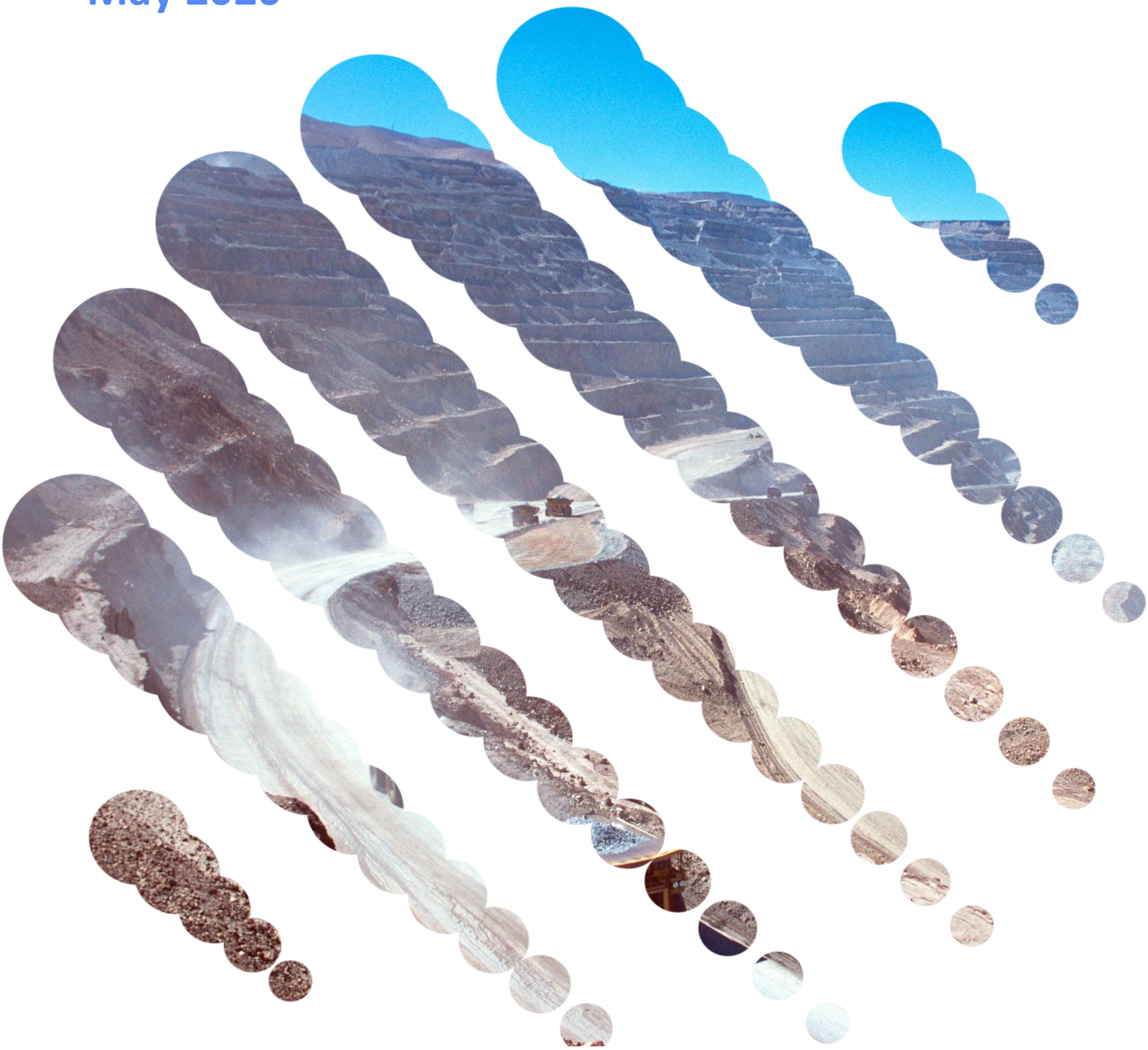
Carbon Performance Assessment in the Diversified Mining Sector:

Discussion paper

May 2020



Simon Dietz, Annabel Farr, Dan Gardiner,
Valentin Jahn and Jolien Noels

Transition Pathway Initiative

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EXECUTIVE SUMMARY

The Transition Pathway Initiative (TPI) is a global initiative led by asset owners and supported by asset managers. Aimed at investors and free to use, it assesses companies' progress on the transition to a low-carbon economy, supporting efforts to address climate change.

This discussion paper proposes a methodology to assess the Carbon Performance of the diversified mining sector. It incorporates company feedback on both the overall methodology and the individual company assessments we have undertaken. We are publishing it now to solicit additional feedback from interested parties, with the aim of improving the methodology still further.

The diversified mining sector is significant both to investors and the climate. The ten largest diversified mining companies have a market capitalisation of over US$350bn and contribute either directly or indirectly via their products to annual carbon emissions of over 1.5 billion tonnes.

To assess the diversified mining sector's Carbon Performance, we extend the Sectoral Decarbonization Approach[1] that we have applied to other sectors. This approach is based on estimating companies' greenhouse gas emissions intensity, with emissions and activity – the numerator and denominator of emissions intensity respectively – defined in ways that are appropriate to the sector in question. Companies' emissions intensities are compared with benchmark emissions intensities, reflecting the goals of the 2015 Paris Agreement on climate change. By applying the methodology, it should be possible to answer the question: is a company aligned with the Paris goals as applied to its sector?

Some mining products like coal and iron ore generate significant downstream emissions. Therefore, our methodology proposes to calculate total company emissions by adding estimates of Scope 3 emissions from processing and use of sold products to companies' disclosed operational or Scope 1 and 2 emissions. Moreover, the absence of consistent Scope 3 disclosures has led us to develop a methodology, which calculates a company's total Scope 3 emissions by applying emissions factors to its mining output, product by product. The diversity of activities in the mining sector creates unique challenges. Our methodology aims to include all significant outputs from mining companies, including energy products. It also proposes a method to eliminate double-counting of Scope 3 emissions associated with metallurgical coal and iron ore production.

