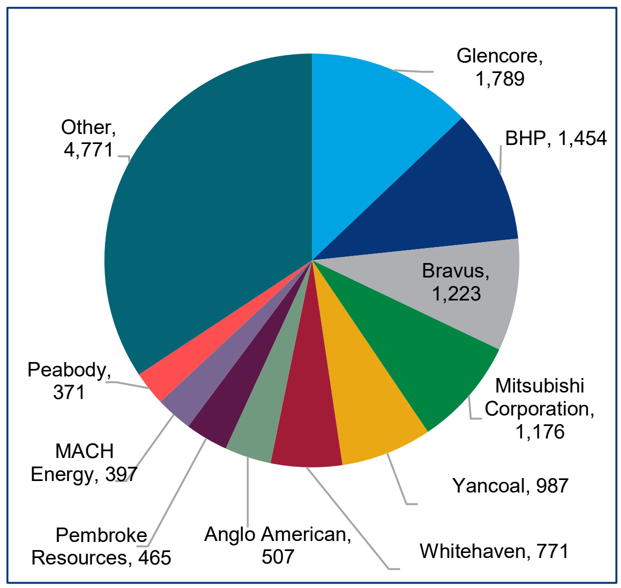
In NSW the bulk of marketable reserves, estimated at 3,113 Mt, are of thermal coal quality. The remaining 748 Mt are comprised of semi soft coking coals (SSCC) which are chiefly used in coke blends for steel making. It should be noted that when market conditions cause the price for thermal coals and SSCC to converge there can be some switching however not all SSCC can be burnt in a power station.

Figure 1 Australian marketable coal reserves by basin (Mt, 2023)



Source: Wood Mackenzie

Figure 2 Australian remaining marketable coal reserves by company (Mt), 2023



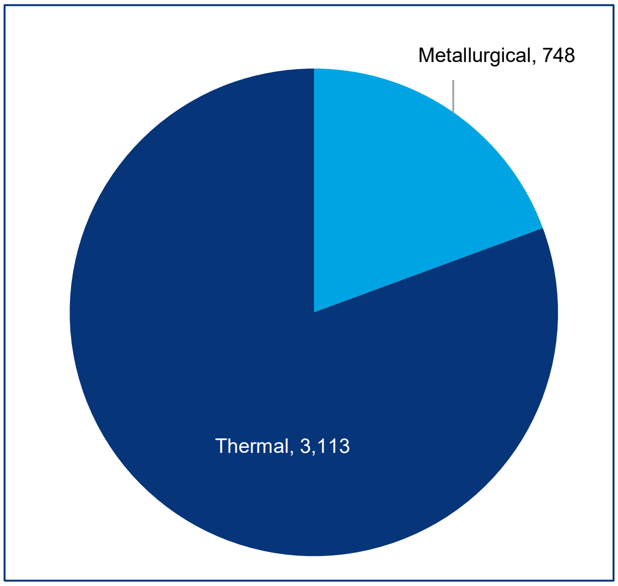
Source: Wood Mackenzie

The NSW coal industry is export focussed. Figure 4 shows that 95% of the thermal coal reserves are of export coal quality while only 142 Mt or 5% of reserves are not suitable for export.

[4] WM develops a view of marketable reserves based on published reserves estimates and a view on whether resources within a mine's footprint can economically be converted to a reserve. Marketable reserves are not a JORC compliant value.

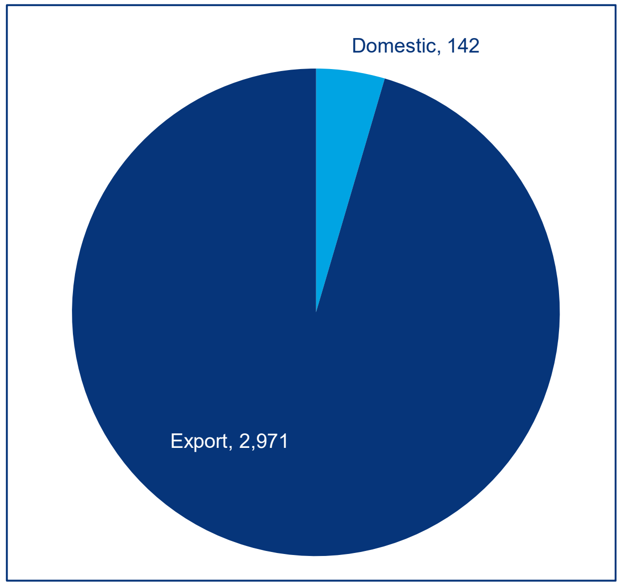
[5] A Basin can also be further subdivided by region or coalfield – e.g., the Newcastle Hunter Valley coalfields are both located in the Sydney basin.

Figure 3 NSW remaining marketable coal reserves by type (Mt), 2023



Source: Wood Mackenzie

Figure 4 NSW remaining marketable thermal coal reserves by market (Mt), 2023



Source: Wood Mackenzie

3.2 Thermal coal quality discussion

Coals used as a fuel are commonly known as thermal or steaming coals. Their use is primarily as a fuel to produce steam in a boiler. The steam is then used in a turbine to generate electricity or steam for home and industrial heating purposes. The majority (more than 90%) of seaborne exports of thermal coal are purchased by electric power generating companies. The next largest consumer of seaborne thermal coal is the cement industry, where coal is used as a fuel to fire cement kilns. Thermal coals are also used in industrial plants in the chemical and paper industries to produce steam for use in these plants.

In the generation of electricity, thermal coals provide the source of heat energy to convert water into steam which in turn is used to drive turbines to produce electricity. Pulverised coal (PC) combustion technology dominates the power generation industry globally and the vast majority of Australian export thermal coal is used in this type of combustion technology.

In a pulverised coal combustion power plant, coal is ground to a similar particle size as talcum powder. This is done to increase the surface area of coal so that it can burn rapidly. The milled or pulverised coal is then simultaneously dried and transported to a large combustion chamber through wall or corner mounted burners using preheated primary combustion air (typically around 20% of the combustion air supply).

In NSW most export coals are washed to remove impurities and increase their saleable value. It should be noted it is not theoretically possible to wash all detrimental properties out of the raw coal[6] and that miners take care to ensure that the product coal meets market expectations without excessive yield loss. Miners will also tailor product coal to market conditions and produce low ash high energy coals for some markets and high ash low energy coals for others. For the domestic market coals are often sold on an unwashed basis as the domestic power stations are able to consume this product.

The following coal quality parameters are of most significance to the commercial acceptance and pricing of thermal coals.

[6] Mineral matter in coal is chiefly comprised of silicon, aluminium, iron, calcium, and sulphur with trace amounts of other elements. The sources of mineral matter in coal can be divided into two categories: organic and inorganic:

- Organic sources of mineral matter in coal refer to the minerals that were taken into the tissues of the plants that make up the coal as they grew. These minerals are retained in the coal formed from these plants and are difficult to remove through washing.
- Inorganic sources of mineral matter in coal refer to the minerals that are present in the sediments in which the coal was formed. These minerals may have been introduced into the coal during or after the coal-forming process from rivers or volcanic activity.

3.2.1 Moisture

Total moisture (TM) refers to the moisture in the coal as sampled and is usually reported on an "as received basis (AR)". The total moisture comprises air dried moisture and free moisture. Air dried moisture is the moisture in the coal sample after achieving equilibrium with the laboratory atmosphere when exposed to it. Air dried moisture is often used to indicate the moisture that is inherent in the coal and the value is typically higher for sub-bituminous or lower rank coals. Free moisture is the difference between total moisture and air dried (inherent) moisture. Typically, this is moisture added during the mining, stockpiling and transportation of the coal. Some portion of the free moisture may be removed by drainage or evaporation.

Moisture (water) is considered a costly contaminant in thermal coals, increasing freight costs per unit of energy (more water means less available energy) and consuming heat from the furnace during combustion. High levels of moisture may also result in coal handling problems.

Typically, a coal sales agreement will specify a maximum total moisture content as part of the agreement specifications. If this maximum is exceeded on shipment, it is usual for the invoiced tonnage to be adjusted on a pro-rata basis. The specified maximum total moisture varies depending on the coal type.

Inherent moisture (IM) is the water bound in the pores of the coal structure or chemically attached to the organic coal matter.

3.2.2 Volatile matter

Volatile matter (VM) refers to the gaseous component of the coal. It is defined as the loss in mass, less that due to moisture, when a coal is heated under standard conditions and out of contact with air. Sub-bituminous coals have higher VM content compared with higher rank bituminous coals. Higher VM bituminous coals are easier to ignite than lower VM bituminous coals and are generally preferred for power generation due to their better combustion performance. Price adjustment clauses may be included in some markets if the contracted VM content is exceeded.

3.2.3 Ash

Ash is the inorganic residue after the incineration of coal to constant weight under standard conditions. The higher the ash the lower the calorific value and the chemical composition of the ash may influence the potential for fouling and slagging[7] in a boiler as well as the fly ash precipitation characteristics. High ash levels also mean higher ash disposal costs for power plant operators. Ash values for seaborne traded bituminous coals exported from Australia generally have contents less than 15%, although in times of supply shortage this may be lifted to 20%. Some coal sales agreements include price adjustment clauses in case the shipped ash level is greater than contracted.

3.2.4 Sulphur

The total sulphur content of a coal generally comprises the "organic" component that is part of the carbonaceous material and the "inorganic" component that is part of the minerals. Sulphur in coal forms sulphur dioxide (SO2) which is a significant pollutant, and most countries regulate the amount of SO2 that is able to be released into the atmosphere. Some power utilities are required to install sulphur scrubbers to stay within the required emission levels.

Export thermal coal agreements can contain price adjustment clauses if total sulphur exceeds 0.5% to 0.7%, and usually are rejected if over 1%. Most coal brands marketed for domestic sales in NSW are less than 1% sulphur.

3.2.5 Hardgrove grindability index (HGI)

The Hardgrove grindability index (HGI) test indicates the relative grindability or ease of pulverisation of a coal in comparison to coals chosen as standards. High HGI values indicate a coal is easy to pulverise and a low value indicates a coal is harder to pulverise and

[7] Ash deposition can occur in various parts of the boiler and cause reduction of heat transfer by coating the internal walls of the boiler and/ or increased wear of the internal lining of the boiler. Slagging refers to ash deposited in high temperature parts of the boiler while fouling occurs in lower temperature parts of the boiler.

therefore requires more energy (and cost) to pulverise to the required size range for feeding to the boiler. Most power utilities prefer HGI values in the range 45 to 60. Higher values may mean the coal generates excess fines[8] during stockpiling and transportation.

