Carbon Performance assessment of coal mining companies: discussion paper

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Transition Pathway Initiative

LSE

Grantham Research Institute on Climate Change and the Environment

About the Transition Pathway Initiative Centre

The Transition Pathway Initiative Centre (TPI Centre) is an independent, authoritative source of research and data on the progress of corporate and sovereign entities in transitioning to a low-carbon economy.

The TPI Centre is part of the Grantham Research Institute on Climate Change and the Environment, which is based at the London School of Economics and Political Science (LSE). It is the academic partner of the Transition Pathway Initiative (TPI), a global initiative led by asset owners and supported by asset managers. As of September 2023, 142 investors globally, representing around US$50 trillion combined Assets Under Management and Advice, have pledged support for TPI. Using companies' publicly disclosed data, the TPI Centre:

- Assesses the quality of companies' governance and management of their carbon emissions and of risks and opportunities related to the low-carbon transition, in line with the recommendations of the Task Force on Climate-related Financial Disclosures (TCFD).
- Assesses whether companies' current and planned future emissions are aligned with international climate targets and national climate pledges, including those made as part of the Paris Agreement.
- Provides the data for the Climate Action 100+ Net Zero Company Benchmark.
- Publishes its methods and results online and fully open access at www.transitionpathwayinitiative.org and on GitHub.

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Executive summary

The coal mining sector is particularly significant to both investors and to climate change: the world's 20 largest publicly-listed coal mining companies had a market capitalisation of over US$514 billion in 2022,[1] while more than 40% of global energy and industrial carbon dioxide (CO_2) emissions came from coal combustion in 2021 [1]. Most of the coal-mining sector's emissions are therefore driven by downstream (Scope 3) emissions, i.e. those generated from the use of sold products.

Coal mining is distinct from other sectors as there is limited scope for companies to expand their traditional business while seeking to align with low-carbon scenarios. In the International Energy Agency's (IEA) Net Zero Emissions by 2050 Scenario ('NZE'), global production of thermal and metallurgical coal falls by 91% and 88% respectively between 2021 and 2050 [1]. This implies that coal mining companies will have to fundamentally reduce their coal output to align with a 1.5°C global warming scenario.

There are two main decarbonisation strategies for companies to achieve this: they can diversify their product portfolio away from coal assets; or they can wind down their 'pure-play' coal business by focusing solely on the reduction of coal production. While diversification strategies can be assessed with the TPI Centre's diversified mining methodology [2], this paper proposes a methodology with which to assess the wind-down strategies of coal mining companies.

To assess the carbon performance of coal mining companies (thermal and metallurgical), we introduce a new Emission Contraction Approach (ECA), which focuses on the rate at which coal mining companies should reduce their carbon emissions in line with global emission reduction targets. This is distinct from the TPI Carbon Performance assessments in other sectors which rely on emission intensity pathways (looking at emissions per unit of output) based on the Sectoral Decarbonisation Approach (SDA). An emission intensity approach in the coal sector would largely resemble a flat line, because the gradual shutting down of coal assets would cause coal production and related emissions to fall in parallel. In contrast, the ECA assesses coal mining companies' emission reduction plans based on absolute emissions.

As thermal coal (primarily used for energy/heating) and metallurgical coal (primarily used for steelmaking) are expected to be phased out at different speeds, these two types of coal are assessed separately. Companies' emission pathways for thermal and metallurgical coal are indexed to a 2021 baseline and compared with three benchmark emissions pathways that reflect the goals of the 2015 Paris Agreement on climate change: 1.5°C; Below 2°C; and National Pledges scenarios.

To test the ECA, we apply the methodology to five pure and diversified coal mining companies: BHP, Glencore, Vale, Coal India and Jardine Matheson, finding a range of levels of alignment in their emissions pathways.

The assessment shows that only Vale is aligned with 1.5°C in the short (to 2025), medium (to 2035) and long term (to 2050), having completely disposed of its coal assets in 2022. While this divestment does not necessarily guarantee real-world emission reductions, it lowers Vale's transition risk arising from coal exposure. By divesting its coal assets and ceasing coal operations, Vale can be removed from the TPI Centre's coal sector altogether in future assessments.

BHP's emission reduction targets align with a 1.5°C scenario in the long term and with Below 2°C in the short and medium term for both types of coal. Glencore's targets align with 1.5°C in the short term and Below 2°C in the medium and long term, but only for metallurgical coal. Coal India and Jardine Matheson do not align with 1.5°C at any of the three points in time.

Figures ES1 and ES2 below show the results for thermal and metallurgical coal respectively.

[1] Based on data provided by FTSE-Russell.