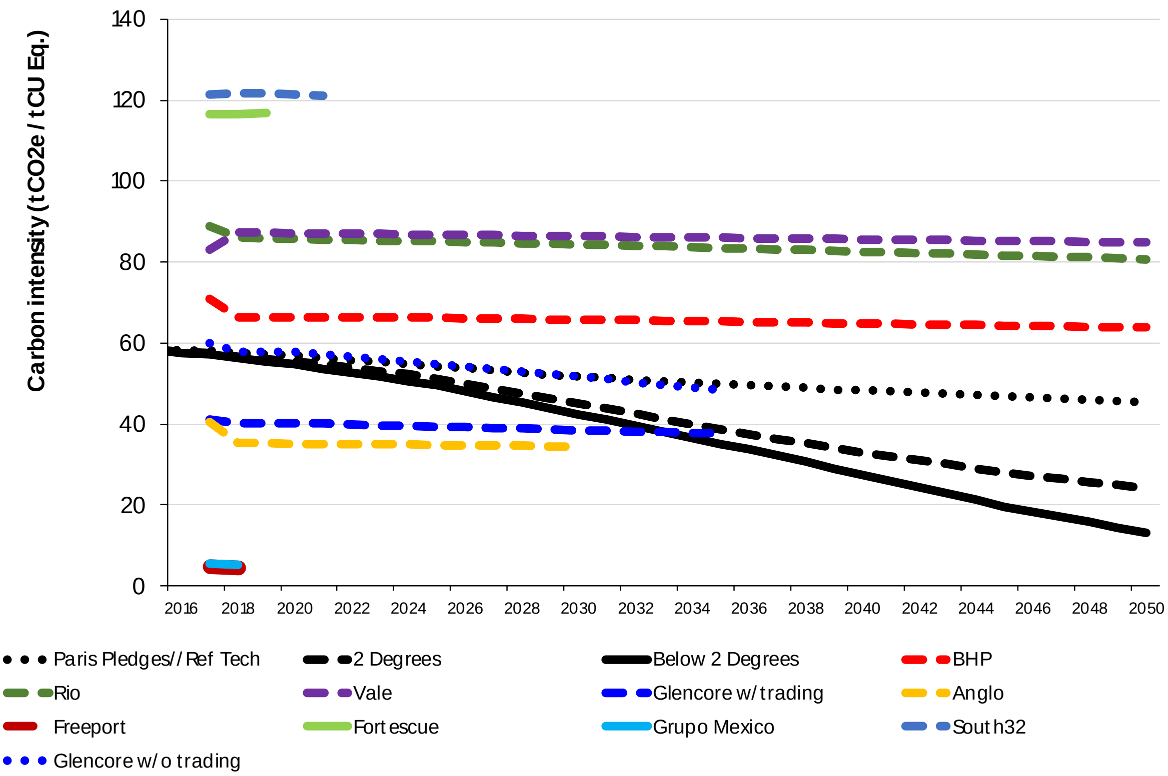
To estimate company activity, TPI proposes converting all mining production (including energy products) into a single Copper Equivalent (Cu Eq.) metric. Conversion to Cu Eq. is made using a "price factor", which is based on a three-year average of the ratio between the price of the commodity and the price of copper. Averaging over three years helps to smooth out volatility, a concern with activity measures based on market prices. We discuss the merits of this approach relative to alternatives including revenue, as well as averaging prices over longer time periods.

[1] The Sectoral Decarbonization approach (SDA) was created by CDP, WWF and WRI in 2015 (https://sciencebasedtargets.org/wp-content/uploads/2015/05/Sectoral-DecarbonizationApproach-Report.pdf).

The results of applying our new Carbon Performance methodology to the 10 largest diversified miners by market capitalisation are shown in Figure ES1. These 10 companies divide into five types:

1. Freeport and Grupo Mexico both have such a low emissions intensity that they are already aligned with the 2050 benchmarks, including Below 2C. Neither of these companies currently mine products with a high lifecycle carbon intensity.
2. Glencore (including its trading business) and Anglo American start below the benchmarks, but their emissions intensity pathways are too flat to keep them in alignment with 2C and Below 2C in the future. They are only aligned with the Paris Pledges benchmark in 2050.
3. BHP, Rio Tinto and Vale are not aligned. They begin above the benchmarks, and their targets only cover Scope 1 and 2 emissions, which does little to reduce their overall emissions intensity.
4. Fortescue and South 32 are substantially above the benchmarks and do not currently have credible long-term targets to substantially reduce emissions intensity.
5. MMC Norilsk did not provide sufficient disclosure to make an assessment.

Figure ES1. The Carbon Performance of the ten largest diversified mining companies*



* MMC Norilsk did not provide sufficient disclosure to make an assessment

Figure ES1 highlights that diversified mining companies need to set significantly more ambitious targets to be aligned with climate goals. Key to this in our view are targets that include Scope 3 emissions. Fortescue and South32 have yet to set credible long-term targets and need to cut their overall carbon intensity by nearly 80% by 2050 to claim alignment with

2C. Stated net zero ambitions from BHP, Rio Tinto and Vale only cover operational emissions, typically just 6% of the emissions we assess. As a result, these companies are actually further away from alignment in 2050 than they are today. Glencore is "projecting" a c. 30% reduction in its Scope 3 emissions by 2035 as it runs down its oil and coal resources, but its marketing activities are not included. Unless Anglo American also begins reducing its Scope 3 emissions, it risks not being aligned with 2C by 2040.

With carbon intensity varying widely between commodities, the most obvious decarbonisation strategy miners can adopt is cutting the production of commodities with the highest emissions intensity. Coal, particularly thermal coal, and iron ore present the biggest opportunities to decarbonise. Coal output at South32 and Anglo American accounts for 25% and 23% of their Cu Eq. output respectively. We estimate that stopping this production would cut South32's emissions intensity by 45% and Anglo's by 31%.