3.2.6 Calorific value

The laboratory determination of calorific value gives the gross calorific value at a constant volume. Gross calorific value is the amount of heat liberated when the coal is combusted under standard conditions (i.e., the energy content). During the actual combustion in boilers the gross value is never achieved because some of the products of combustion, mainly water, are lost in the gaseous state with their associated heat of vaporisation. The maximum achievable calorific value under these conditions is the net calorific value. Net calorific value as received basis (NAR) is the net calorific value determined on the sample as shipped, received, or as fired.

Typically, the seaborne thermal coal trade for bituminous coal specifies calorific value in gross as received energy (GAR) terms. This value is determined on the coal as shipped (or as received at the discharge port). For bituminous coal such as Newcastle type thermal coal, a GAR calorific value can be approximated to a NAR (net as received) calorific value by deducting a factor of 260kcal/kg. This factor does not necessarily apply to low rank Indonesian sub-bituminous coals. The higher the calorific value the more valued the coal.

In the past export quality thermal coals were those with the highest energy content along with the lowest levels of impurities (as buyers are essentially buying energy transporting inferior coals long distances was not cost effective) and coal fired power infrastructure in Australia was built to be able to consume lower quality (in particular lower energy and higher ash content) material that was not suitable for export.

3.3 Australian coal quality

Australia contains an almost complete range of coal types from the lignite basins in Victoria, South Australia (SA) and Western Australia (WA) to semi-anthracite and anthracite deposits in Queensland. Sub-bituminous deposits exist in WA, SA, and Victoria with New South Wales (NSW) and Queensland dominated by bituminous thermal and metallurgical coals. Figure 5 shows Australian thermal coal quality in comparison to other seaborne supply.

Except for minor quantities exported from the Collie Basin in Western Australia, export quality coal originates from Queensland and NSW. Australia's export thermal coals are generally high-quality bituminous coals.

Standard export contract specifications include ash at up to 14%, energy contents around 6,322 kcal/kg (gar) and maximum total sulphur of 0.6%. At 6,021 kcal/kg (gar), Australian thermal coals have a higher average energy content than the global average of 5,365 kcal/kg (gar).

The total moisture content of Australian coal ranges from 5.5% to 18.5%, a small deviation compared to the global range of 4.5 – 55.3%. Average total moisture content of Australian thermal coal is 10.8%, almost half the global average of 21.3%.

Increasing amounts of non-standard thermal coal is being produced to satisfy demand from emerging Asian coal markets including China and India. These products include partially or completely unwashed (bypass) products from premium thermal coal operations and have typical energy levels of 5,500 kcal/kg (nar) and ash levels from 17% to 23%. While the average ash content of Australian thermal coals is 15.6%, higher than the global average of 13.2%, these products can be washed to a higher energy and lower ash basis if market conditions change. Table 1 shows the average yield (i.e., the weighted average saleable coal available after washing) for the three coal producing basins in NSW. As the Gloucester Basin produces metallurgical coal the coal is washed to a lower ash level - lowering the yield in comparison to the Sydney basin which mainly produces thermal coal. Some mines in the Gunnedah Basin have raw coal of sufficiently low ash to be sold unwashed – increasing the overall yield for the basin.

Table 1 NSW – 2022 average yield by basin

Basin	2022- estimated average yield
Gloucester	68%
Gunnedah	88%
Sydney	76%

Source: Wood Mackenzie

[8] Coal fines (small particles of coal), also called tailings, are a wasteful by-product of the coal mining process that have a low market value, are generally expensive to dispose of, and are left in stockpiles or slurry ponds at or near mining sites.

NSW coals can be classified in broad terms (although there are exceptions):

- **Sydney Basin**
  - Southern coalfield – contains hard coking coals for export and domestic steel making.
  - Western coalfield – contains high ash thermal coals best suited for domestic consumption.
  - Newcastle coalfield – contains high ash thermal coals best suited for domestic consumption but can be washed for export.
  - Hunter Valley – contains mid ash coals able to be sold unwashed for domestic thermal consumption but is mostly washed to benchmark thermal standards or where possible SSCC for export.

- **Gunnedah Basin** – contains low ash thermal coals some of which are of seaborne benchmark quality on an unwashed basis.
- **Gloucester Basin** – contains metallurgical coal with properties between SSCC and HCC.

Table 2 NSW – 2022 weighted average domestic coal quality

	TM	IM	VM	Ash	TS	SE gar
NSW weighted average domestic quality	8.8	2.9	27.4	24.0	0.5	5,403

Source: Wood Mackenzie

3.3.1 Pricing of seaborne thermal coals

Thermal coal produced in NSW has long been seen as the benchmark quality for high energy coal traded in the seaborne market. Coal meeting the benchmark specification shipped from the port of Newcastle is the standard specification for a number of price indexes used to set contract prices.

NSW is also known for the production of a high ash bituminous coal type that has grown in acceptance in India and China. Both these countries have similar quality domestic coals and have built their power infrastructure around a higher ash specification. As these coals are produced on a raw or semi washed basis at a lower production cost, they can be offered at a discount to the higher energy benchmark coals.

In recent years, coal buyers have been increasing tolerance limits on coal quality as tight supply conditions have forced them to diversify their supply sources. Buyers have also been encouraged to seek lower cost coals as prices for “standard coals” increase. This is particularly the case for markets in India and China. Japanese utilities remain the most conservative of buyers in relation to quality and have been slow in utilising sub-bituminous coal for example, unlike Indian buyers who have largely supported the rapid growth in Indonesian coal exports of sub-bituminous coal.

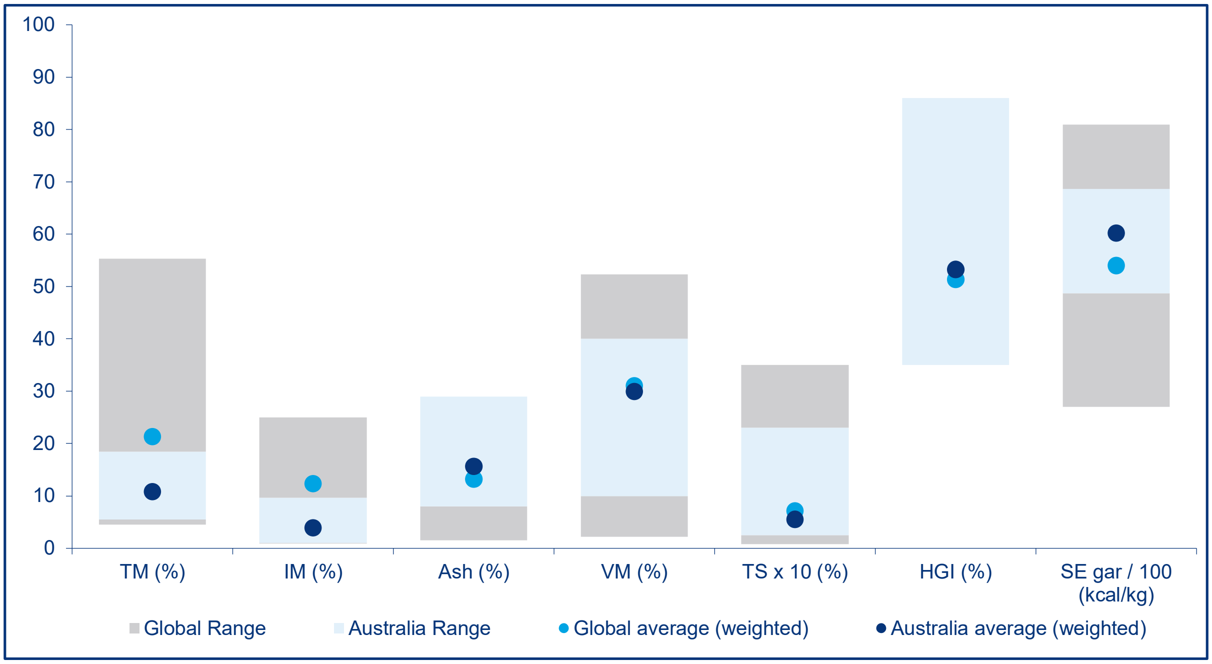
These limits can vary as boiler designs change and are subject to commercial influences. For example, a buyer may still use “off specification” coal if price penalties can be negotiated to compensate for a potentially higher fuel cost in using the coal. It is also possible that other properties of the coal that are favourable may offset the negative properties. The major European and Asian power companies specify a range of coal qualities that they prefer. Coal brands with specifications which fall outside these ranges may also be purchased by these consumers if the following conditions are met:

- The price is attractive relative to coals that do satisfy their boiler design standards
- The average fuel cost warrants either the extra cost of coal blending or incurring the economic penalty of lower efficiency of the operating unit[9].

The willingness of buyers to accept “out of specification” or “non-preferred” coals depends on the condition of the market. In a market that has a surplus or adequate supply of preferred coals buyers will generally opt to buy only those coals that meet their preferred quality limits. In the case of Japanese Power Utilities, where there is a strong preference for buying only those coals that meet boiler design specifications and on a consistent delivered basis, offering discounted prices for non-preferred coal may still not encourage them to purchase the coal.

[9] It should be noted that while plants can accept inferior coal the economics of doing so needs to be carefully considered in terms of load loss and regulations regarding emissions.

Figure 5 Seaborne thermal coal quality data (2023)



Source: Wood Mackenzie

Thermal coal prices are dependent predominantly on the coal's energy content. The achieved price is adjusted on a pro rata basis as detailed in Figure 6. In addition to the energy discount formula high ash bituminous, sub-bituminous and low rank thermal coals generally receive an additional value in use penalty which varies based on market conditions.

Figure 6 Formula explaining adjusting coal price by contained energy (GAR)

$$\boldsymbol{Adjusted\ price = index\ price * \frac{product\ coal\ energy}{6,322 kcal/kg}}$$

Source: Wood Mackenzie

Other quality specifications such as ash and sulphur content are also important to some consumers, so it is common to receive an additional premium or discount based on these factors, or for rejection limits to apply. Typical price adjustments are summarised in Table 3. It should be noted that these are only indicative and that often pricing is based on an energy adjustment as per the formula plus or minus a premium or discount agreed between the buyer and seller.

Table 3 Typical effects of thermal coal quality on price

Property	Newcastle benchmark value	Typical price adjustment	Comment
Total moisture (ar)	10%	Shipment tonnage adjusted pro-rata for the percentage by which total moisture as shipped exceeds benchmark value. Rejection limits may apply above ~13%.	Buyers prefer lower moisture due to its effect on ocean freight costs.
Inherent moisture (ad)	2.5%	No adjustment	
Ash (ad)	14.5% max.	Usually, no adjustment but rejection limits may apply.	Can be discounted for each % above the benchmark. Additionally certain markets/ importers have mandated maximum levels
Sulphur (ad)	0.6% max.	Discounted by 0.5 US$/tonne for each 0.1% above benchmark value.	Sulphur content has a direct effect on SO_X emissions.
Volatile matter (ad)	30% min.	Usually no adjustment.	
Gross calorific value (gar)	6,322 kcal/kg	Adjusted on a pro-rata basis.	This is the primary basis for pricing.
Gross calorific value (gad)	6,700 kcal/kg		
Net calorific value (nar)	6,063 kcal/kg		

Source: Wood Mackenzie

The choice of coal varies from utility to utility often as a function of boiler plant design. While consumers of thermal coal have the benefit of a wide range of coal types, the properties of the coal (particularly specific energy, ash, sulphur, and total moisture) have a direct impact on the costs of electricity generation, or in the case of the general industry, on the cost of the product. This can in many cases be compensated for in the price of coal.