Figure ES1. Thermal coal emission pathways for five focus companies up to 2050

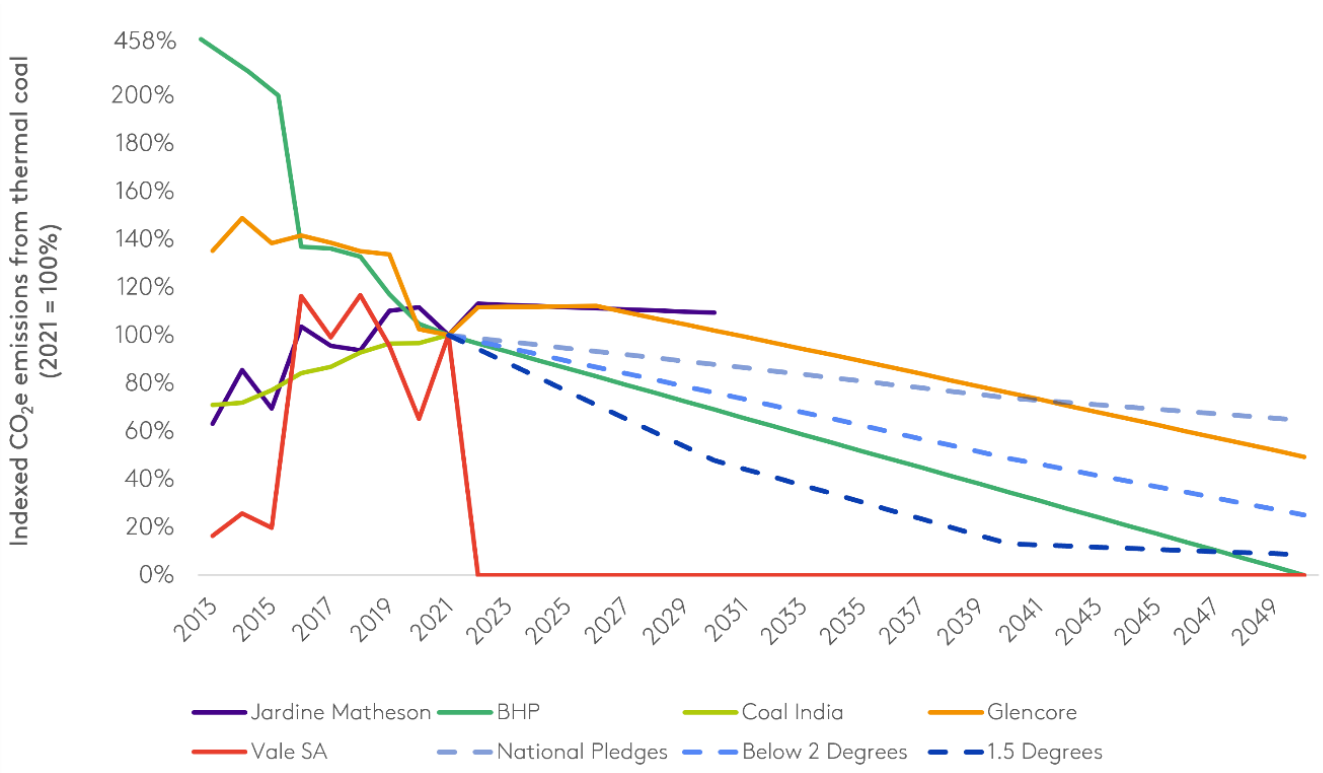
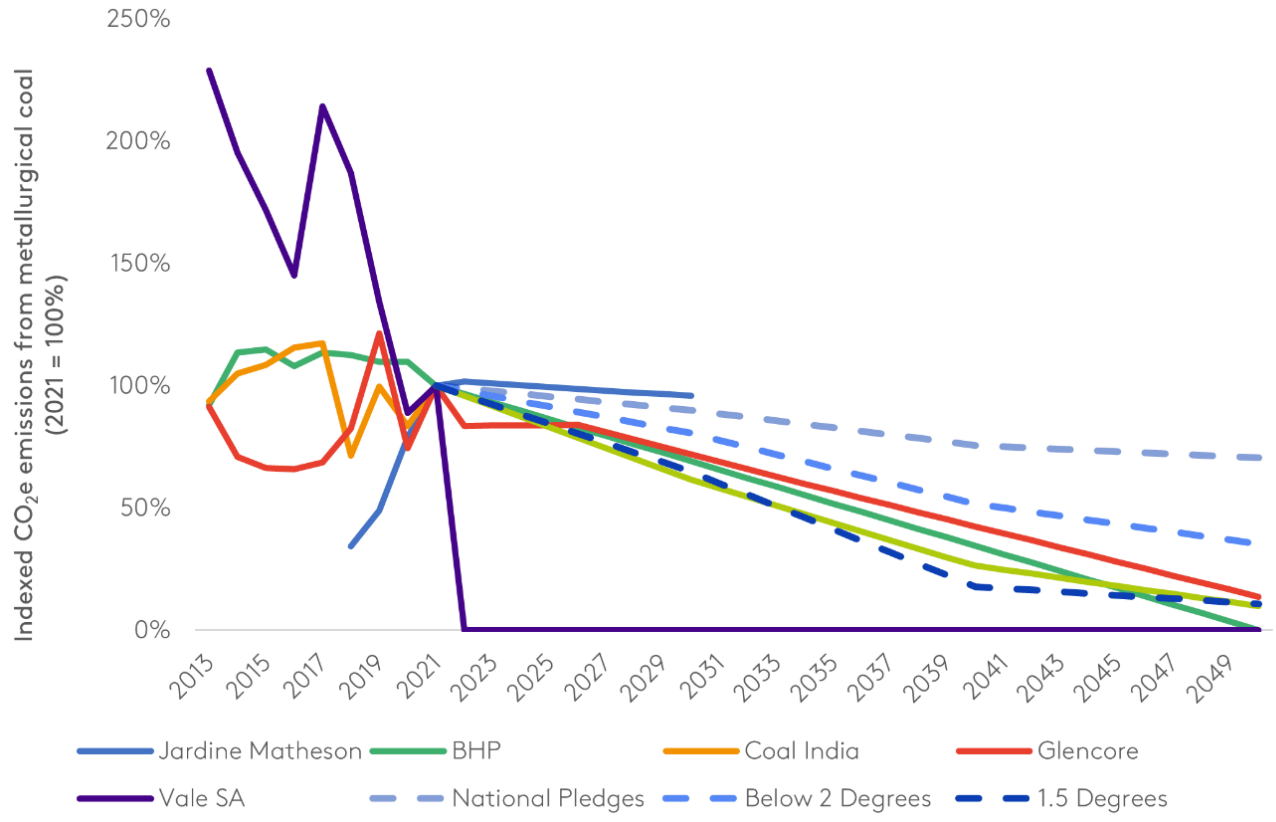


Figure ES2. Metallurgical coal emission pathways for five focus companies up to 2050



1. Introduction

This discussion paper provides an overview of the new methodology developed by the TPI Centre to assess the carbon performance of coal mining companies.

To date, the TPI Centre has developed methodologies to assess the carbon performance of 11 high-carbon sectors, including electricity utilities, oil and gas, food, high-carbon industrial and transport sectors. The methodology proposed in this paper enables the assessment of the decarbonisation pathways of coal mining companies according to their specific characteristics, which vary in comparison to other sectors. It also provides an initial assessment of a small sample of companies as a proof of concept. The TPI Centre is publishing it now is to solicit feedback from interested parties, with the aim of improving the methodology further.

2. Conceptual approach to assessing the coal sector

Coal mining is the first sector for which the TPI Centre will carry out a Carbon Performance assessment based on absolute emissions (the volume of greenhouse gases released into the atmosphere) as opposed to emissions intensity (the volume of greenhouse gases generated per unit of economic output). This section summarises the reasons for this, and why we propose a new method, the Emissions Contraction Approach (ECA), for the assessment of the coal mining sector.

2.1. The Sectoral Decarbonisation Approach

For all sectors covered to date, the TPI Centre's Carbon Performance assessments have been based on the Sectoral Decarbonisation Approach (SDA), which adopts an emissions-intensity approach [3]. The SDA translates greenhouse gas emissions targets made at the international level (e.g. under the Paris Agreement to the UN Framework Convention on Climate Change) into appropriate benchmarks, against which the performance of individual companies can be compared.[2]

The SDA is built on the principle of recognising that different sectors of the economy (e.g. food production, electricity generation and automobile manufacturing) face different challenges arising from the low-carbon transition, including where emissions are concentrated in the value chain and how costly it is to reduce emissions. The SDA therefore adopts a sector-by-sector approach, comparing companies within each sector against each other and against sector-specific benchmarks, which establish the performance of an average company that is aligned with international emissions targets.

The SDA can be applied by taking the following steps:

- A global carbon budget is established, which is consistent with international emissions targets, for example keeping global warming below 2°C. To do this rigorously, some input from a climate model is required.
- The global carbon budget is allocated across time and to different regions and industrial sectors. This typically requires an Integrated Assessment Model, and these models usually allocate emission reductions by region and by sector according to where it is cheapest to reduce emissions and when. Cost-effectiveness is, however, subject to some external influences such as political and societal preferences, and the availability of capital. This step is therefore driven primarily by economic and engineering considerations, but with some awareness of political and social factors.
- In order to compare companies of different sizes, sectoral emissions are normalised by a relevant measure of sectoral activity (e.g. physical production, economic activity). This results in a benchmark pathway for emissions intensity in each sector:

$$\text{Emissions intensity} = \frac{\text{Emissions}}{\text{Activity}}$$

  Assumptions about sectoral activity need to be consistent with the emissions modelled and therefore should be taken from the same economy–energy modelling, where possible.

[2] Another initiative that is also using the SDA is the Science Based Targets Initiative (SBTi): http://sciencebasedtargets.org/.