Diversifying away from iron ore is more complicated. Unlike coal, there is no direct low-carbon substitute for steel. Reduction in supply from large miners is likely to be offset by increased supply from smaller (potentially less efficient) players. Decarbonising the steel sector is likely to need a combination of reducing end demand, greater recycling, improving technology, offsets, and carbon capture and storage. There is scope for miners to play a proactive role, helping to accelerate these initiatives and preferentially supplying efficient (lower-carbon) producers. Theoretically this strategy could be captured by applying customer-specific Scope 3 emissions factors to miners' iron ore production. However, it is not clear how this could be done credibly from existing public disclosure.

The issue of how to capture downstream initiatives to decarbonise steel production in our mining assessments is one of several topics we are seeking feedback on:

- **Trading**. We propose including trading/marketing activities in our assessments, but aim to exclude "financial trading" where it does not involve the transfer of ownership in the underlying asset. How can disclosure evolve to ensure trading activities are captured consistently?
- **Emissions factors**. Selecting appropriate, credible emissions factors for all the different forms of production across the sector is not straightforward and can make a big difference to results. TPI proposes adopting a single lifecycle factor for each commodity that can be adjusted by production stage. How should consistency and transparency of approach be balanced against accurately replicating the emissions intensity of specific products?
- **Adjusting metallurgical coal emissions**. Our proposed methodology aims to ensure emissions from metallurgical coal and iron are not double-counted in the benchmark, or in company assessments. Does this approach improve the accuracy of our overall emission intensity calculation for companies like Anglo American and BHP that produce both products?

1. INTRODUCTION

1.1. The Transition Pathway Initiative

The Transition Pathway Initiative (TPI) is a global initiative led by asset owners and supported by asset managers. Established in January 2017, TPI investors now collectively represent nearly US$19 trillion of Assets Under Management and Advice.[2]

On an annual basis, TPI assesses how companies are preparing for the transition to a low-carbon economy in terms of their:

- *Management Quality* – all companies are assessed on the quality of their governance/management of greenhouse gas emissions and of risks and opportunities related to the low-carbon transition.
- *Carbon Performance* – in selected sectors, TPI quantitatively benchmarks companies' carbon emissions against the international targets made as part of the 2015 UN Paris Agreement.

TPI publishes the results of its analysis through an open access online tool hosted by the Grantham Research Institute on Climate Change and the Environment at the London School of Economics (LSE): http://www.transitionpathwayinitiative.org.

Investors are encouraged to use the data, indicators and online tool to inform their investment research, decision making, engagement with companies, proxy voting and dialogue with fund managers and policy makers, bearing in mind the Disclaimer that can be found on page 2. Further details of how investors can use TPI assessments can be found on our website at https://www.transitionpathwayinitiative.org/tpi/investors.

1.2. About this report

This discussion paper is the first attempt to develop a methodology to assess the Carbon Performance of the diversified mining sector.

The structure of the report is as follows:

- *Section 2* explains how TPI has assessed Carbon Performance in other sectors, e.g. automotive, cement, electricity, oil and gas, and steel;
- *Section 3* establishes the fundamentals of adapting the methodology for the diversified mining sector;
- *Section 4* covers further methodological issues, including the sensitivity of the benchmark to product mix and how to estimate company carbon intensities using public disclosures;
- *Section 5* reports the results from an initial application of this methodology to the 10 largest diversified mining companies by market capitalisation.
- *Section 6* contains a discussion of strategic options for diversified miners seeking to decarbonise.

[2] As of February 2020.

2. TPI'S CARBON PERFORMANCE ASSESSMENT

TPI's Carbon Performance assessment is based on the Sectoral Decarbonization Approach (SDA)[3]. The SDA translates greenhouse gas emissions targets made at the international level (e.g. under the 2015 UN Paris Climate Agreement) into appropriate benchmarks, against which the performance of individual companies can be compared.

The SDA is built on the principle of recognising that different sectors of the economy (e.g. oil and gas 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. Other approaches to translating international emissions targets into company benchmarks have applied the same decarbonization pathway to all sectors, regardless of these differences [1].

Therefore, the SDA takes 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 aligned with international emissions targets.

Applying the SDA can be broken down into 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 economy-energy model, and these models usually allocate emissions reductions by region and by sector according to where it is cheapest to reduce emissions and when (i.e. the allocation is cost-effective). Cost-effectiveness is, however, subject to some constraints, such as political and public 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 path 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.
- Companies' recent and current emissions intensity is calculated and their future emissions intensity can be estimated based on emissions targets they have set (i.e.

[3] The Sectoral Decarbonization approach (SDA) was created by CDP, WWF and WRI in 2015 (https://sciencebasedtargets.org/wp-content/uploads/2015/05/Sectoral-DecarbonizationApproach-Report.pdf).

this assumes companies exactly meet their targets).[4] Together these establish emissions intensity paths for companies.

- Companies' emissions intensity paths are compared with each other and with the relevant sectoral benchmark pathway.

TPI uses three sectoral benchmark pathways/scenarios, which in most sectors are defined as:

1) *Paris Pledges*, consistent with the emissions reductions pledged by countries as part of the Paris Agreement in the form of Nationally Determined Contributions or NDCs. These are insufficient to limit the increase in global average temperature to 2°C or below.
2) *2 Degrees*, consistent with the overall aim of the Paris Agreement to hold "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", albeit at the low end of the range of ambition.
3) *Below 2 Degrees*, consistent with a more ambitious interpretation of the Paris Agreement's overall aim.

The source of data for these scenarios is usually the modelling of the International Energy Agency (IEA), via its biennial *Energy Technology Perspectives* report [2].

In line with TPI's philosophy, companies' emissions intensity paths are derived from public disclosures (including responses to the annual CDP questionnaire, as well as companies' own reports, e.g. sustainability reports) as far as possible.

Further details of how the Carbon Performance methodology is applied in specific sectors can be found in TPI's sectoral Methodology Notes (https://www.transitionpathwayinitiative.org/tpi/publications).