In NSW power stations have been designed around coals available in the Sydney basin and have tolerances to consume higher ash coal than typically preferred for exports – this could either be unwashed product or middlings left over after washing of thermal or metallurgical coal destined for the export market. This was to be able to take advantage of coal that would not be able to be exported. In the past the power stations were supplied by local mines that dedicated part or all of their production for domestic consumption. Many of these mines have since depleted their reserves and closed or have taken advantage of the rise of high ash coal demand from seaborne consumers.

It is Wood Mackenzie's understanding that the fleet in NSW can burn most coals produced in the state although there are exceptions where the coal does not meet the boiler requirements or would cause emissions of sulphur oxides (SO_x) and nitrogen oxides (NO_x) to exceed allowable levels. Coal supply to NSW and Queensland generators range in energy content from ~4,500kcal/kg gar (Tarong - QLD) to 6,850 kcal/kg (Stanwell – QLD). Power Stations typically have coal specifications included in contracts and verify this through using accredited laboratories to test samples of the coal delivered.

3.4 Australian thermal coal overview

Australian coal production has grown moderately from 2015 to 2020 before falling due to the Covid19 pandemic. Coal production in Australia fell 3% in 2021 due to disruptions to export supply and lower domestic coal demand because of growth in renewables but has since recovered to pre covid levels and is expected to grow moderately to 2026 where it will peak.

For thermal coal, domestic supply will continue to decline as demand falls due to the continuous addition of renewables and the planned build of grid-scale batteries and green hydrogen to support an earlier retirement of coal-fired plants. Thermal coal exports are expected to remain firm to 2026-2027, but thereafter are expected to enter a period of structural decline due to the growth in renewables and gas in key markets Japan and Korea.

Thermal coal demand will face longer-term substitution risk from increased nuclear and green fuel adoption, especially if the pace of the energy transition accelerates. Thermal coal export supply will continue to face significant challenges in replacing reserve depletion, with a lack of projects currently under construction or close to a final investment decision. Producers are continuing to repay debt and reward shareholders with buybacks and dividends ahead of project development or M&A.

Figure 8 shows the production outlook for thermal coal in NSW from known mines and projects split by the domestic and export market. Overall production in NSW is forecast to peak in 2023 and plateau around 170 Mt before falling significantly in 2030 due to the scheduled closure of BHP's 15 Mtpa Mt Arthur mine. Domestic supply is estimated to have already peaked and will fall steadily from 18 Mt in 2023 to zero by 2038.

Over 95% of Australia's domestic thermal coal demand is used in power generation with the remainder utilised chiefly in cement production. Australian domestic thermal coal is supplied by captive mines (i.e., those with no access to export markets) and export mines that produce a domestic product. Coal supply in both Western Australia and Victoria is essentially captive due to the quality of the coal not being acceptable to seaborne consumers in Victoria's case and cost of production and poor infrastructure pathways in Western Australia. In Queensland there are several captive operations with no export pathways and other domestic supply that has limited export potential due to coal quality. In NSW only one mine has no access to export infrastructure. As contracts have expired miners have sought to negotiate the terms of new contracts to include export price linkages.

NSW has the largest installed CFG capacity in the NEM followed by Queensland, then Victoria. With multiple near end of life plant closures in recent years, installed capacity is down to approximately 23 GW from 27 GW in 2012. Most NSW and Queensland generators are located in export coal supply regions.

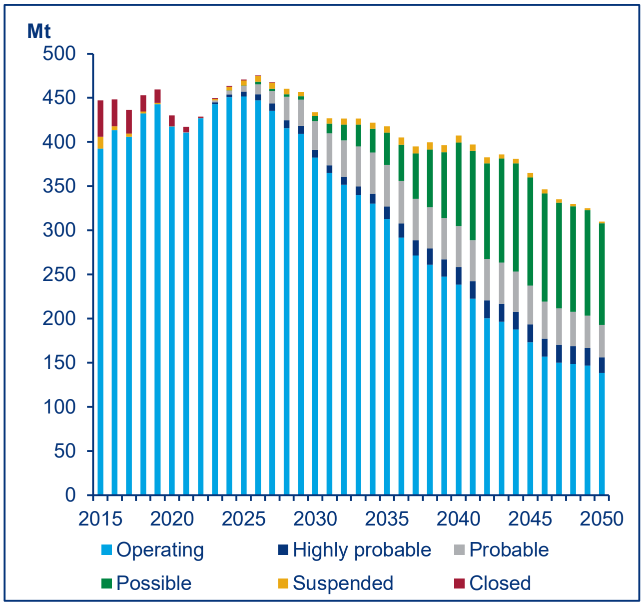
In NSW there are five active coal fired power stations Bayswater, Liddell, Eraring, Mt Piper and Vales Point. Table 4 sets out the details for each plant including their current main suppliers and coal delivery systems.

The following charts are based on analysis undertaken prior to the new Directions and do not reflect how the market may operate after the directions are enacted.

Figure 9 sets out the domestic supply for 2022 by state. Figure 10 shows current and forecast NSW domestic supply versus demand. This domestic supply is based on the mines currently contracted and shows that until 2026 there is sufficient supply to meet demand.

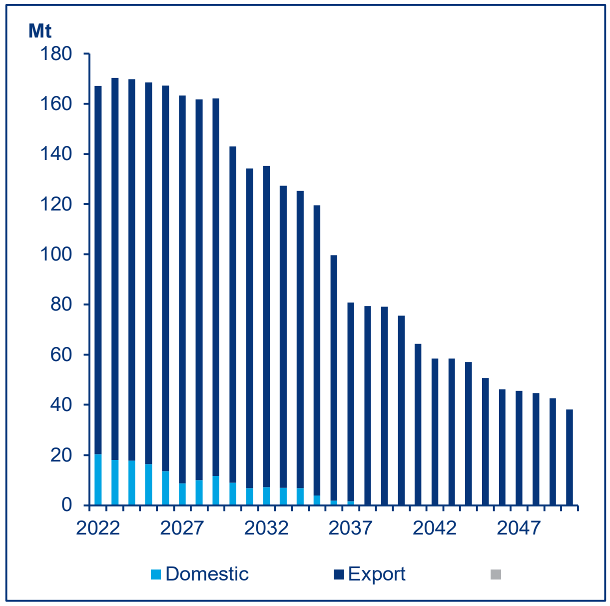
There is a symbiotic relationship with many of the mines supplying the domestic market and mines are scheduled to close as domestic demand falls with the closure of each power station. It should be noted that should the plants lives be curtailed or extended the demand profile will change.

Figure 7 Australian coal production by status (Mt)



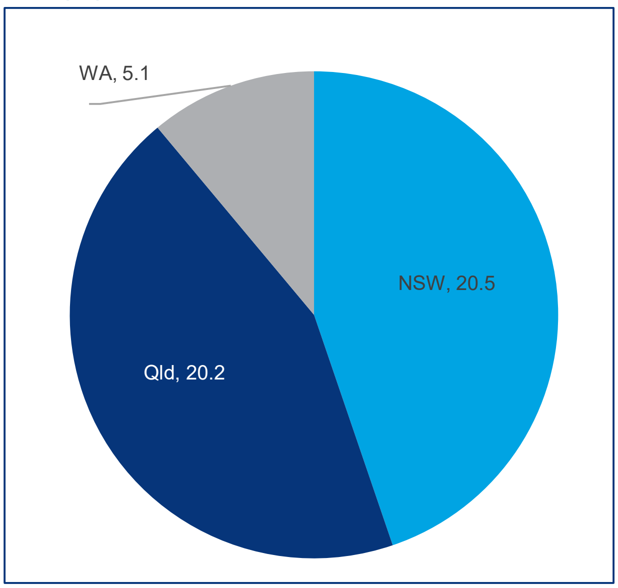
Source: Wood Mackenzie

Figure 8 NSW thermal coal production by market (Mt)



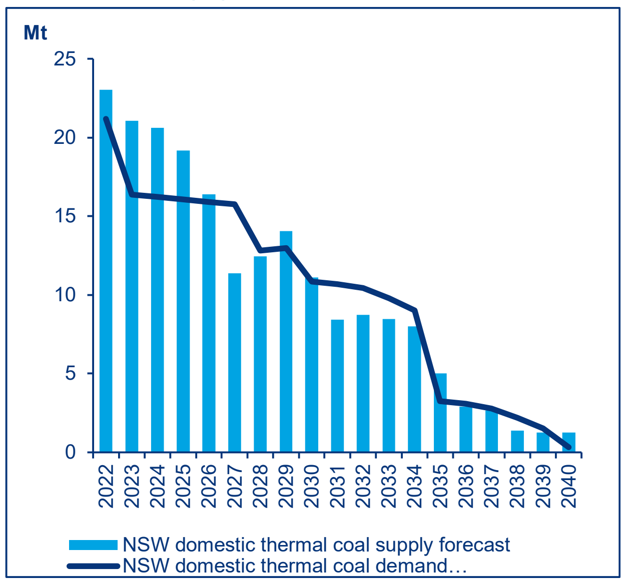
Source: Wood Mackenzie

Figure 9 2022 Aggregated domestic thermal supply by state (Mt)



Source: Wood Mackenzie

Figure 10 NSW domestic thermal coal supply and demand outlook (Mt)



Source: Wood Mackenzie

Table 4 NSW Power Station List

Power station	Owner	Installed Capacity (MW)	Coal (Mt)	Contract mine	Contract Expiry	Comment
Bayswater	AGL Energy	2,690	9.0	Mt Arthur Mangoola	Expired 2019 2024	Expected retirement in 2035

				Wilpinjong	2026	
Liddell	AGL Energy	2,000	4.1	Mangoola Wilpinjong	2024 2026	Expected retirement in April 2023
Eraring	Origin Energy	2,880	7.0	Myuna Mandalong Wilpinjong Mt Owen Mt Pleasant	2022 2022	Expected retirement in 2032
Mt Piper	Energy Australia	1,320	3.5	Springvale	2024	Expected retirement in 2042
Vales Point B	Delta Electricity	1,320	4.2	Mandalong Chain Valley Wilpinjong Mt Owen Mt Pleasant	2022	Expected retirement in 2029 however some proposals to continue operation past 2030

Source: Wood Mackenzie

Historical domestic thermal supply in NSW is shown in Table 5. Over the last 10 years supply has been relatively constant in terms of overall volume although there is variation on an individual mine basis as mines deplete or export focus mines have varied domestic supply on an annual basis. The 'Type' column shows mines that are captive (C), mines that produce more for the domestic market than they export (CE), mines that produce more for the export market than the domestic market (ED) and mines that only export their coal (E).