- Companies' recent and current emissions intensity is calculated, and their future emissions intensity is estimated based on the emission targets they have set (this assumes companies meet their targets).[3] Together, these establish emissions intensity pathways for companies.
- Companies' emissions intensity pathways are compared with each other and with the relevant sectoral benchmark pathway.

2.2. The Emission Contraction Approach

Decarbonisation pathways for coal mining are characterised by a steep decline in coal production. In the International Energy Agency's (IEA) Net Zero by 2050 scenario, global production of thermal and metallurgical coal falls by 91% and 88% respectively between 2021 and 2050. This implies that both types of coal mining companies will have to significantly reduce their coal output.

Coal mining companies can adopt one of two main decarbonisation strategies: they can diversify their product portfolio away from coal assets, or they can wind down their 'pure-play' coal business, i.e. that which focuses on the reduction of output rather than diversification. Diversification strategies can be assessed with the TPI Centre's diversified mining methodology [2], which is based on the SDA, as outlined above. However, for wind-down strategies, an Emission Contraction Approach (ECA) is more appropriate as coal production and Scope 1–3 emissions would reduce roughly proportionally. There would therefore be hardly any change to a company's emissions intensity; the intensity pathway would resemble a flat line. Some reduction in emissions intensity could be achieved by abating operational Scope 1 and 2 emissions, but since these emissions account for a small share of coal miners' total carbon footprint (see Section 3.3.), the impact would be small.

Like the SDA, the ECA is based on sectoral carbon budgets that are derived from an Integrated Assessment Model. However, instead of dividing the sectoral carbon budget by a sector-specific activity metric, the benchmark pathways represent the relative (percentage) change in absolute emissions. The relative change in companies' absolute emissions is then compared with the absolute emissions reduction rate in low-carbon benchmark scenarios.

The ECA is intended to respond to the question of managed phase-outs, which has been raised by different investor alliances such as the Glasgow Financial Alliance for Net Zero (GFANZ) and the Institutional Investors Group on Climate Change (IIGCC) [4; 5]. The ECA is not the first method to assess companies' transition efforts on the basis of absolute emissions, however. The Sciened-Based Targets initiative (SBTi) uses a similar method, the Absolute Contraction Approach (ACA), to assess absolute Scope 1 and 2 (and in certain cases also Scope 3) targets [6]. The key difference is that the ACA applies an economy-wide emissions reduction rate to all sectors while the ECA is based on a sector-specific carbon budget.

2.3. The complementarity of absolute and intensity approaches

Absolute emissions approaches, such as the ECA, and emissions intensity approaches, such as the SDA, each come with their own strengths and limitations. They should not be seen as mutually exclusive, but rather as complementary methods for assessing companies' alignment with climate targets.

The benefit of emissions intensity as a metric is that it enables companies' carbon footprints to be compared, controlling for the important factor of company size. Absolute emissions are strongly correlated with company size, so comparisons between companies using this metric can be more reflective of their relative size than how carbon-efficient their production activities and products are. The SDA was developed to extend the emissions intensity approach from historical and current assessments of carbon footprints to the ambition of future targets. By requiring greater emission reductions from companies with higher starting intensities, it puts the onus on the most carbon-intensive companies to act. Furthermore, by assuming emission reductions are cheaper the more carbon-intensive a company's starting point is (because the easy and cheap measures have not yet been deployed), it also promotes overall economic efficiency. Another factor to consider is that companies undergo structural changes over

[3] Alternatively, future emissions intensity could be calculated based on other data provided by companies on their business strategy and capital expenditure plans.

time. Acquisitions and divestments – and wider market fluctuations – can result in important changes in companies' absolute emissions. While intensity pathways are not immune to such impacts, they tend to be less volatile as they normalise emissions relative to activity.

However, as mentioned above, intensity approaches are unsuitable for assessing the ambition of company strategies involving the winding down of high-carbon assets and reducing carbon-intensive production, because both emissions and activity would fall in concert. In addition, intensity approaches do not necessarily guarantee that overall absolute emissions stay within the global carbon budget that is set by the relationship between carbon emissions and temperature rise. While the SDA derives emissions intensity benchmarks from calculating forecasted activity in relation to absolute emissions, the global carbon budget could be breached if overall activity grows faster than projected. Absolute emissions approaches ensure that companies meet their targets by directly reducing their total carbon footprint. If all companies align with a climate target through the ECA, the underlying carbon budget cannot be exceeded, as all companies are required to reduce their absolute emissions at the same rate.

In conclusion, the choice between an absolute and an intensity approach depends on several factors, such as the goal of the analysis and the characteristics of the sector. Absolute and intensity approaches can be used in combination to evaluate companies' transition efforts. For example, diversified mining companies involved in coal mining can be assessed using the SDA for their overall portfolio, while the ECA can be employed for a specific assessment of their coal business.

3. Applying the Emission Contraction Approach to the coal mining sector

3.1. The coal mining sector's role in climate change

The coal mining sector is globally significant – not only in terms of carbon emissions, but also its economic weight: the combined market capitalisation of the 20 largest coal miners amounted to over US$514 billion in 2022.[4] The vast majority of the sector's lifecycle emissions, i.e. all emissions associated with the sector's activities, stem from use of sold products (Scope 3), i.e. the combustion of thermal coal for energy in buildings and electric power plants, and metallurgical coal in steel manufacturing. With an average emission factor[5] of 94.6 tCO_2/TJ, thermal coal is the most carbon-intensive of the commonly used fossil fuels [7].

Total global combustion of thermal and metallurgical coal produced 15,106 megatonnes of carbon dioxide ($Mt\ CO_2$) in 2021. The IEA expects total global emissions from coal to fall to just 114 Mt by 2050 in its Net Zero Emissions by 2050 (NZE) Scenario. Some of the emission reductions will come from the demand side through carbon capture and storage (see Section 6), but they are mostly driven by significant drops in the supply of coal. The IEA expects thermal coal to be phased out from global electricity generation by 2040 [1].

3.2. Selecting coal mining companies for assessment: thermal and metallurgical coal

In selecting the coal sector companies to use for our Carbon Performance assessment, we first take all companies included in the sub-sector 'coal' of the Industry Classification Benchmark v2.6 [8] and then further screen the companies to determine whether they operate coal mining activities. This excludes companies involved in, for example, coal trading rather than mining, electricity generation with thermal coal, or steel production with metallurgical coal. As in other sectors, we select the largest companies by free-float market capitalisation for our assessment.

While thermal coal and metallurgical coal have similar geological origins, their properties and structures are different, and their end uses vary considerably. Thermal coal is mostly burned for electricity generation whereas metallurgical coal is mostly used in steel manufacturing. Such differences in application mean that these two types of coal will be phased out at different speeds in low-carbon transition scenarios. We therefore categorise coal mining companies into two distinct sub-sectors: thermal coal mining and metallurgical coal mining, and calculate separate benchmark paths for them.[6]

[4] Based on data provided by FTSE-Russell.
[5] An emission factor is a coefficient used to quantify the amount of greenhouse emissions that a specific activity, such as combusting one tonne of coal, emits into the atmosphere.
[6] Peat and lignite accounted for only 4% of global coal supply in 2021 [6], so they are excluded from this assessment.