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

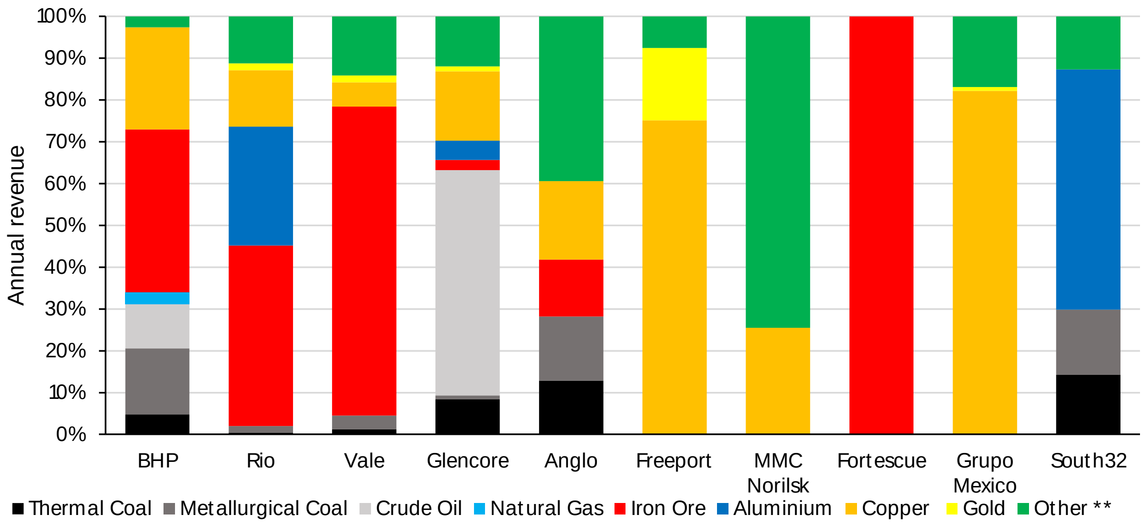
3. APPLYING THE METHOD TO THE DIVERSIFIED MINING SECTOR

3.1. Defining the diversified mining sector

Our definition of diversified miners includes companies in the "Non-ferrous metals", "Iron and Steel" and "General Mining" subsectors (ICB: 1755, 1757 and 1775 respectively). Steel manufacturers are part of the "Iron and Steel" subsector (1755) and are already covered as a separate sector by TPI [3]. They are therefore excluded from this analysis to ensure the focus is on mining companies. Rio Tinto and South32 are included in this report, however their aluminium activities are also covered in TPI's stand-alone assessment of the aluminium sector [4].

Diversified mining companies extract a wide variety of natural resources from the earth's crust, including energy products (e.g. coal, crude oil and natural gas), ores requiring processing (e.g. iron ore into steel, or bauxite into alumina), metals needing to be processed into a finished product (e.g. copper, gold, silver and nickel), and precious gems such as diamonds [5]. As Figure 1 highlights, some companies produce a wide range of outputs, whilst others are more focussed. Portfolios also vary substantially between companies. Of the ten largest companies in the sector, no two have an identical, or even strongly similar, portfolio.

Figure 1. Revenue by product for the ten largest diversified mining companies*



* Based on the latest reported financial year (as of Jan-20). Includes Glencore's trading activities, but excludes Grupo Mexico's Transportation and Infrastructure divisions (see Section 3.2)

** Other includes: Cobalt, Ferroalloys, Lead, Manganese, Molybdenum, Nickel, Palladium, Platinum, Salt, Silver, Titanium Dioxide, Uranium, Zinc and Diamonds (see Table 3)

3.2. Establishing the assessment boundary

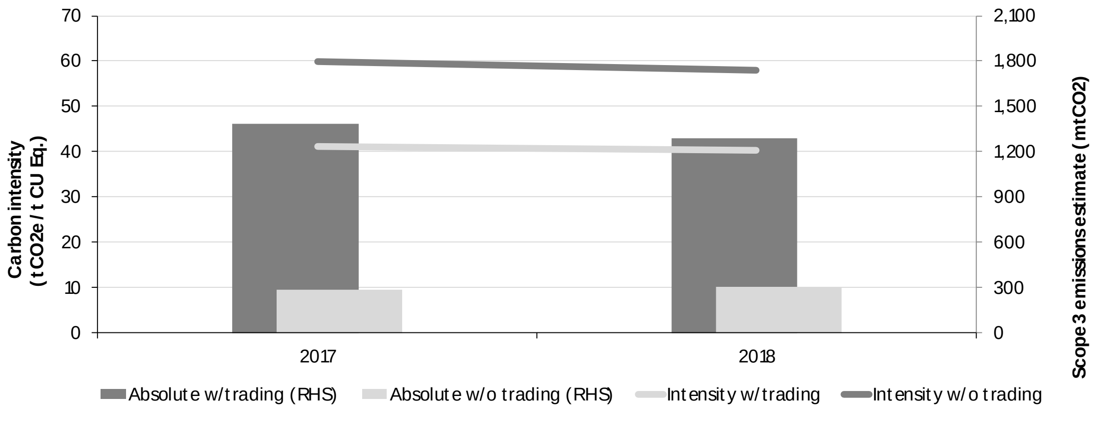
One challenge posed by such a diverse sector is establishing the assessment boundary. In this case, the question is which activities and commodities to include, and which to exclude. We propose making our assessment of diversified mining companies as broad as possible, including as many commodities as feasible. This is guided by the principles of (i) fully reflecting companies' transition risk, and (ii) taking into account the critical role of commodity portfolio diversification in enabling diversified mining companies to make the transition to a low-carbon economy.