Table 5 Historical NSW domestic coal supply by mine (Mt)

Mine Name	Type	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Airly	CE					0.08	0.6	0.46	0.49	0.64	0.35	1	1.08	1.02
Angus Place	C	3.3	3.38	3.72	3.97	2.95	0.3							
Awaba	C	0.72	0.86											
Bengalla	ED	0.5	0.2	0.2				0.34	0.65	0.75	0.75	1	1	1
Berrima	C	0.22	0.26	0.2	0.22									
Bulga	ED							0.09	0.52	1.75	1.58	1.1	0.1	1.24
Chain Valley	C	0.1	0.09	0.28	0.46	0.88	0.88	1.2	1.36	0.4	0.79	1.38	1.25	1.4
Charbon	C	0.01	0.03	0.01	0.01	0.05	0.02							
Charbon (Underground)	C	0.05	0.03	0.01	0.01	0.01								
Clarence	ED	0.15	0.15	0.15	0.15	0.15	0.47	0.44	0.19	0.17	0.19	0.18	0.18	0.21
Cullen Valley	C	0.57	0.8	0.53	0.01	0								
Dendrobium	ED	0	0	0	0	0	0	0.03	0.17	0.16	0.03	0.13	0.15	0.1
Hunter Valley Operations	E	0	0	0	0.3	0.3	0	0	0	0	0	0	0.04	0
Invincible	C	1	1	0.83	0.27	0								
Mandalong	CE	4.08	3.69	4.26	3.2	4.51	4.37	4.89	3.89	3.92	2.5	4.1	2.37	2.13
Mangoola	ED	0	0	0	0	1.86	2.61	2.63	2.52	2.74	2.6	1.77	1.49	2
Mannering	C	0.7	0.56	0.42	0	0	0	0.09	0	0	0	0	0	0
Mt Arthur Operations	E	3.5	1.5	1.25	1.39	1.2	1.08	1.32	1.61	1.26	1.52	0	0	0
Mt Owen Complex	ED								0.46	1.22	1.28	0.45	0.01	0.01
Mt Pleasant	ED									0.05	3.41	1.11	0.27	0.25
Muswellbrook	E	0.1												
Myuna	C	1.39	1.59	1.49	1.64	1.87	1.71	1.38	1.8	2.17	1.57	0.97	0.87	1
Narama	E	4.41	3.98	2.53	2.5	1.66								
Newstan Extension	E			0.12	0.2	0.25								
Pine Dale	C	0.29	0.01	0.25	0.29	0.06								
Ravensworth North	ED							0.58	0.41	1.16	1.05	1.2	1.1	1
Springvale	CE	1.71	1.45	0.9	1.05	1.48	1.54	2.97	3.13	3.29	1.7	2.59	1.94	1.84
Tarrawonga	ED	0.04	0.04	0.05	0.06	0.06	0.04	0.06	0.07	0.06	0.06	0.1	0.08	0.05
United	E	0.01												

Warkworth	E	0.6	0.6	0.6	0.6	0.6								
Werris Creek	E												0.03	
West Wallsend	E	0.58	0.83	0.85	0.8	0	0.22	0.76						
Westside	E	0.8	0.91	0.1										
Wilpinjong	CE	5.98	5.21	5.85	7.1	6.96	7	6.6	6.3	7.56	7.25	7	6.96	7

Source: Wood Mackenzie

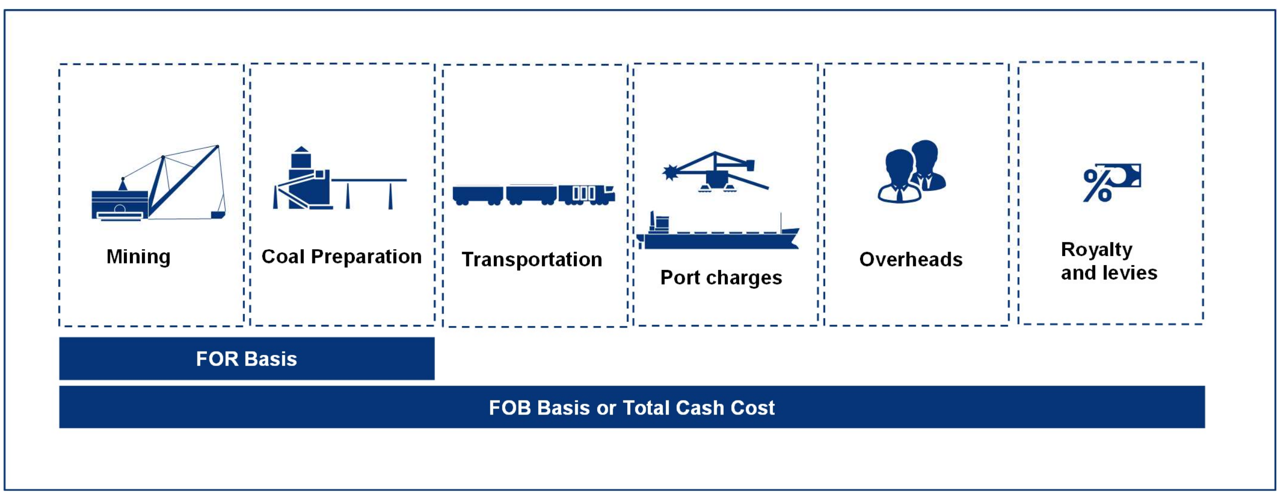
4. Coal costs

4.1 Coal mine cost overview

Costs incurred in producing coal can be grouped into categories based on the point the coal is sold and the point where royalties are applied. Figure 11 sets out the typical categories used in assessing the cost of production for export coal mines.

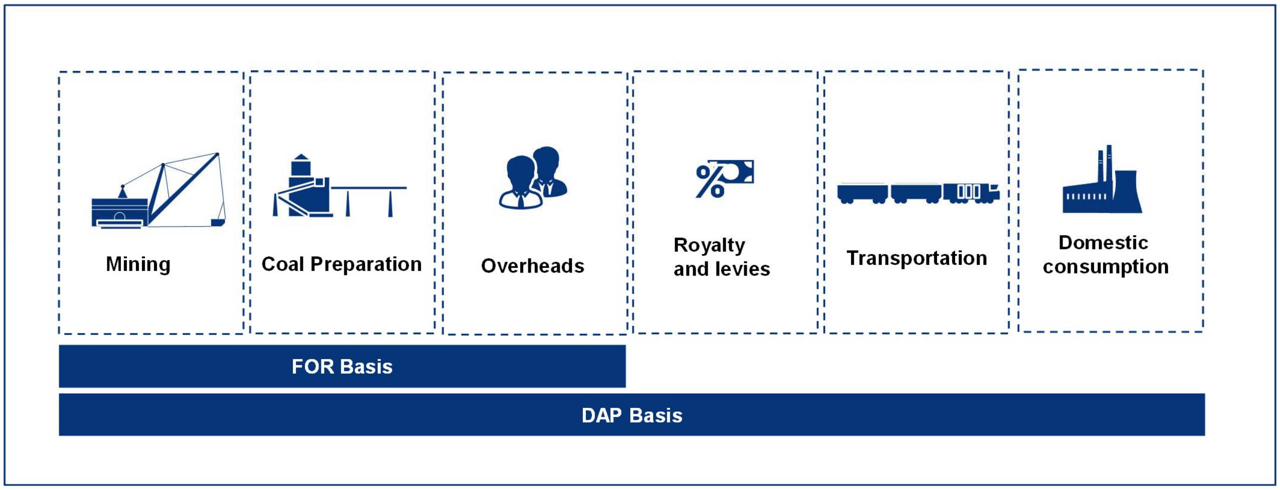
- **Mining** buckets together labour, the direct costs incurred in bringing coal from the pit to the run of mine (ROM) stockpile (such as fuel, explosives, electricity etc) and indirect costs such as rehabilitation.
- **Coal preparation** includes the direct costs of washing the coal and the yield or volume loss.
- **Transportation** to port or power station in NSW includes above rail charges (i.e., the charges levied by the rail service provider to transport the coal) and below rail charges which are levied by the rail track owner.
- **Port charges** include unloading, any blending undertaken at the port and ship loading.
- **Overheads** are charges imposed on the mine from the mine's owner and are typically based on coal marketing that is undertaken at a group level.
- **Royalties and levies**. Royalties include those imposed by the government and vendor royalties which are made by private agreement. Royalties are based on the sale price of the coal. Levies include the research contribution to the Australian Coal Association Research Program (ACARP), the long service leave levy, the safety levy, mine subsidence and mines rescue and the Coal21 fund.
- **Sustaining capital** is the ongoing (annual) capital investment that a refinery must make to continue to operate. This includes maintenance capital and investment required to adapt to regulatory changes.
- **Development capital** is capital required to increase production, or develop a new area of the mine.

Figure 11 Cost structure of export coal mines



Source: Wood Mackenzie

Figure 12 Cost structure of domestic coal mines



Source: Wood Mackenzie

In addition to the categories described above there are a number of points where the coal can change hands - for export coal this point is typically as the coal is transferred over the rail of the ship, also known as free on board (FOB) basis. For domestic coal this is typically when the coal is loaded on the transport to the end user which if the coal is railed this point is termed free on rail (FOR) as set out in Figure 12.

There are some exceptions to the sale point as there are times where the miner organises the transportation to the end user which is termed delivered at place (DAP).

Table 6 sets out estimated weighted average production prices in NSW. 2022 costs are estimated to have risen 16% for all Australian production from 2021 estimates with royalties being the key contributor to the rise. Diesel, electricity, and labour costs were also significantly higher in the second half of the year, together with lower output levels across several mine sites.