3.3. Deriving the benchmark emission pathways

A key input for calculating decarbonisation pathways under the Emissions Contraction Approach (ECA) is a timeline for absolute greenhouse gas emission reductions that is consistent with meeting a particular climate target (e.g. limiting global warming to 1.5°C). Following the decarbonisation scenarios of other TPI Centre assessments, three scenario benchmarks are used for coal mining:

1. A 1.5°C scenario, which is consistent with the overall aim of the Paris Agreement to keep "the increase in the global average temperature to well below 2°C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5°C above pre-industrial levels" [9]. This scenario gives a probability of 50% of holding the global temperature increase to 1.5°C. It is underpinned by the IEA's NZE Scenario.
2. A Below 2°C scenario, which is also consistent with the overall aim of the Paris Agreement to limit global warming, albeit at the lower end of the range of ambition. This scenario comes close to a probability of 50% of holding the global temperature increase to 1.7°C [1]. It is underpinned by the IEA's Announced Pledges Scenario (APS), which replaces the Sustainable Development Scenario (SDS).
3. A National Pledges scenario, which is consistent with the global aggregate of current emission reductions related to policies introduced or under development as of mid-2021. According to the IEA, this scenario is expected to lead to a global temperature increase of 2.5°C by 2100 with a probability of 50% [1]. It is underpinned by the IEA's Stated Policies Scenario (STEPS).

Industry emission projections are also needed to construct benchmark pathways for coal mining. While the majority of lifecycle emissions from the sector come from the combustion of coal that is sold, operational emissions from coal mining are also significant, accounting for approximately 1,652 megatonnes of carbon dioxide equivalent ($MtCO_2e$) in 2021. Additionally, methane from coal mining accounts for one-third of total methane emissions related to energy production [10]. Three types of emission projections are needed to construct benchmark pathways for coal mining companies:

- Downstream use of sold products' emissions from the combustion of thermal and metallurgical coal;
- Operational methane emissions leaked from thermal and metallurgical coal mines;
- Operational CO_2 emissions from extracting and processing coal.

We obtain all three of these inputs from IEA publications [1; 10; 11]. Even though combined downstream emissions from the combustion of thermal and metallurgical coal are available for all scenarios, totals split by type of coal are not disclosed. We instead use projections of thermal and metallurgical coal supply and apply emissions intensity factors from the IPCC [7].[7] These bottom-up estimates assume that the emission intensity from coal combustion remain constant. This implies that mitigation actions taken by end-users of coal, in the form of carbon capture and storage for example, are not deducted from the coal sector's downstream emissions. Although customer mitigations actions are desirable, we do not include them in the scope of this assessment. This point is discussed in greater detail in Section 6.

Projections of methane released during coal mining are available by type of coal for the APS scenario. Projections of total methane emissions from all types of coal are also available for the NZE scenario. [11] We assume that the split by type of coal is the same in the APS and NZE scenarios. To estimate methane emissions from coal mining in the STEPS scenario, we estimate a linear relationship between methane and mined coal (again by type) based on the data available for the APS.

While the projections take into consideration various methane leaks from coal operations, e.g. during the mining, processing, transport and storage of coal, methane emissions from closed and abandoned coal mines are not included. This is consistent with company reporting, as coal miners do not seem to routinely report methane emissions from their closed and abandoned mines in their corporate carbon disclosures. This lack of reporting is problematic as methane emissions from closed and abandoned mines that remain

[7] Projections for coal supply are available for 2030 and 2050. To obtain a 2040 projection, we assume that coal supply falls in line with global emissions from coal combustion (excluding emissions captured by end-users).

under the ownership of companies still represent a potential transition or liability risk. The TPI Centre will monitor the reporting situation of methane and might adjust the benchmarks to include them in the future.

Operational CO_2 emissions from extracting and processing coal are available for the year 2021 [10]. They account for approximately one-third of total operational greenhouse gas emissions from global coal supply in 2021. As no scenario-specific projections are available, it is assumed that these operational CO_2 emissions fall in parallel with methane emissions. Similarly, in the absence of projections by type of coal, we split operational CO_2 emissions according to the split of mined thermal and metallurgical coal supply.

Lastly, we add up the three types of emissions to obtain the total absolute emissions from thermal coal and metallurgical coal. As the ECA aims to assess the relative change in coal miners' emissions, we index the benchmarks to 2021 (so that this represents 100%).

Figures 1 and 2 show the benchmark pathways for thermal coal and metallurgical coal mining companies respectively in terms of absolute carbon emissions from 2021 to 2050. Tables 1 and 2 provide the underlying data.

Figure 1. Absolute emissions benchmark pathways for thermal coal miners by warming scenario

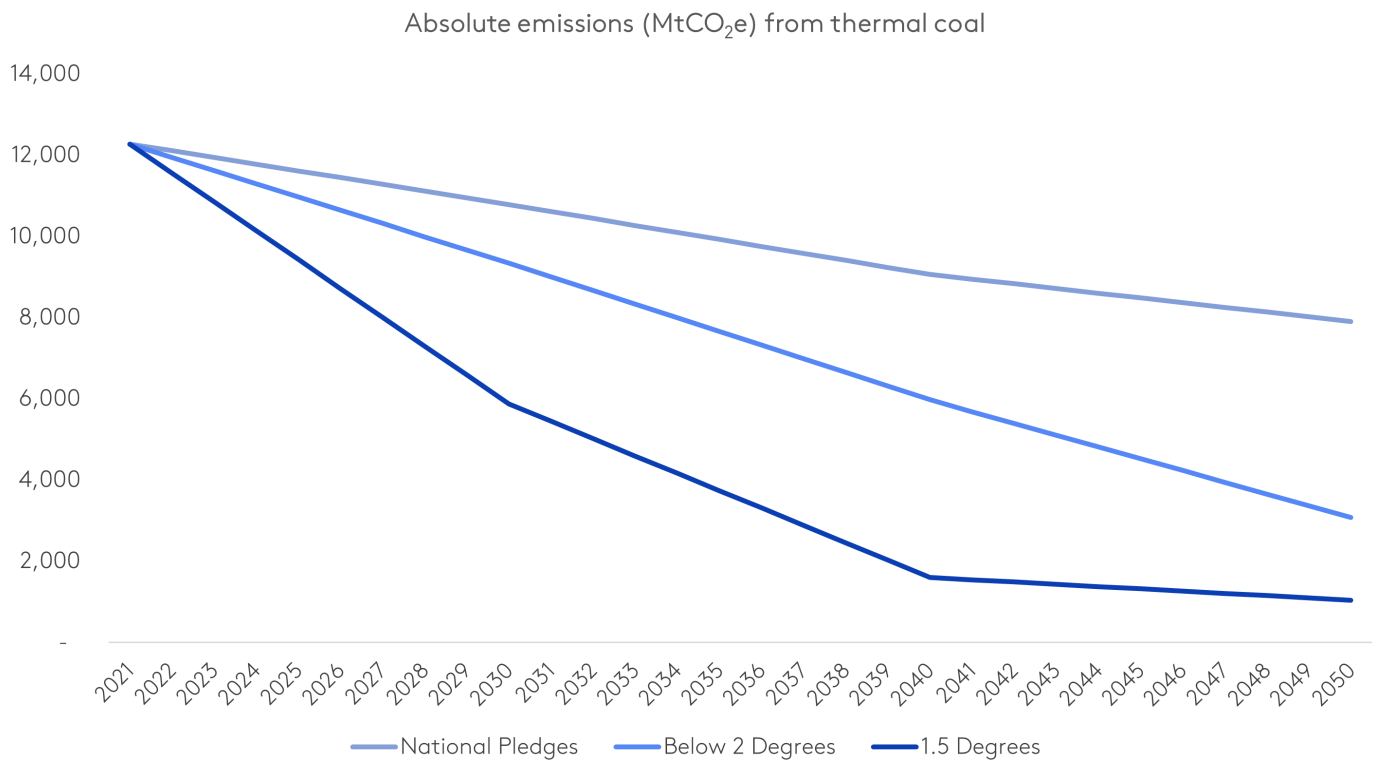


Table 1. Absolute emissions benchmark pathways for thermal coal mining companies by warming scenario