Along the way, we have considered and rejected various options to limit the assessment boundary. One option we looked at was distinguishing between energy (coal, oil and natural gas) and non-energy products. As Figure 1 highlights, of the ten largest diversified miners only Glencore and BHP sell substantial volumes of oil and gas. Energy products are much more emissions-intensive than most other mining products. Given TPI assesses oil and gas producers separately [6], there is an argument to exclude some or all energy products from the methodology for diversified miners and focus on non-energy products. The impact of excluding energy products from the diversified mining benchmark is shown in Figure 5. However, we believe that including companies' energy products means our assessment better reflects companies' transition risks and is therefore more holistic.

The objective of making the scope of our assessment as broad as possible also leads us to propose including natural resource marketing/trading activities. These activities account for over 80% of Glencore's revenues. Whilst they are operationally very different in character to natural resource extraction, trading carbon-intensive products creates similar transition risks for investors. Excluding them opens up a decarbonisation strategy that would simply transfer transition risk to an unassessed activity without any decarbonisation taking place.

We do aim to exclude "financial trading", in which no change in ownership of the underlying asset takes place. However, it is not straightforward to distinguish this from other forms of trading based on public disclosure. In addition, some mining companies trade emissions-intensive products, but do not publicly disclose volumes. We solicit feedback on these issues to help develop a consistent approach. Recognising that some investors may want to compare production entities in isolation, we show the impact of excluding trading on Glencore's assessment. As Figure 2 highlights, including trading activities increases our estimate of Glencore's absolute emissions nearly fivefold, but in fact it lowers intensity by 18 percentage points.

Figure 2. The impact of trading on Glencore's emissions intensity and absolute emissions



While we aim to cover a broad range of activities within this methodology, we do not intend to include activities outside the natural resources sector. Consequently we do not intend to capture Grupo Mexico's Transportation and Infrastructure divisions (25% of its 2018 revenues).

3.3. Estimating carbon emissions

Following the establishment of a broad assessment boundary, our emissions measure needs to capture the full climate impact of the diversified mining sector, while being calculated consistently across the sector and its constituents.

Operational (Scope 1 and 2) emissions

The extraction, grinding and transportation processes that characterise the diversified mining sector typically consume large amounts of energy and consequently generate substantial operational (Scope 1 and 2) carbon emissions. The emissions intensity of operations varies widely by natural resource, location and extraction method. A mineral located close to the surface and/or near the primary processing site will require significantly less energy to produce. Typically diversified mining companies disclose Scope 1 and 2 emissions and we incorporate these data in our company assessments.[5]

Scope 3 emissions

The downstream processing and use of natural resources produced and sold by mining companies (i.e. outside the companies' boundaries) can be very emissions-intensive. Emissions from the burning of thermal and metallurgical coal and the processing of iron and bauxite ores are estimated to be on average 10x greater than the associated operational emissions and can be up to 30x greater [7]. Therefore, in our view, any assessment of the climate impact of the sector should include these downstream emissions.

Two Scope 3 categories are particularly relevant for the mining sector:

1) **Processing of sold products (Category 10).** Iron ore and bauxite require substantial energy inputs to be converted into useful products. The processing required to produce finished gold and copper products also requires energy. We apply factors calculated by industry and academic research to these products to estimate their Scope 3 emissions (see [8] and [9] respectively). For other metals, we were either unable to locate emissions factors or we deem the downstream processing-based emissions to be immaterial.
2) **Use of sold products (Category 11).** Hydrocarbon-based energy products (coal, crude oil and natural gas) release CO_2 when burned. We apply IPCC factors [10] to these energy products to calculate Scope 3 emissions.

Adding up estimates of Scope 3 emissions product by product enables global Scope 3 emissions for the diversified mining sector to be estimated.

Non-CO_2 greenhouse gas emissions

Our proposed methodology also includes non-CO_2 sources of emissions. For the benchmarks, we estimate fugitive methane (CH_4) from coal, oil and gas production using EDGAR data [11]

[5] We do not need to separately estimate Scope 1 and 2 emissions for the benchmarks, because they are already included in global primary energy emissions. For the purposes of Table 3 only, we provide an estimate of current, sector-wide operational emissions by multiplying the average operational emissions intensity of the companies we have assessed (nine of the ten largest) by sector Cu Eq. and subtracting this product from our estimate of total emissions.

and use IPCC scenario pathways for our future projections. According to the IAI [12], global PFC emissions in 2014 from aluminium smelting were equivalent to 34 Mt CO_2.

The treatment of Scope 3 "processing of sold products" emissions

We propose an adjustment to this bottom-up method of calculating emissions, which reduces potential double-counting of Scope 3 emissions. All CO_2 emissions we estimate from "processing of sold products" reflect emissions released when fossil fuel is burned to supply energy. However, these emissions have already been included in our benchmarks through the application of Scope 3 "use of sold product" emissions factors to primary energy products. Therefore adding the "processing of sold products" and "use of sold products" emissions together risks double-counting.

This issue can be best highlighted by looking at metallurgical coal and iron ore. Metallurgical coal, which we define as coking coal plus coke oven coke (according to the IEA segmentation), and which accounts for c. 20% of total coal production, is used as both an energy and carbon source in steel production. The emissions released during this process are included in the Scope 3 "use of sold products" factor we apply to this coal. However, the Scope 3 ("processing of sold products") factor we apply to iron ore production also takes into account these emissions (even though most of the emissions released are actually from burning coal). Therefore, to eliminate this double-counting, we assume that all Scope 3 emissions from steelmaking are included in the emissions factor we apply to iron ore, and propose removing the equivalent Scope 3 emissions generated by metallurgical coal from the benchmarks. We make a similar adjustment for all other "processing of sold products" emissions.

Adjusting for captured emissions

We also adjust our emissions benchmarks to reflect the IEA's estimates of CO_2 captured and stored (i.e. CCS) in different scenarios. The need to capture process emissions from the steel sector in particular, as well as the potential for firms supplying primary energy to reduce the climate impact of their activities using CCS, make this an important source of emissions reduction in our benchmarks. In the 2C benchmark scenario, captured emissions rise to 5.8 Gt CO_2 by 2050.