Table 6 Weighted average coal costs from NSW domestic thermal coal producers (A$ real)

	Mining ($A/t)	Coal Preparation ($A/t)	Product Transport ($A/t)	Overheads ($A/t)	Royalty and Levies ($A/t)	Total Cash Cost ($A/t)	Margin
2020	42.1	2.51	0.93	3.64	6.1	55.3	18.4
2021	46.5	2.54	0.92	3.41	5.37	58.7	5.56
2022	46.4	2.37	0.92	3.07	6.65	59.4	21.2

Source: Wood Mackenzie

4.2 Costs incurred in coal preparation

Coal preparation is essentially preparing the coal for transportation and end use. There are several stages of preparation and not all coals move through all the stages. These are:

- **Crushing** - the first step in coal processing is crushing the coal into smaller pieces. Crushing allows larger impurities to be removed and also makes the coal less likely to damage infrastructure such as rubber conveyor belts.
- **Screening** - coal is screened to separate out any larger pieces or impurities. This is typically done using a vibrating screen, which separates the coal into different size fractions. Some coals are able to be sold at this point.
- **Washing** - this is typically done using a dense medium separation process, which involves adding a dense liquid (usually a magnetite suspension) to the coal and then separating the coal from the liquid using a cyclone separator. Coal fines can also be collected during this process. Material rejected during this process can be divided into reject – which is sent for disposal and 'middlings' which are comprised of coal that cannot be brought up to the export specification level. While middlings may not meet export quality specifications, they are often suitable for domestic use.
- **Drying** - to removes any remaining moisture. This is typically done using a rotary dryer or fluidized bed dryer.

- **Sorting and stockpiling** - The final step in coal processing is sorting the coal by quality and size. This is typically done using a conveyor belt system, which sorts the coal into different piles based on its properties.

- **Blending** – some mines will blend coals from various pits or seams to ensure specific coal quality requirements are met.

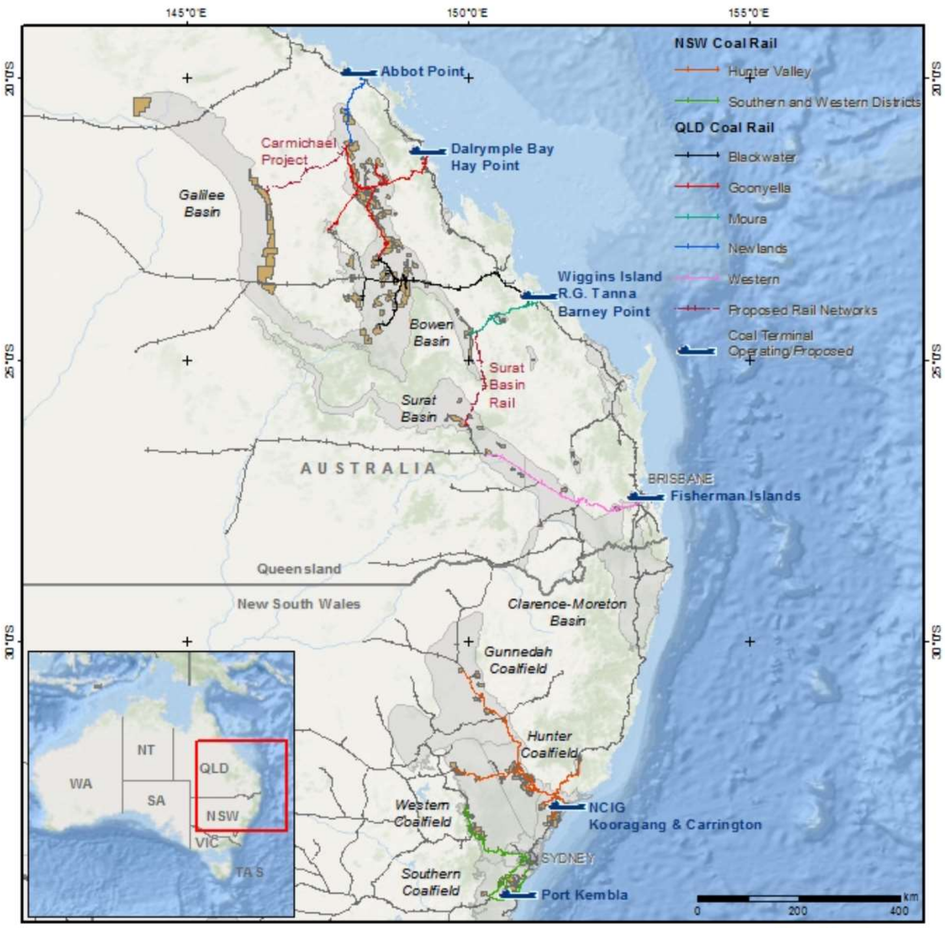
There are only a handful of coals produced in NSW that can meet the benchmark high energy Newcastle export specification without being washed. Coal suitable for domestic consumption is therefore either a primary product, that is raw coal that has been crushed and screened or a secondary product in the form of rejected middlings produced during the preparation of export coal.

5. Coal transportation infrastructure

5.1 Location of Australian coal export ports

Australian east coast coal exports are through nine terminals at six ports, which are serviced by various rail systems. East coast ports are located from Port Kembla in the south to the most northerly, Abbot Point, Figure 13. Most exporting mines have only a single export path (rail system and port) option however a few mines in Queensland can access multiple ports depending on capacity and cost. In NSW the Sydney metropolitan network, while accessible, is a significant barrier for coal mines to access their non-standard port.

Figure 13 Eastern Australia coal infrastructure map



Source: Wood Mackenzie

5.2 Port and Rail Capacity and Expansions

5.2.1 Port Capacity

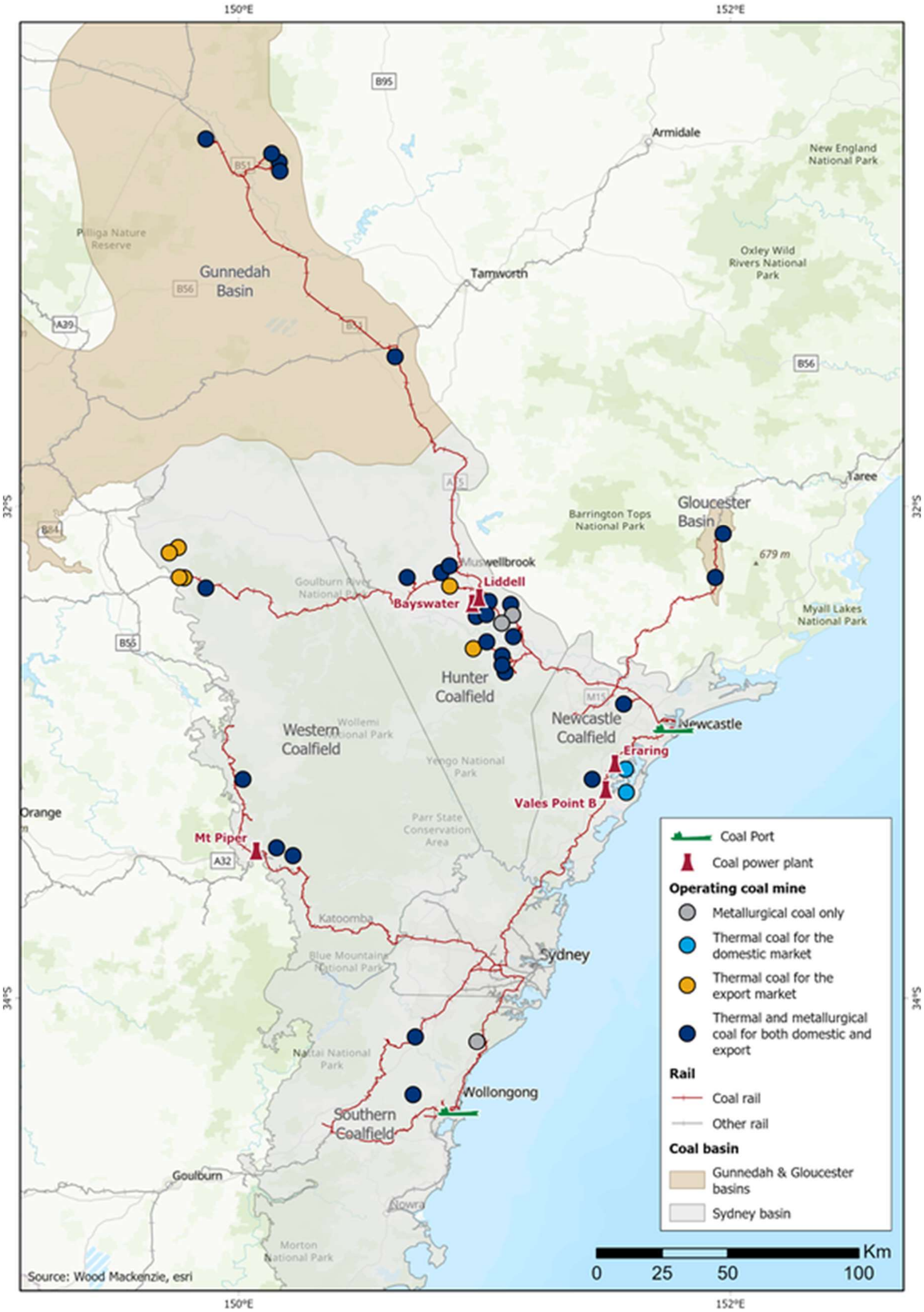
Export port capacity increased rapidly between 2000 and 2015 as demand for Australian coal grew, Figure 15. Capacity additions occurred in both NSW and Queensland with the Port of Newcastle having the highest additional capacity, doubling through the period. Overall, Australia's port capacity increased an additional 259 Mtpa taking total coal port capacity to 531 Mtpa. The last port expansion to occur was at the Port of Gladstone, where the new Wiggins Island Coal Terminal with capacity of 27 Mtpa, started in May 2015. The Hay Point Coal Terminal Expansion was also completed at the end of 2014, increasing capacity there from 44 Mtpa to 55 Mtpa in 2015. In NSW the PWCS T4 expansion has been shelved.

Post 2016 no new capacity has been added and there is unlikely to be any additional port capacity until 2033 when the Adani Carmichael project requires additional capacity at Abbot Point.

5.3 NSW coal infrastructure

Figure 14 below details the producing coal basins in NSW, operating mines, power stations and rail and port infrastructure. In general, domestic coal is sourced from the closest mines and export coal is sent to the closest port via the shortest route to minimise transportation cost.

Figure 14 Coal basin and infrastructure map of NSW



5.3.1 Port of Newcastle

The Port of Newcastle contains three coal terminals: Kooragang, Carrington and the Newcastle Coal Infrastructure Group (NCIG) terminal. Kooragang and Carrington are owned and operated by Port Waratah Coal Services (PWCS), a consortium of New South Wales coal producers and Japanese coal consumers. Glencore and Rio Tinto hold the largest capacity allocation at PWCS.

Carrington is the smallest of the terminals, with a capacity of 25 Mtpa. A shiploader at Carrington was upgraded in 2016, which could increase notional capacity by 5 Mtpa to 30 Mtpa, although approvals are not in place to export beyond 25 Mtpa. Kooragang is the largest of the terminals: it was expanded to 108 Mtpa during 2012, taking total PWCS capacity to 133 Mtpa. The additional expansion at Kooragang was completed in 2013, increasing capacity to 120 Mtpa. Combined PWCS capacity is 145 Mtpa from 2015.