	2021	2030	2040	2050
National Pledges				
Methane emissions from thermal coal mining ($MtCO_2e$)	744	594	465	435
Emissions from extracting and processing thermal coal ($MtCO_2$)	403	365	308	259
Emissions from the combustion of thermal coal ($MtCO_2$)	11,126	9,823	8,287	7,208
Total carbon emissions ($MtCO_2e$)	12,273	10,782	9,060	7,902
Thermal coal supply (Megatonnes of coal equivalent [Mtce])	4,560	4,026	3,396	2,954
Indexed reduction from 2021 (%)	100%	88%	74%	64%
Below 2°C Scenario				
Methane emissions from thermal coal mining ($MtCO_2e$)	744	457	206	128
Emissions from extracting and processing thermal coal ($MtCO_2$)	403	249	119	72
Emissions from the combustion of thermal coal ($MtCO_2$)	11,126	8,622	5,647	2,872
Total carbon emissions ($MtCO_2e$)	12,273	9,339	5,972	3,072
Thermal coal supply (Mtce)	4,560	3,538	5,069	2,182
Indexed reduction from 2021 (%)	100%	76%	49%	25%
1.5°C Scenario				
Methane emissions from thermal coal mining ($MtCO_2e$)	744	219	63	28
Emissions from extracting and processing thermal coal ($MtCO_2$)	403	115	35	16
Emissions from the combustion of thermal coal ($MtCO_2$)	11,126	5,541	1,479	993
Total carbon emissions ($MtCO_2e$)	12,273	5,874	1,595	1,037
Thermal coal supply (Mtce)	4,560	2,271	907	153
Indexed reduction from 2021 (%)	100%	48%	13%	8%

Figure 2. Absolute emissions benchmark pathways for metallurgical coal miners by warming scenario

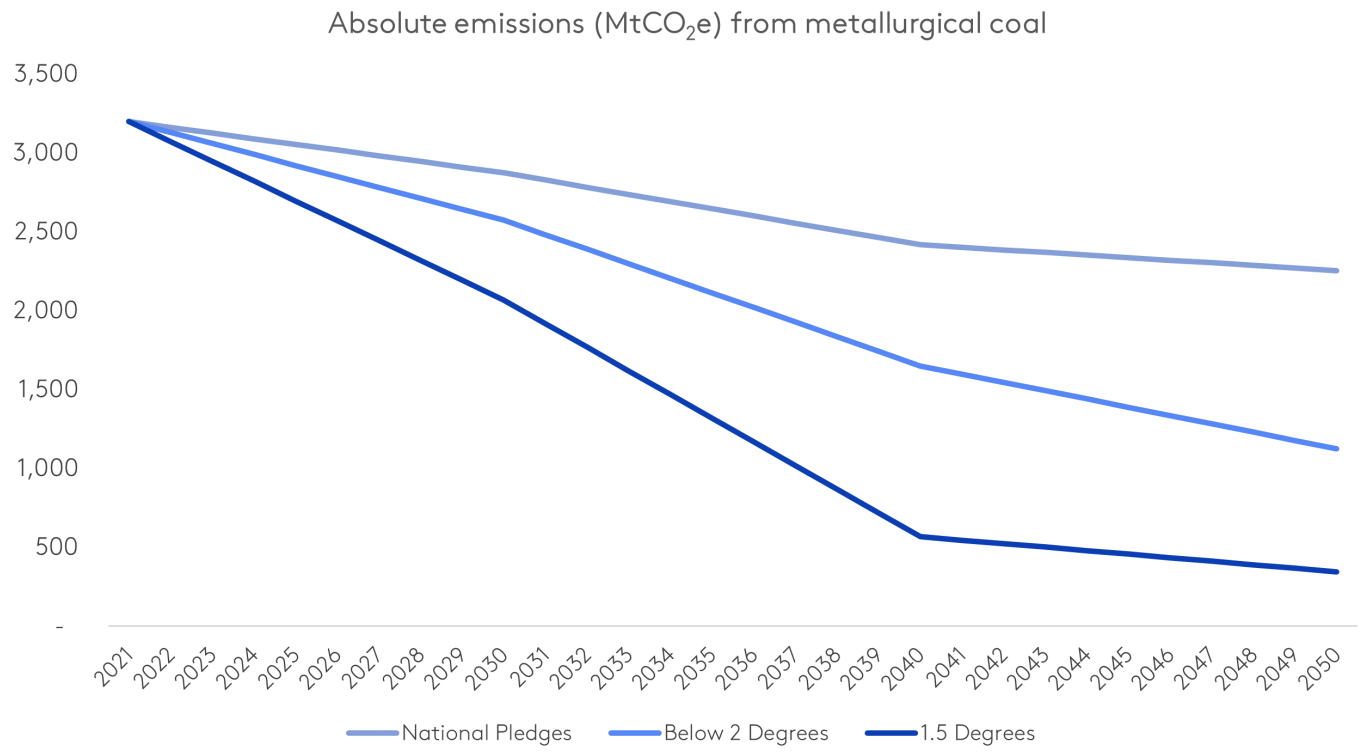


Table 2. Absolute emissions benchmark pathways for metallurgical coal miners by warming scenario

	2021	2030	2040	2050
National Pledges				
Methane emissions from metallurgical coal mining ($MtCO_2e$)	326	262	215	203
Emissions from extracting and processing metallurgical coal ($MtCO_2$)	91	85	72	65
Emissions from the combustion of metallurgical coal ($MtCO_2$)	2.781	2.527	2.132	1.987
Total carbon emissions ($MtCO_2e$)	3.198	2.874	2.418	2.255
Metallurgical coal supply (Mtce)	1.030	936	790	736
Indexed reduction from 2021 (%)	100%	90%	76%	71%
Below 2°C Scenario				
Methane emissions from metallurgical coal mining ($MtCO_2e$)	326	206	111	72

Emissions from extracting and processing metallurgical coal ($MtCO_2$)	91	60	29	23
Emissions from the combustion of metallurgical coal ($MtCO_2$)	2.781	2.309	1.510	1.029
Total carbon emissions ($MtCO_2e$)	3.198	2.575	1.650	1.124
Metallurgical coal supply (Mtce)	1.030	855	559	805
Indexed reduction from 2021 (%)	100%	81%	52%	35%
1.5°C Scenario				
Methane emissions from metallurgical coal mining ($MtCO_2e$)	326	99	34	16
Emissions from extracting and processing metallurgical coal ($MtCO_2$)	91	36	11	5
Emissions from the combustion of metallurgical coal ($MtCO_2$)	2.781	1.933	522	324
Total carbon emissions ($MtCO_2e$)	3.198	2.010	568	345
Metallurgical coal supply (Mtce)	1.030	716	193	120
Indexed reduction from 2021 (%)	100%	65%	18%	11%

3.4. Estimating companies' emission reductions

To measure companies' decarbonisation efforts against the ECA, data on Scope 1, 2 and 3 (Category 11, use of sold products) emissions from thermal coal and metallurgical coal are needed, indexed to 2021. All the data needed for the calculations can be obtained from company disclosures.