3.4. Establishing a common denominator: copper equivalent

Finding an activity measure – the denominator of emissions intensity – that is relevant to companies with such different and often diverse portfolios is another challenge. In developing this methodology, we have considered a number of different denominators.

Metrics that exclusively rely on the volume of physical output (e.g. tonnes of rock mined/milled/metal output) struggle to capture both energy products and the full range of mining products. A company focused on high-value, low-volume products (e.g. precious metals) would have, *ceteris paribus*, a much higher intensity than one focussed on high-volume commodities.

A revenue-based denominator was also considered. Using revenue would allow commodities of different values to be compared with relative ease. However, there are two drawbacks to revenue as an activity measure. First, revenue is volatile, which exposes the methodology to year-on-year fluctuations driven by commodity price fluctuations. Second and more importantly, it is difficult to make long-term revenue projections for the diversified mining sector. These projections are essential for benchmarking (see below).[6]

Instead, the methodology developed here proposes using a **copper equivalent (Cu Eq.)** denominator. Cu Eq. volume is defined as the weight (in tonnes) of copper that has a revenue equal to that of the commodity in question. Calculating Cu Eq. requires establishing the market price of copper and the product to be converted. The ratio of these two prices is called the "price factor". Table 1 illustrates how production is converted into a Cu Eq. measure using iron ore as an example. A full list of price factors is shown in the Appendix.

Table 1. Conversion into Copper Equivalent (Cu Eq.) volume

	Calculation step	2016	2017	2018	Source
A	Annual Iron Ore sales (million tonnes)			238	Company A
B	1-yr average Iron ore price (US$ per tonne)	58	72	69	World Bank Commodity Market Outlook [13
C	1-yr Average Copper price (US$ per tonne)	4,868	6,170	6,500	World Bank Commodity Market Outlook [13
D	Price factor (B/C)	0.012	0.012	0.011	
E	3-yr average price factor (average D)			0.011	
F	**Copper Equivalent volume (Cu Eq, mt), (A x E)**			**2.72**	

Since calculating Cu eq. requires inputting market prices, it is subject to fluctuation, like revenue. However, Cu eq. is less volatile than underlying commodity prices, because of covariation between the price of copper and the price of other commodities. This is shown in Table 2. To further reduce volatility, we calculate a three-year average price factor. A five-year average was also considered, but the lack of consistent data across all commodities made it difficult to calculate. Following feedback from companies on this issue, we will look further at ways to average over longer periods when we publish formal assessments later in the year.

We believe this Cu Eq. metric should also be relatively well understood in the mining sector. Metal equivalent calculations are often used by mining companies and analysts to compare commodities of different value and where production has different grades or contains multiple metals.

Table 2. Coefficients of variation for key commodity prices, Cu Eq. and average Cu Eq. values

	Crude oil	Coal	Aluminium	Iron Ore	Copper	Gold
Nominal prices (1960 - 2018)	0.84	0.61	0.40	0.84	0.70	0.82
Cu Eq.	0.62	0.37	0.37	0.31	-	0.52
3-yr Cu Eq.	0.58	0.31	0.35	0.27	-	0.49
5-yr Cu Eq.	0.55	0.27	0.33	0.24	-	0.46

* The coefficient of variation is the ratio of the standard deviation to the mean and is a way to measure variation in a comparable way across metrics with different scales.

[6] One could assume revenue grows at the same rate as GDP; GDP growth projections are widely available. However, structural change generally dictates that the size of the primary sector, including mining, shrinks over time, so revenue would not be expected to grow at the same rate as GDP.

3.5. Estimating and forecasting a global Cu Eq. benchmark

Determining the alignment of diversified mining companies with the Paris Agreement goals requires constructing global benchmarks from this Cu Eq. denominator. We do this using the bottom-up methodology shown in Table 3, aggregating data from individual products to estimate global Cu Eq.

We use IEA ETP [2] data to estimate global hydrocarbon energy production (coal, segmented by type, plus crude oil and natural gas). We also use IEA ETP data to estimate global primary aluminium and steel production (with iron ore production converted from steel production using a ratio of 1.4 tonnes of iron ore to 1 tonne of steel [14]). Estimates for 18 additional commodities are collated from a variety of sources [15, 16, 17, 18, 19, 20].

We then need to project future production corresponding to our three benchmark scenarios, i.e. the Paris Pledges, 2C and Below 2C. IEA ETP projections are available for the energy products, aluminium and iron ore. Long-term projections of production are generally unavailable for other commodities, so we link production growth for these 18 commodities with real GDP growth projections from the IEA ETP, for the purposes of consistency.

3.6. Summarising the proposed Carbon Performance metric

We propose the following metric to assess Carbon Performance in the diversified mining sector:

$$\text{Emissions intensity} = \frac{\text{Scope 1 + Scope 2 + Scope 3 (Cat. 10 + 11 only) + CH4 + PFC - Captured CO2}}{\text{Sales volume Cu Eq.}}$$

Table 3 summarises the data sources and methods we use to calculate Carbon Performance benchmarks for the diversified mining sector using this metric. The resulting benchmarks are shown in Figure 3.