NCIG, Newcastle's third coal terminal, started operating in 2010. It is owned and operated by a consortium of five coal producers: BHP, Banpu, Peabody, Yancoal and Whitehaven. Additional contracted shippers through the terminal include MACH Energy and Idemitsu. The terminal was constructed in stages: it reached full Stage 1 capacity of 30 Mtpa in 2011 and the Stage 2 expansion to 53 Mtpa was completed in mid-2012. NCIG reached nameplate capacity of 66 Mtpa at the end of 2013. In 2020 NCIG received approval to lift capacity at the terminal to 79 Mtpa. Capacity availability at NCIG fell in late 2020 due to damage to a shiploader.

PWCS has explored further expansions in capacity, including obtaining government approvals, but there has been insufficient demand to warrant the build of a new terminal.

5.3.2 Port Kembla

Port Kembla contains a single coal terminal, which is operated by a consortium of coal producers: South32, Banpu, Wollongong Coal (formerly Gujarat NRE), Peabody and GFG Alliance. The terminal exports coal produced in the Western and Southern coalfields.

It has a current capacity of approximately 18 Mtpa. Capacity can be increased further, however all expansion plans are presently on hold given low throughput and utilisation levels.

5.3.3 NSW Rail Networks

There are about 9,400 kilometres of nominal route standard gauge rail across NSW, of which around 6,700 kilometres is operational. The network can be divided into three broad types:

- **Country Regional Network (CRN)** – managed by John Holland. Mt Piper Power Station is located within this Network.
- **NSW Interstate, Hunter Valley, and Metropolitan Freight Networks** – managed by the Australian Rail Track Corporation (ARTC). AGL’s Bayswater and Liddell Power Stations are located within this Network.
- **Metropolitan Passenger Network** – managed by Sydney Trains. Eraring and Vales Pt Power Stations are located within this Network.

Private sector operators provide rail freight services and apply to the three network managers for access.

The Port of Newcastle is serviced by the Hunter Valley rail line. Three branch lines feed the main line: the Ulan line and Gunnedah line which join at Muswellbrook from the west and north-west respectively, and the line from the Gloucester basin, north-west of Newcastle.

The Hunter Valley line is a duplicated rail line which is dedicated to coal between Maitland and Newcastle. Wood Mackenzie estimates rail capacity on the Hunter Valley network as approximately 10% above the declared inbound throughput as reported by the Hunter Valley Coal Chain Co-ordinator (HVCCC). Despite the growth in capacity, the rail network's capacity remains constrained at a number of sections with additional investment by the Australian Rail Track Corporation (ARTC) required.

The Ulan and Gunnedah branch lines are single lines and share with non-coal traffic. Capacity on the Gunnedah Basin line will need to be increased to cater for the planned development of Vickery and further expansion of Maules Creek. Axle loads were increased to 30 tonnes in the first quarter of 2015, and a number of projects including passing loops are planned. Over the longer term duplication of the existing line is the preferred option to increase track capacity across the Liverpool ranges.

Port Kembla is serviced by the western and southern districts rail line. The Western system transports coals from the western coalfield, north-west of Lithgow. The southern system transports coal from mines in the southern coalfield such as Tahmoor and Metropolitan. Rail capacity is expected to remain unchanged at 20 Mtpa.

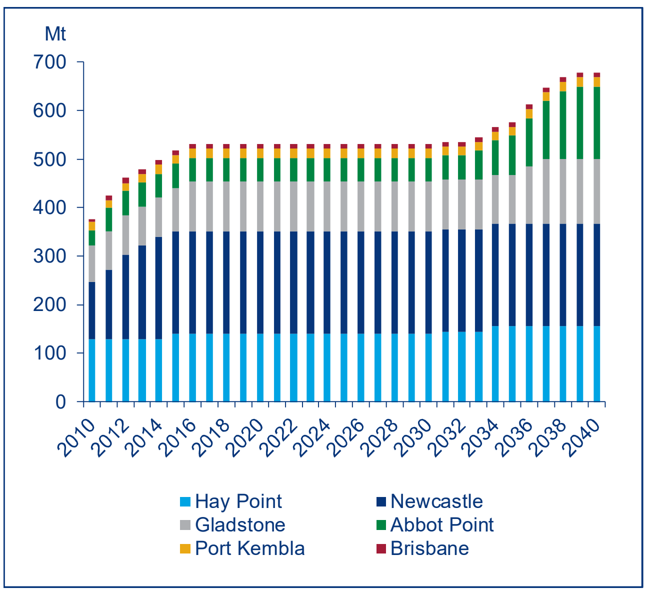
Coal is currently railed through the metropolitan network from the western coalfield to port for export however there are time of day restrictions and speed restrictions limiting volumes. Table 7 details our understanding of the infrastructure at each power station for receiving coal.

Table 7 NSW power station coal handling infrastructure

Power station	Owner	Coal delivery
Bayswater	AGL Energy	Antiene rail unloader allows supply from Mangoola and Wilpinjong.
Liddell	AGL Energy	The Antiene loop faces north – meaning coal from the lower Hunter Valley or Newcastle coalfield is not able to easily supply these plants. The AGL Rail infrastructure is modern and allows for the operation of Export Size Trains (Cargos of circa 8000 tonnes)
Eraring	Origin Energy	Balloon loop (facing north) – has accepted delivery from the western coalfield (Airly) however only in small volumes. There are a combination of dedicated underground and overland conveyors from Mandalong mine to Eraring. The underground conveyors utilise the old workings at Cooranbong mine. The Eraring Rail infrastructure is limited to half export train types with cargos of circa 4000 tonnes.
Mt Piper	Energy Australia	Conveyor from Springvale product stockpile. Mt Piper has no established rail infrastructure of its own but relies on the Rail unloading system at Springvale – owned by Centennial. Mt Piper is linked to the wider NSW rail network through the rail unloader at Springvale on the Western district rail line. The Western system transports coals from the western coalfield, north-west of Lithgow to Port Kembla.
Vales Point B	Delta Electricity	Balloon loop (facing north) – has accepted delivery from the western coalfield (Airly) however only in small volumes. Vales Pt has accepted coal by road in the past. There are a combination of dedicated underground and overland conveyors from Mandalong mine to Vales Pt. The underground conveyors utilise the old workings at Cooranbong mine and a new Delta drift to the surface for the Vales Point connection. The Eraring Rail infrastructure is limited to half export train types with cargos of circa 4000 tonnes.

Source: Wood Mackenzie

Figure 15 Port Export Capacity



Source: Wood Mackenzie

Table 8 East Coast Rail Capacity

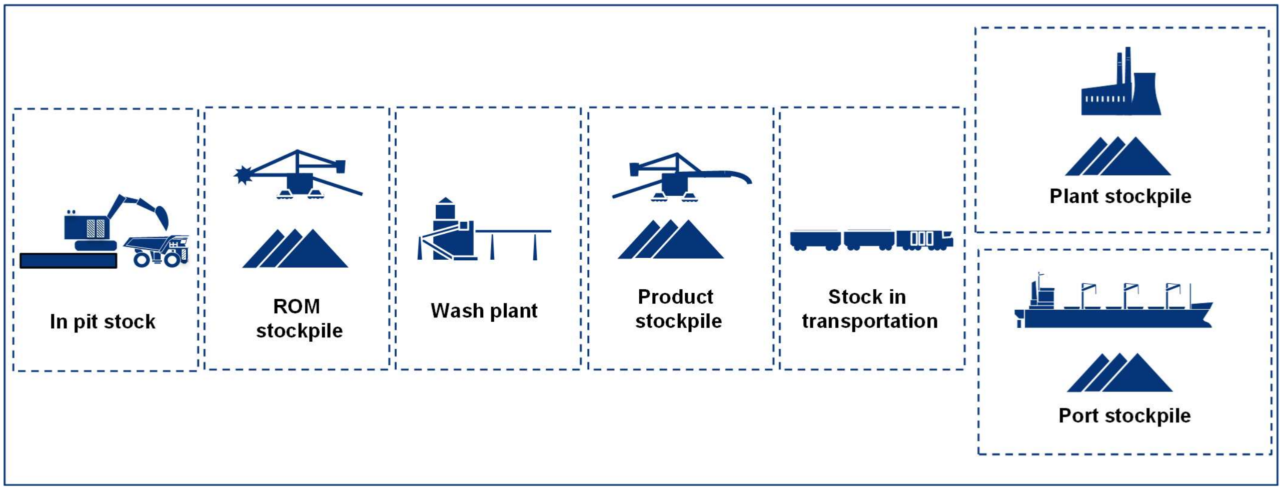
Port	Coal Terminal and Rail System	2020	2025	2030	2035	2040
Qld	Western	9.7	9.7	9.7	9.7	9.7
Qld	Blackwater	105.0	105.0	120.0	135.0	135.0
Qld	Goonyella	140.0	140.0	140.0	140.0	155.0
Qld	Newlands/ Galilee	53.0	53.0	53.0	90.0	90.0
NSW	Hunter Valley Rail	211.0	211.0	211.0	211.0	211.0
NSW	Southern/ Western Rail	20.0	20.0	20.0	20.0	20.0

Source: Wood Mackenzie

5.3.4 Stockpile capacity in NSW

There are no multi-user intermediate coal storage facilities in NSW. The coal industry is geared to be as lean as possible to reduce cost. This in turn means that once coal is delivered to a point rehandling for redirection to a new destination is almost impossible on a technical level and would be prohibitively expensive as the coal would need to be loaded by front end loaders and most likely would have to be trucked to the new destination.

Figure 16 Coal stockpile and handling process



Source: Wood Mackenzie

Stockpiles at mines are sized in proportion to the mines production rate to minimise time product is not being processed or moving towards the point where it is sold so that the investment in producing the coal can be realised as quickly as possible. Stockpiled coal can also be hazardous as once exposed to oxygen in the atmosphere some coals can spontaneously combust. Over time oxidation will also degrade the quality of stockpiled coal. Finally, there are environmental challenges with stockpiles in terms of dust generation and water run off that needs to be carefully managed.

Based on coal production and export statistics current stockpile capacity at mine sites in NSW is around 8% of annual exports. To meet the new requirement of having coal on hand miners will either:

- **Partition** the existing stock yard for the reserved coal and reduce the working area for exports. This will require careful consideration of the mine and sales schedules to ensure stock piling does not become a bottleneck at the site.

- **Increase** stockpile capacity. This will most likely be a variation to the mines permits and will require an engineering study to comply with environmental requirements, registering a variation to the site plan with the relevant authority and has a high likelihood of being challenged on environmental grounds.