The majority of emissions stem from the coal combustion activities of coal companies' clients – Scope 3, Category 11 emissions – a category that is rarely disclosed by coal companies. These are instead estimated through calculations that apply the IPCC's emissions intensity factors to coal companies' disclosed sales. Where coal sales are not available, they are approximated using coal production volumes.

Most coal mining companies disclose the Scope 1 and 2 emissions generated by their operations. However, diversified companies do not always specify the share of emissions resulting from their coal operations. When they are missing, Scope 1 and 2 emission figures from coal mining are estimated using an industry-wide average for emissions intensity per tonne of mined thermal or metallurgical coal (0.284 tCO_2e/t). This average intensity is derived from the 2021 benchmark data (see Table 1 and 2).

Where operational emissions from coal mining are disclosed, but a split of emissions by type of coal is not available, we estimate them using the company-specific ratio of thermal and metallurgical coal sales as a proportion of total coal sales.

4. Company emission disclosures

4.1. Emission reporting boundaries

Companies disclose emissions using different organisational boundaries, i.e. the range of the company's activities that are included within the disclosure. Broadly, there are two different approaches that companies can use: (i) the 'equity share approach', which accounts for greenhouse gas emissions based on the share of equity in operations; and (ii) the 'control approach', which accounts for greenhouse gas emissions from operations that are under the control of the company (either financial or operational).

Both approaches to organisational boundaries are employed across the companies assessed by the TPI Centre, and both are accepted, as long as: the boundary that has been set allows a representative assessment of the company's emission intensity; and the same boundary is used for reporting company emissions and activity. This ensures that a consistent estimate of emissions intensity is obtained. Currently, limiting the assessment to one particular type of organisational boundary would severely restrict the number of companies that can be assessed.

When companies report historical emissions or emission intensities using *both* equity share and control approaches, the TPI Centre chooses the reporting boundary based on which method provides the longest available time series of disclosures, or is most consistent with disclosure on activity, and any targets.

4.2. Data sources and validation

All the data used in the TPI Centre's assessments are based on companies' own disclosures. The sources for the Carbon Performance assessment include responses to the annual CDP questionnaire, as well as companies' own reports, e.g. sustainability reports.

Given that the TPI Centre's Carbon Performance assessment is both comparative and quantitative, it is essential to understand exactly what the data in company disclosures refer to. Company reporting varies not only in terms of what is reported, but also in terms of the level of detail and explanation provided. The following cases can be distinguished:

- Some companies provide data in a suitable form and they provide enough detail on those data for analysts to be confident that appropriate measures can be calculated or used.
- Some companies provide data, but the disclosure details are not in a suitable form for the Carbon Performance assessment (e.g. they do not report the measure of company activity needed). These companies cannot be included in the assessment.
- Some companies do not provide enough detail on the data disclosed and therefore are also excluded from the assessment (e.g. the company reports an emission intensity estimate, but does not explain precisely what it refers to).
- Some companies do not disclose their carbon emissions and/or activity.

Once a preliminary Carbon Performance assessment has been made, it is subject to the following procedure to provide quality assurance:

- Internal review: the preliminary assessment is reviewed by a TPI Centre analyst who was not involved in the original company assessment.
- Company review: the internal reviewed assessment is sent to the company, which then has the opportunity to consider it and confirm the accuracy of the disclosures used. Only information in

the public domain can be accepted as a basis for any change. This review opportunity is offered to all companies, including those who provide unsuitable or insufficiently detailed disclosures.

- Final assessment: feedback from the company is reviewed and, if it is considered appropriate, incorporated by the TPI Centre analysts in the final assessment result.

4.3. Coverage of emission reduction targets

Companies disclose various types of emission reduction targets, but they can be broadly categorised into absolute emission targets and emission intensity targets. Absolute emission targets are expressed in terms of a decrease in total company emissions while emission intensity targets are expressed in terms of company emissions per unit of output/activity and make no direct reference to total emissions. To date, we have not come across an intensity target in the coal sector. However, should this occur in the future, the same approach would be adopted as in other sectors assessed by the TPI Centre. Specifically, the emission intensity target would be converted into an absolute target, assuming that a company's thermal coal and metallurgical coal sales grow in line with coal supply as projected in the National Pledges scenario. If both an absolute and intensity target are disclosed, we would verify that both are consistent with or complement each other. If so, we prefer the absolute target. If not, further research would be needed.

In contrast to other sectors, the TPI Centre incorporates production-based targets in its assessment of coal mining companies, as they are the main lever available to coal companies to reduce their carbon footprint. Quantified targets to reduce the sales of coal products can directly be translated into corresponding Scope 3 downstream emission targets by applying the IPCC emission factors. Targets can cover different scopes of emissions and apply to specific operations or to the whole organisation. When company targets are not provided for the full scope of our analysis, assumptions are required to project how emissions outside the scope of the target may evolve. Consistent with the assessment approach used for sectors, we assume the emissions of activities outside the scope of the target remain constant at the level of the latest disclosure year. In the context of coal, companies' targets typically do not differentiate between thermal and metallurgical coal. In this case, we assume that reduction efforts are uniform across both types of coal.

Some companies disclose net targets. Unlike gross targets, net targets include emissions offsets or negative emissions, either within company boundaries or outside them. The TPI Centre accepts both types of targets and does not make an explicit distinction between them. Although we recognise that there are additional risks related to relying heavily on offsetting, in principle it is a cost-effective mechanism to reduce emissions. Moreover, companies rarely disclose the detailed contribution of offsets to their overall targets. Some companies disclose a target range, in which case the mid-point value is used. Most companies express targets relative to emissions in a base year (e.g. 2010), but some companies disclose targets without disclosing the base year. In this case, we assume that the base year is the latest year of disclosure prior to the publication of the target.

4.4. Responding to companies

Allowing companies the opportunity to review their assessments is an integral part of the TPI Centre's quality assurance process. Each company receives its draft assessment and the data that underpins the assessment, and has the opportunity to review and comment on both. Companies are allowed to contact us at any point to discuss their assessment.

If a company seeks to challenge its result or representation, our process is as follows:

- The TPI Centre reviews the information provided by the company. At this point, additional information may be requested.
- If it is concluded that the company's challenge has merit, the assessment is updated and the company is informed.
- If it is concluded that there are insufficient grounds to change the assessment, the TPI Centre publishes its original assessment.

- If the company requests an explanation regarding its feedback after the publication of its assessment, the TPI Centre explains the decisions taken.
- If a company requests an update of its assessment based on data publicly disclosed after the research cut-off date communicated to the company, the TPI Centre can note the new disclosure on the company's profile on the Centre's website.