Figure 3. Carbon intensity benchmarks for the diversified mining sector

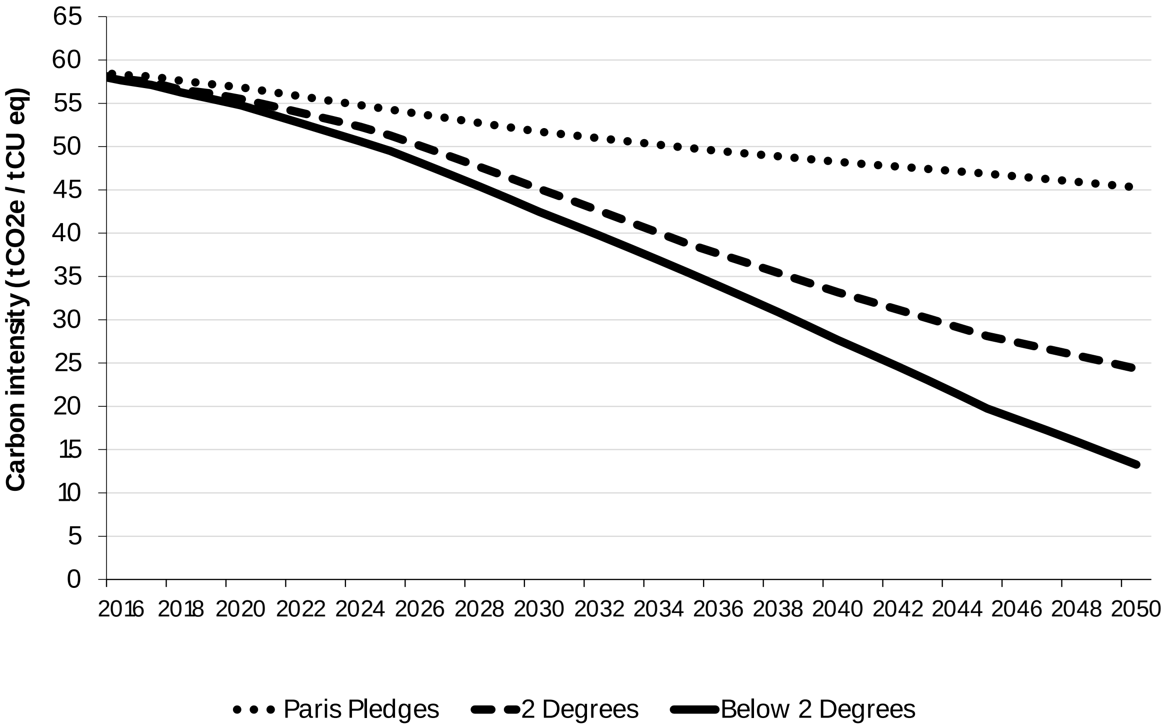


Table 3. Production, emissions and method of calculation for our diversified mining benchmark

Classifi-cation	Product / Raw Material	2018 Global production: Mt	Price factor	Cu Eq. (mt)	Source	2018 Global emissions (CO_2): Scope 1 & 2	Scope 3	Emission Factor	Metric and source	2018 - 2050 Forecast methodology: Production	Emissions
Energy products	Metallurgical Coal *	1,204	0.03	33.1	IEA ETP 2017 primary energy demand module	Scope 1 & 2 emissions estimate: 1490 mt. Calculated from average operation intensi of top ten miners of 2.26 tCO2e/t Cu Eq.)	3,232	94.6-107	tCO_2/TJ [10]	IEA ETP 2017 primary energy demand module: fossil fuel output falls by 40% by 2050 in a 2 Degree Scenario	IEA ETP primary energy demand module.
	Thermal Coal **	5,104	0.02	85.8			10,499	94.6-101	tCO_2/TJ [10]		
	Crude Oil	3,793	0.07	270.0			12,295	73.3	tCO_2/TJ [10]		
	Natural Gas	2,555	0.06	144.9			6,839	56.1	tCO_2/TJ [10]		
ETP Metals	Iron Ore	2,199	0.01	25.1	IEA ETP 2017 industry module		2,817	1.3	tCo_2/t (1.85 tCO2/t steel w/1.4t of iron ore per t of steel [14])	IEA ETP 2017 industry module: iron ore production expected to grow by 1.7%pa and Al by 0.25% in a 2 Degree Scenario	IEA ETP 2017 industry module: in a 2 Degree Scenario the emission intensity of both steel and Al. is expected to halve by 2050
	Aluminium (Primary, from Bauxite/Alumina)	65	0.32	21.1			674	14.4***	tCO_2/t. 5t Bauxite reduces to 2t Alumina reduces to 1t Al. [21]		
Other (non-ETP metals)	Copper	20.6	1.0	20.6	ICSG [15]		87	4.2	tCO_2e/tCU [8]	Increases driven by real GDP according to IEA: 2014-2025: 4.2%, 2025-2035: 3.5%, 2035-2050: 2.2%.	Constant intensity (growth inline w/GDP)
	Gold	3.5	7.0	24.6	WGC [16]		82	23,435	tCO_2/tAU [9]		
	Cobalt	0.1	8.5	1.0	USGS [17]		-	Scope 3 emissions assumed to be immaterial (see text)			Scope 1&2 emissions assumed to decline according to change in the energy mix given the IEA ETP. Scope 3 emission factors assume to be immaterial
	Ferroalloys	13.6	0.4	4.9	USGS [17]		-				
	Lead	4.9	0.4	1.8	ILZSG [18]		-				
	Manganese	16.7	0.2	3.3	USGS [17]		-				
	Molybdenum	302.2	0.0	1.2	USGS [17]		-				
	Nickel	2.2	1.9	4.2	USGS [17]		-				
	Palladium	0.0	5,917	1.3	USGS [17]		-				
	Platinum	0.0	5,368	1.1	USGS [17]		-				
	Salt	291.8	0.0	2.8	USGS [17]		-				
	Silver	0.0	93.1	2.5	USGS [17]		-				
	Titanium Dioxide	7.4	0.0	0.1	USGS [17]		-				
	Uranium	0.1	9.6	0.6	WNO [19]		-				
	Zinc	13.2	0.4	5.9	ILZSG [18]		-				
	Diamonds****			2.8	Bain [20]		-				
Total		**15,596**	**0.04**	**658.6**		**38,014**					
	Elimination of Scope 3 CO_2 emissions (see text)					-3,659					
	Other GHGs (Methane + PFC) CO_2e					2,943					
	Captured Emissions					-65					
Adj Total		**15,596**	**0.04**	**658.6**		**37,233**					