5.3.5 Take or pay arrangements

Take or pay contracts are a type of agreement between two parties, such as a coal miner and a transport provider, in which the miner agrees to either use the transport providers infrastructure to transport a certain quantity of coal or pay for it, regardless of whether they actually utilise the infrastructure or not.

In a take or pay contract, the coal seller is obligated to either purchase a minimum amount of transportation capacity, known as the "take" component, or pay a penalty for failing to do so. If the seller does take delivery of the minimum amount, they are still free to purchase additional quantities of the product as needed.

Take or pay arrangements are common in the NSW coal value chain between coal miners and rail companies, coal miners and ports and between coal miners and domestic power stations. In all these examples the take component is on the miner except for the last example where the buyer i.e., the power station has the ‘take’ part of the contract.

6. Approaches to determining fair margin

The Australian Energy Regulator ("AER") has instructed us that the relevant fair margin should be defined as:

1. The fair margin relates only to domestic thermal coal production, in line with the type of coal shipments covered by the Direction.
2. The fair margin definition should be complementary to our assessment of production costs, with no double counting (or omission) of relevant costs.
3. The fair margin is consistently defined as a sector-wide benchmark, applied equally across all firms.
4. A practical and streamlined margin assessment is preferable to a margin calculated through a process involving a materially greater regulatory burden.
5. The fair margin reflects the margin on existing investments— with the intention that it is to support the ongoing operation of the coal mines named in the Direction.
6. In the context of this intervention, the fair margin reflects the long-term average, to provide a stable margin that would apply regardless of the movement in future commodity cycles.

In this section we provide advice on how a fair margin might be estimated that aligns with this definition ("Fair Margin").

In Wood Mackenzie's experience, mining companies typically choose to invest in and manage their businesses based around well-established principles of profitability including what they and their supporters view as an appropriate return on investment. The specific rates of return targeted by each company vary significantly depending on the perceived risks and can change over time as the risk profile of the investment changes.

Traditionally companies and regulators commonly look towards the estimated Weighted Average Cost of Capital (WACC) associated with the investment to help set minimum expectations regarding the required rate of return, pricing and indirectly, margins. Key drivers of WACC include the cost of debt, cost of equity and the associated volatility of profits. This approach and derivatives of it are naturally more complex than the approaches instructed by the AER under these directions.

While WACC calculations are helpful in assessing a minimum required rate of return, in practice, most Australian mining companies tend to use alternative approaches in setting their required rate of return for investment and ownership. These alternative methods include the company determining their own discount rate based on their own assessment of the risks they face; using WACC plus a further risk premium; previous experience; or a discount rate representative of a related industry, or an industry perceived to be similar. Usually there is little transparency in how each company sets its own rate or what that rate is. Through Wood Mackenzie's discussions with the coal mining companies it follows and investment banks involved with the industry, it has determined that an appropriate discount rate for both investment and ongoing support of Australian coal mines is currently around 15% (real) and in some cases, may be as high as 20-30% (real) for investment purposes. Should an assessment of Fair Margin be done using this approach (outside of the scope of this assignment), Wood Mackenzie believes a real rate of approximately 15% would be appropriate.

Considering our instructions, Wood Mackenzie has reviewed its historical data on NSW domestic coal production, costs and prices and has determined that it is appropriate to conduct the Fair Margin analysis for the period inclusive of calendar years 2016 through to 2021. This period is believed to extend across a time span representative of a typical commodity price cycle, commonly thought of as 6-7 years, albeit it excludes the most recent 15 months of the cycle where coal prices are likely to have reached their near-term peak. The last 15 months of this cycle are viewed as being exceptionally unusual and warranting exclusion from the Fair Margin analysis.

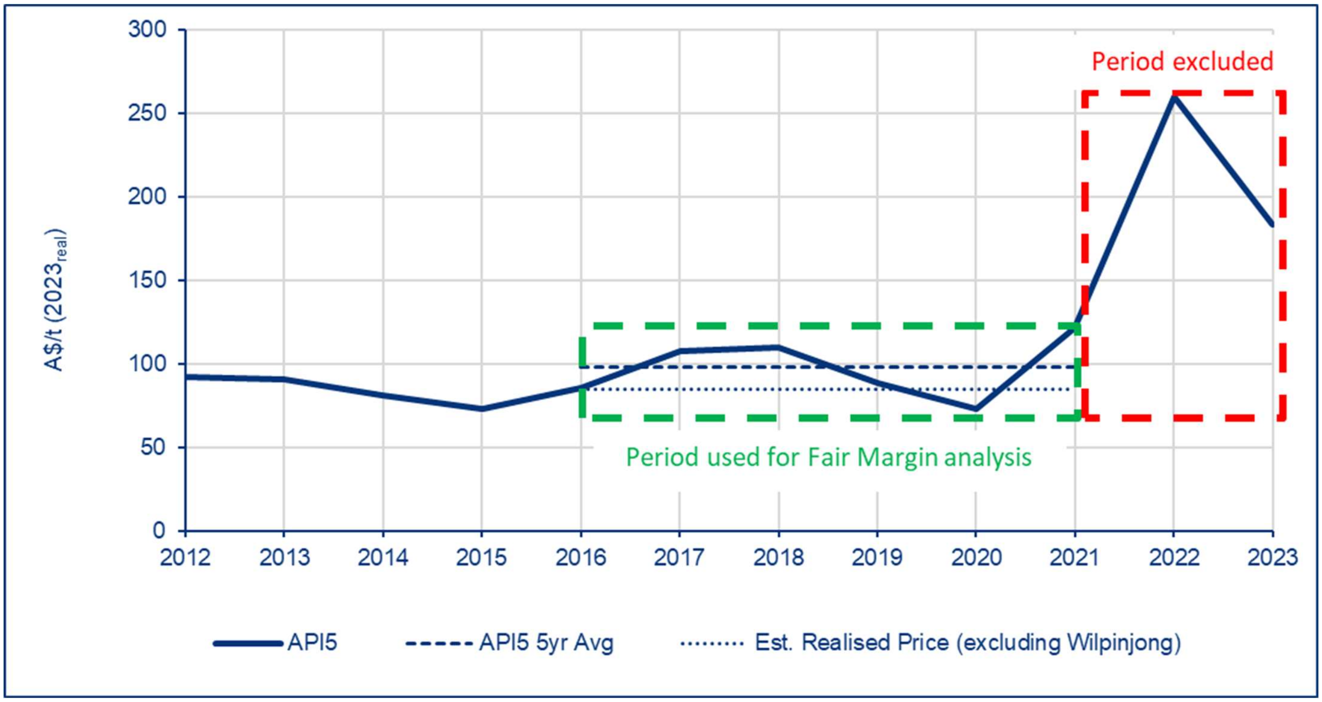
Wood Mackenzie utilises a range of reported and unreported data to obtain information on mine costs and realised prices. Cash costs included in the analysis cover direct cash costs associated with production e.g. coal mining and processing, logistics e.g. conveying or railing, selling, head office cash costs, and royalties. Further details of Wood Mackenzie's approach are provided in Appendix 1. Third party sources of information relevant to our NSW domestic coal production and cost analysis include:

- NSW Coal Services (for information on marketable production, yield, strip ratio, productivity, employees)
- Company annual, half yearly and quarterly production and financial reports, including associated presentation material
- Company sustainability reports and other environmental documentation (e.g. annual environmental management reports)

- Direct meetings with producers to obtain feedback on assessed costs and margins.

Figure 17 highlights the position of the Fair Margin analysis period in context of the last two cycles and shows the API5 (5,500 kcal/kg NAR) export coal price relevant to NSW during this period, its average, and the estimated average price NSW domestic coal producers, excluding Wilpinjong achieved. Wilpinjong's coal pricing is excluded from this average as it is a particularly large, low-cost producer and is understood to be able to price its domestic coal differently from other suppliers.

Figure 17 API5 price history



Source: Wood Mackenzie

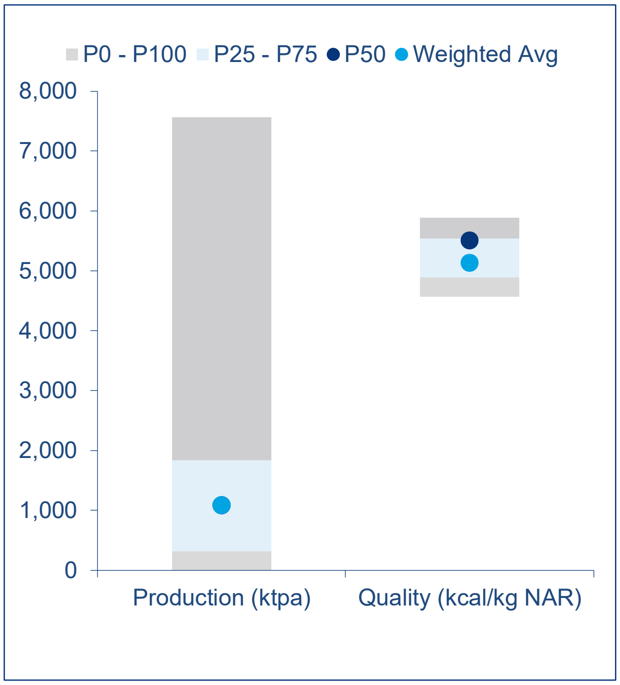
Wood Mackenzie recommends that the Fair Margin analysis be conducted using costs and pricing data based in real 2023 terms, to help ensure the data being used is comparable and reflective of the business environment faced during the term of the directions. As such, the analysis completed as part of this project has been done using real 2023 terms (1 January 2023).

In determining a Fair Margin, Wood Mackenzie suggests basing it in dollar per tonne terms rather than percentages. A common margin based on percentages has the benefit of providing each producer with a return commensurate with their own unique cost structure that would more easily deliver a common rate of return on investment across the industry but provides little incentive for each producer to operate efficiently. Rather, a margin based on dollar per tonne terms is both easier to understand and apply and provides a much stronger incentive for producers to operate efficiently, in turn, likely saving on costs associated with these directions.

Following the instruction that the fair margin is consistently defined as a sector-wide benchmark applied equally across all firms, Wood Mackenzie recommends that all producers supplying domestic coal to NSW during the 2016-2021 period be included in the determination of the Fair Margin. This would help ensure equality and alignment of Fair Margin across the industry with historical norms (i.e. industry compensation under a Fair Margin is aligned, in aggregate, with the past) but will result in some individual producers receiving lower or higher margins compared to the situation without application of a Fair Margin. Figure 21 illustrates the level of margin difference individual suppliers could have expected should a Fair Margin have been set at the average margin achieved by the industry during that period. Setting a Fair Margin in dollar per tonne terms also helps ensure that low profitability, or moderately loss-making suppliers, have better prospects of staying in business during the term of the directions, effectively helping secure diversity of coal supply for local electricity generators.