If a company chooses to further contest the assessment and reverts to legal means to do so, the company's assessment is withheld from the TPI website and the company is identified as having challenged its assessment.

5. Initial assessment results

5.1. Company selection

As a proof of concept, here we apply the new methodology to five coal mining companies. We select the top three coal mining companies by free-float market capitalisation (identified using data from FTSE Russell [8]): BHP, Glencore and Vale, as well as Coal India (a large pure coal player) and Jardine Matheson (a large, diversified company with a coal business) to test the application of the methodology on other business models.

5.2. Company performance

Figures 3 and 4 show the emission pathways for the five companies, which are calculated based on their disclosures, which are summarised as follows:

- BHP aims to achieve a 30% reduction in Scope 1 and 2 emissions by 2030 compared with a 2019 baseline and has announced a net zero goal across Scopes 1–3 by 2050.
- Coal India has not disclosed a carbon emission reduction target that can be used in this analysis.
- Glencore discloses short- and medium-term targets of a 15% reduction in its Scope 1–3 emissions by 2026 and a 50% reduction by 2035, compared with 2019 levels. Additionally, the company states the ambition to achieve net zero emissions across Scopes 1–3 by 2050. Glencore's trading business is excluded from the targets.
- Jardine Matheson intends to grow non-coal revenues from its coal subsidiaries to 88%–90% by 2030. However, these intentions do not clearly indicate planned reductions in carbon emissions from coal so they could not be incorporated into the assessment. By contrast, PT Astra, a subsidiary of the company, discloses a group-wide target of a 30% reduction of Scope 1 and 2 emissions by 2030 compared to 2019. As this target directly refers to the company's carbon emissions from coal, it was included in the assessment.
- Vale aims to reduce its Scope 1 and 2 emissions by 33% by 2030 compared to 2017 levels and to achieve net zero by 2050. The company also aims to make a 15% reduction of its Scope 3 net emissions by 2035 compared to 2018. However, since the company sold its coal business in 2022 and announced its objective to no longer own coal assets, the aforementioned targets are not included in the assessment. Instead, we assume that Vale's Scope 1, 2 and 3 emissions from coal mining remain zero until 2050.

Vale serves as a good example of the TPI Centre's general approach to divestment from the coal sector. When a company disposes of its coal assets, its emissions are eliminated. We illustrate this for Vale in Figures 3 and 4: the company aligns with the 1.5°C benchmark in the short (to 2025), medium (to 2035) and long term (to 2050). After completing its coal divestment, the company ceases its direct involvement in coal mining and will subsequently be removed from the coal assessment, being assessed as a diversified mining company only. In contrast, companies that announce a gradual phase-out plan, implying the continued ownership of coal assets for years into the future, remain in the coal sector assessment until full divestment has been completed.

The assessments for thermal coal show that BHP's emission pathway is well within the National Pledges scenario, and it aligns with Below 2°C in 2025 and 2035, and with 1.5°C in 2050. Glencore's emission pathway exceeds all benchmarks in 2025 and 2035, but falls below the National Pledges benchmark in 2050. Coal India and Jardine Matheson do not align with any of the benchmarks at any point in time.

The results are the same for metallurgical coal, apart from Glencore, which aligns with 1.5°C in 2025 and Below 2°C in 2035 and 2050.

Figure 3. Thermal coal emission pathways of five coal mining companies up to 2050

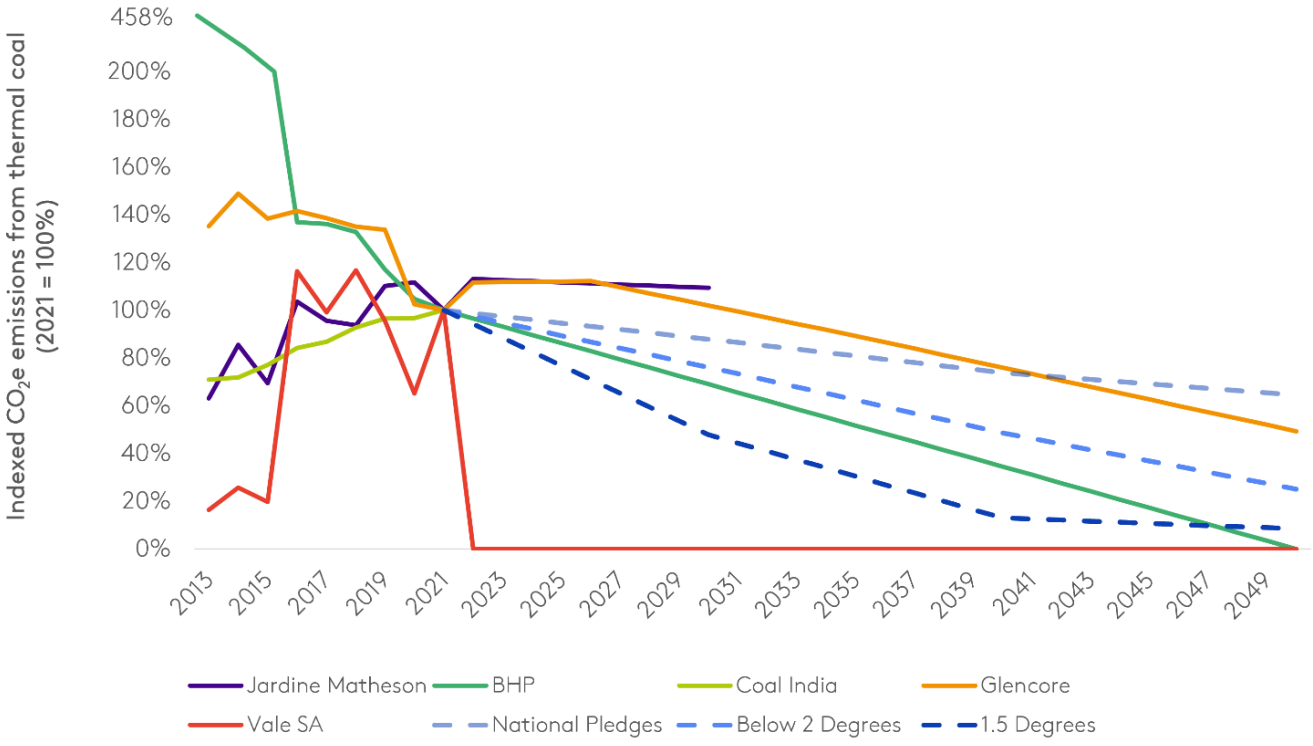
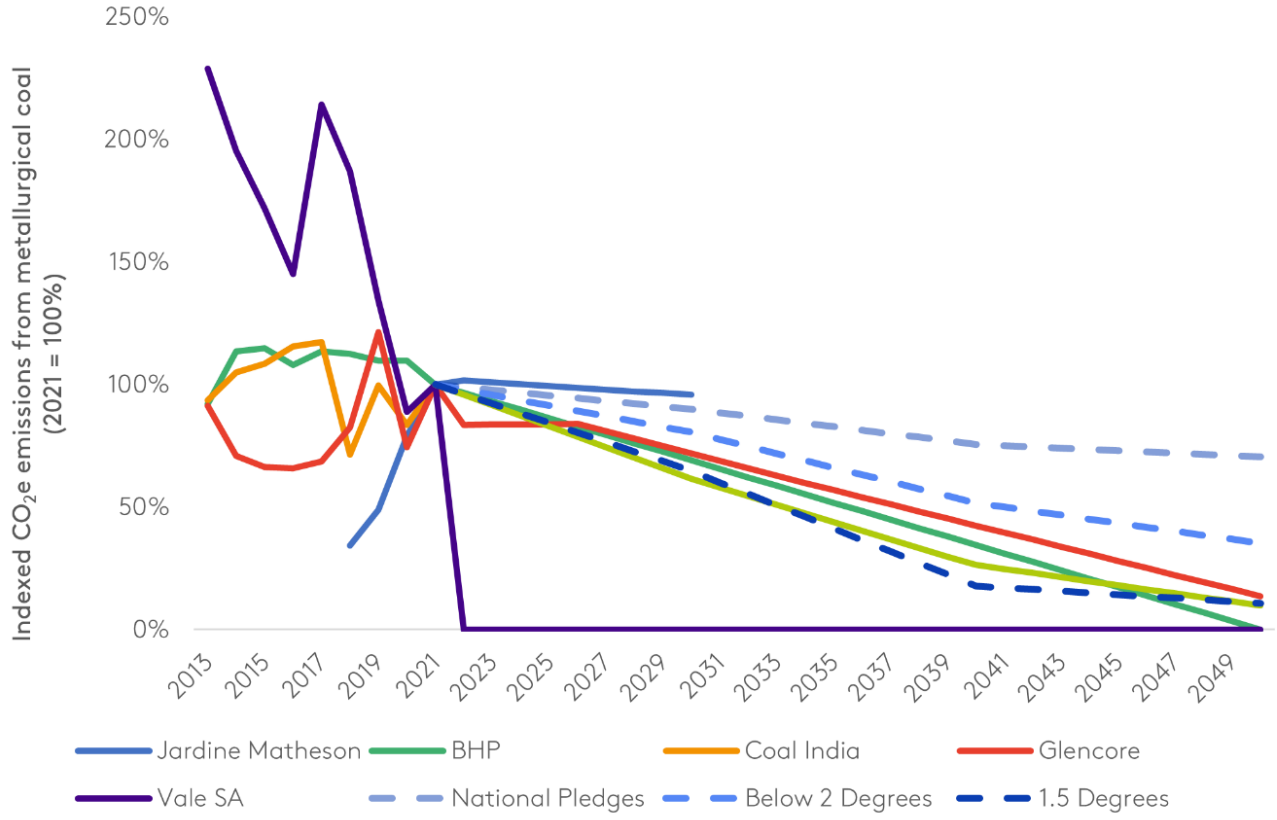