Figure 18 through Figure 21 below summarise some key outcomes from the Fair Margin analysis. The 143 Mt of domestic coal estimated to have been sold during this period averaged 5,134 kcal/kg (NAR), materially below the specification targeted under these directions. On average, each mine supplied approximately 1.1 Mtpa, with Wilpinjong being the largest producer, supplying approximately 6.9 Mtpa on average, or about 29% of the total domestic coal delivered. Real costs increased by A$17.9/t, a rate of 7.5% CAGR, and are likely to have increased at a noticeably faster rate since the end of the Fair Margin analysis period (31 December 2021). Correspondingly, real margins decreased over the period but at a much faster rate of -23% CAGR, particularly affected by unusually low margins at Wilpinjong in 2021. The average real margin on a 5,500 kcal/kg NAR basis (done to align the actual calorific value of the coal produced with the coal specification under the directions) for all NSW domestic coal sold during the period was A$21.7/t.

Figure 18 Production and quality

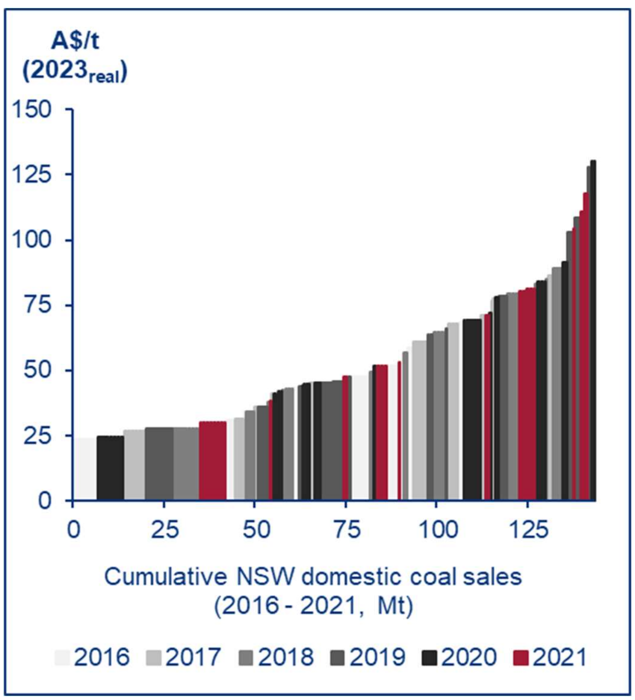


Source: Wood Mackenzie

Figure 19 Cost price and margin analysis

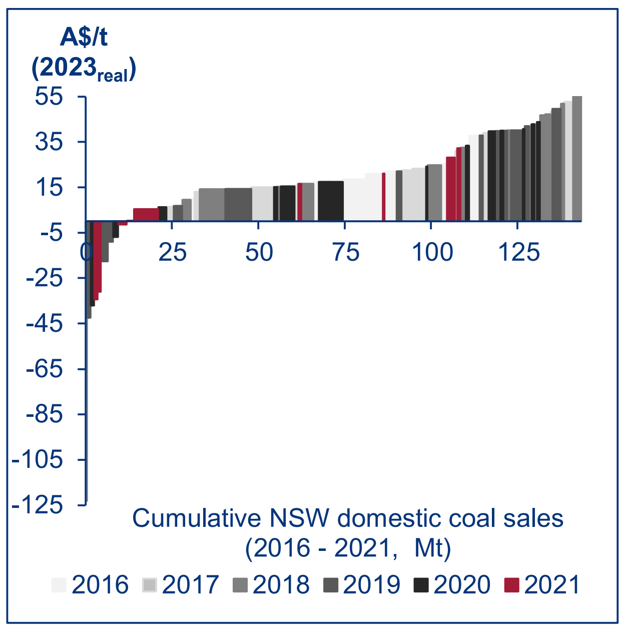
Source: Wood Mackenzie

Figure 20 Domestic supply cost curve



Source: Wood Mackenzie

Figure 21 Domestic supply margin curve



Source: Wood Mackenzie

Finally, Wood Mackenzie recommends that the level of Fair Margin be set such that domestic coal suppliers are compensated enough to provide a fair return to their investors without providing them with abnormally high or super profits. By excluding the period post-

2021, most of this risk is already removed. A significant portion of the residual risk can be removed by targeting a Fair Margin close to what the industry achieved as a whole during the analysis period as it is believe that the margins the industry made during that time were high enough to encourage businesses to stay in operation without promoting large-scale, unsustainable development.

Following the recommended approach and based on the analysis conducted over the review period, Wood Mackenzie recommends that a Fair Margin of approximately A$21.7/t for 5,500 kcal/kg (NAR) coal be applied to each suppliers' costs.

Anecdotal (albeit dated) examples of mines supplying domestic coal in Australia via cost plus contracts suggests long established miners originally received between 3% and 7% premiums on their cash operating costs with the higher percentage going to captive mines unable to access the more profitable export markets and lower margins going to mines focused on exporting and who could sell low cost 'reject' material to the domestic market. These examples are from the period where coal miners were able to access much lower cost capital and when expected returns from investors were also materially lower. They are not expected to be relevant to today's environment.

7. Wood Mackenzie coal research methodology summary

The aim of Wood Mackenzie's coal/metals mine reports is to provide a detailed review of the key technical, commercial and economic issues surrounding the historic and future development of a mine.

Wood Mackenzie's approach to producing its reports is to conduct primary research, supported by a range of data and information available in the public domain and our in-house deep industry and regional knowledge. This allows us to generate high-quality proprietary information and analysis, using our proprietary models, and insightful commentary on all major mine developments around the world.

Wood Mackenzie's research analysts conduct extensive and detailed research into their respective focus areas. We use a wide variety of sources, but we do not purchase data other than from entities which own the data and are entitled to sell it to us.

7.1 Internal data sources

Our research uses our propriety databases and costing models which have been built up over many years of industry research and analysis.

7.2 External data sources

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

Information source	Description
Interviews with mining company and government conta	Wood Mackenzie aims to conduct mine visits and interact with operators on an annual basis in all regions and countries. If possible this interaction is extended to all of the other non-operating company participants in any mine or development. In addition meetings are held with contacts in the relevant government and regulatory organisations.
Government publications and other regulatory informati	In many countries the relevant regulatory authorities publish an annual review of mining activities that have taken place each year in that country. This may contain for example details of new licences awarded, production levels, and any new legislation impacting the sectors. We also review other regulatory authority information, such as websites, press releases and historical databases.
Company annual reports and other company document	Wood Mackenzie regularly reviews all key company annual reports, investor presentations and SEC or other stock exchange (e.g. ASX, SEDAR) filings. In addition, we review other company sources of information, such as websites and press releases.
General and industry-specific media	Our analysts regularly review general media and a wide variety of industry-specific publications.

7.3 Data validation

Our data are subject to a rigorous integrity checking and quality control process. We have developed a comprehensive set of checks, which are carried out on a regular basis, at a mine, country, regional and global level.

In addition to the checking and validating process for each individual asset, Wood Mackenzie's analysts perform holistic checks on the sector, country or region to ensure consistency and feasibility. For example, a number of mines in an area may be competing for development or production expansion, but concurrent development of all of them as predicted by their respective owners may be unfeasible. This might be due to the lack of available market demand, or the constraining limits of export infrastructure capacity. In such instances, Wood Mackenzie's regional experts will make their own assessment as to the likely schedule of developments and adjust the various project parameters in our analyses accordingly.

7.4 Updating process

Wood Mackenzie focuses its research and updating processes with the aim that each impactful mine will be updated at least annually. In performing these updates, we generally work to quarterly publication deadlines, although analyses may be published at any time throughout the year. We prioritise our updates based on a number of factors, including the last publication date, the level of client interest and the scale of individual asset developments.

Wood Mackenzie also aims to update a proportion of its analyses more frequently than annually. These updates will usually focus on, for example, assets that have been materially affected by a significant event or areas of higher client interest.

To support our updates, research activities by the various regional teams occur continually throughout the 12-month period to fit in with access to the various research sources. For example, the information contained in company annual reports and government publications is collated as and when those documents are published. Hence, at the start of a particular update, a certain amount of information on the sector and individual assets will already have been gathered. Wood Mackenzie's analysts then commence the detailed research and updating processes specific to the relevant asset.

7.5 Analysis validation

Using all possible published (i.e. publicly available) information together with information gathered from company interviews, Wood Mackenzie's analysts complete a draft of each mine analysis. In an important part of the updating process, where possible, these drafts are forwarded to each operator, and very often to the other non-operating company participants in any particular mine, for their comments. This stage of the process is designed to ensure that each analysis is as accurate as possible, within the limits of what may be differing interpretations of a particular development amongst the various equity holders. It should be stressed that the final analysis produced is Wood Mackenzie's view of the most likely development of an asset and may not necessarily reflect the view of the operator, partners or other parties.

7.6 Capital and operating costs

Wood Mackenzie develops capital and operating expenditure forecasts associated with our view of production and mine life for an asset or group of assets.

Capital expenditure (capex) costs are broken down into development or expansionary capex, and sustaining capex required to maintain production. Development or expansionary capex is further broken down, where appropriate, into exploration and acquisition costs, mining development works, mining equipment, handling facilities, processing plants, general infrastructure, transport infrastructure, any other capital costs, and finally any closure or final rehabilitation costs.

Operating costs are estimated for mining operations based on paid production rather than sales volumes. Allowance for co-products or by-product revenue is also made, with unit costs presented either on a normal or pro-rata basis. Under normal costing, full operating costs are allocated to the commodity under analysis and net by-product revenue is credited to give a net cash operating cost. On a pro-rata basis, the operating cost is shared amongst different metals according to their contribution to net revenue.

Operating costs are divided into direct cash costs and indirect cash costs. The cost definitions used in the coal/metals mine research are shown below.

Cost	Description
C1-	The direct cash cost associated with the mining, processing and transport of the marketable product. Includes general and administration overhead costs directly related to mine production.
Total cash cost	The direct cash cost (C1-) plus royalty, levies and other indirect taxes (excluding profit related taxes).

Sustaining capital expenditure can be added to the total cash cost to give a full cash cost measure. Cash margins are analysed on different levels according to need. Common points are a M1 basis (revenue less C1™ costs), operating basis (revenue less total cash cost), or on a full cash cost basis (revenue less total cash cost plus sustaining capex.

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Wood Mackenzie

Wood Mackenzie™ is the trusted provider of data, analytics, and insights, establishing us as the global research and consultancy business powering the natural resources industry. Our dedicated oil, gas & LNG, power & renewables, chemicals, and metals & mining sector teams are located around the world, giving our clients first-mover advantage. **For more information visit: woodmac.com**

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