Figure 4. Metallurgical coal emission pathways for five coal mining companies up to 2050



6. Discussion of methodology, findings and limitations

The Emission Contraction Approach proposed and tested in this paper is a new TPI Centre methodology that offers a way to effectively assess the carbon performance of thermal coal and metallurgical coal mining companies according to the specific characteristics of their low-carbon transition pathways. Here we summarise the main discussion points raised in this paper.

Applying the Emission Contraction Approach to coal mining companies:

- Coal supply falls rapidly in low-carbon scenarios, albeit at different rates for thermal and metallurgical coal. The ECA, which is based on absolute emissions, can capture the pace at which a company phases out its coal operations.
- As the vast majority of coal sector emissions stem from the combustion of coal by end-users, the scope of the assessment includes emissions from the use of sold products. Hence, in the coal sector, the specific measure used to assess companies is Scope 1, 2 and 3 (use of sold product) carbon emissions indexed to 2021.
- Companies do not always publicly disclose all categories of emissions required to carry out this assessment. In particular, the reporting of methane emissions is often missing and doubts about data reliability have been raised. If Scope 1 and 2 data is missing, the assessment uses an average industry-wide intensity. Scope 3 emissions from the use of sold products are estimated by applying the IPCC emissions intensity factors to sold coal. This ensures that Scope 3 calculations are consistent across all companies.
- As an alternative to emission-based pathways, it would be possible to benchmark companies against production-based pathways that directly reflect the reduction in thermal and metallurgical coal supply. However, such an approach would require a separate assessment of coal mining companies' Scope 1 and 2 emissions. The advantage of emission-based Scope 1, 2, and 3 pathways is their ability to provide a comprehensive assessment of coal mining companies in one single metric.

Initial assessment findings

- In applying the ECA to five coal mining companies, we find that only one (Vale) is aligned with a 1.5°C scenario in the short, medium and long term. By selling its coal assets in 3033, Vale has reduced its transition risk from exposure to coal-related activities to zero. However, it is crucial to note that this divestment does not necessarily guarantee real-world emission reductions. This ultimately depends on whether the new owner of these coal assets intends to phase them out or not.
- BHP's emission reduction targets align with a 1.5°C scenario in the long term and with Below 2°C in the short and medium term for both thermal and metallurgical coal. The remaining companies assessed, Coal India, Glencore and Jardine Matheson, do not plan to reduce their coal-related carbon emissions at the rate required to keep global warming to 1.5°C across any of the three time horizons.

Challenges and limitations

- The ECA's use of absolute emissions means benchmarking companies against the same emission reduction rate, which imposes a kind of one-size-fits-all solution that does not account for varying costs of emission reduction across companies. This also affects the emission intensity approach insofar as it requires companies to converge with sectoral benchmarks, but it is arguably less

acute. However, in the case of coal, such variations in transition costs may be small as companies' main decarbonisation lever is to shut down their business. Some coal mines may be easier to shut down or have higher operational emissions than others, but we mitigate this concern by including operational emissions in the analysis.

- Changes in market share, such as through mergers and acquisitions, can lead to significant fluctuations in companies' emission pathways. However, these fluctuations indicate shifts in transition risk, as acquiring additional coal assets increases a company's transition risk. Ultimately, all coal assets must be wound down.
- No established mechanisms currently exist to track Scope 3 emission reductions targets that explicitly rely on customer mitigation actions, such as the use of carbon capture and storage or the purchase of carbon offsets. They are therefore not included in the assessment boundary of the ECA methodology, which only considers a coal mining company's own transition efforts. To ensure consistency, customer mitigation actions are excluded from the company assessments and the benchmarks.
- A minor share of coal supply is utilised for industrial purposes other than combustion by end-consumers, such as in chemical products.[8] However, no scenario-specific projections regarding the evolution of this share is available. The most conservative assumption would be to assume that it remains constant. Considering that the indexed pathways represent changes in reduction rates, such an adjustment would have a negligible impact on both the benchmarks and the company assessments.
- Assessments are complicated by the trading activities of coal companies, which we believe are widespread but may not be fully disclosed. Although it is operationally very different to coal mining, trading carbon-intensive products also creates transition risks, given the dependence of companies' revenues on underlying carbon-intensive products. Excluding them would risk a decarbonisation strategy simply transferring transition risk to an unassessed activity without any decarbonisation taking place.
- The TPI Centre aims to exclude 'financial trading', in which no change in ownership of the underlying asset takes place from its assessment. However, based on public disclosure, this is not straightforward to distinguish from other forms of trading. We therefore encourage companies to explicitly disclose financial trading volumes.

[8] Coal consumed for non-energy use accounted for less than 5% of total coal consumption in 2017 [12].

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