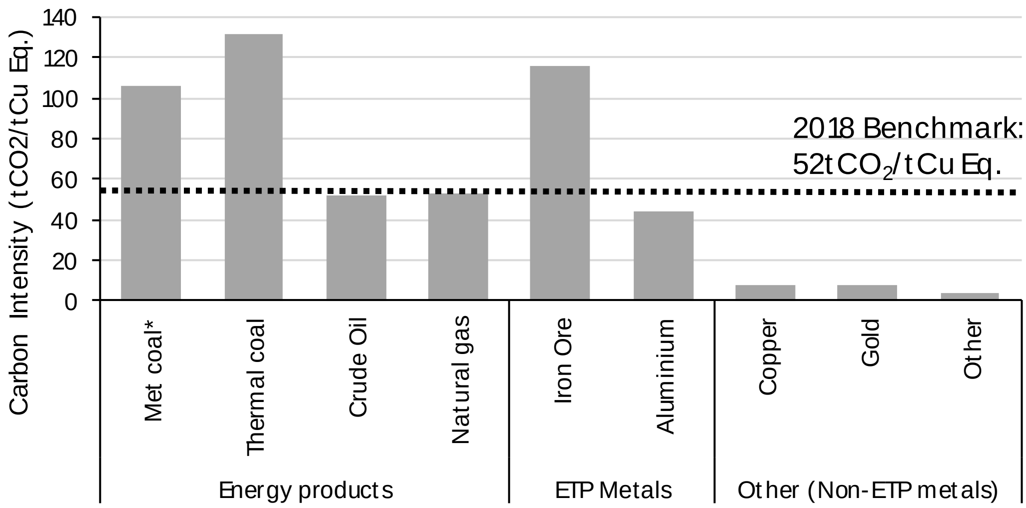
* Coal primarily used for steelmaking ** A range of coal grades modelled separately *** Lifecycle emissions factor of 14.4 tCO_2e/t primary aluminium, 90% of emissions released converting alumina into aluminium with c.80% occurring outside the mining industry (incurring Scope 3 emissions) **** Cu Eq. estimated by dividing the size of the diamond market by average 2018 price/t Cu eq.

4. FURTHER METHODOLOGICAL ISSUES

4.1. The sensitivity of the benchmark to product mix

The natural resources in our proposed benchmark include commodities with very different emissions intensities (see Figure 4). Energy products generally have high emissions intensities. We estimate that lifecycle (i.e. including Scope 3) emissions intensities range from 52 tCO_2/tCu Eq. for crude oil to an average of 132 tCO_2/tCu Eq. for thermal coal. Non-energy products (ETP Metals and Other) have much lower intensities in general, although iron ore is a notable exception: emissions from steel-making result in a lifecycle emissions intensity of 112 tCO_2/tCu Eq.

Figure 4. Lifecycle emissions intensity by product (CO_2 only)*



Assumes 4.0 tCO_2/tCU Eq. in operational emissions for all products with the exception of aluminium and copper, where lifecycle factors of 14.4 tCO_2e/tAl. and 4.2 tCO_2/tCu are used respectively. A gross CO_2-based benchmark is chosen, as allocating negative emissions and non-CO_2 emissions by product is difficult. Metallurgical coal emissions are excluded from the benchmark, but are shown here for illustrative purposes (see text).

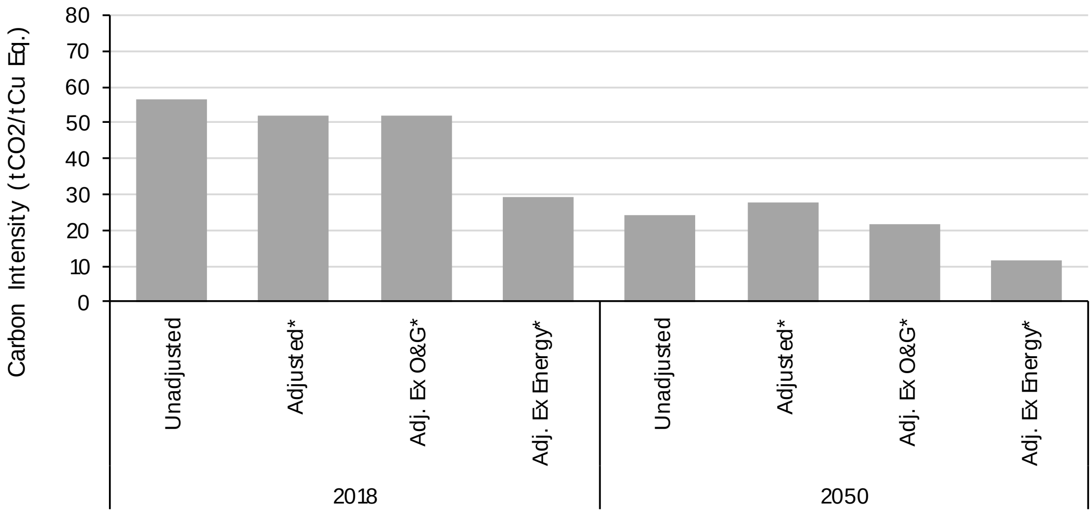
As a result of their high intensity, energy products (thermal coal, oil and gas) account for 89% of CO_2 emissions in the sector benchmark, but just 81% of Cu Eq. production (an average emissions intensity of 58 tCO_2/tCu Eq. vs. 52 tCO_2/tCu Eq. for the benchmark). Oil and gas is broadly neutral for the benchmark, accounting for 63% of emissions and Cu Eq. production. With an average emissions intensity of 128 tCO_2/tCu Eq., thermal coal generates 33% of emissions despite accounting for just 13% of Cu Eq. production.

As Figure 1 highlighted, of the ten largest diversified mining companies, only Glencore and BHP sell substantial volumes of oil and gas currently (54% and 11% of 2018 revenues respectively). As long as industry leaders are engaged in this emissions-intensive activity, we believe it is important to capture it within our benchmark. However, if BHP were to divest from its drilling activity and/or Glencore to reduce crude oil trading, inclusion of oil and gas within the benchmark would be more difficult to justify. Removing oil and gas makes little difference to the overall intensity of the benchmark in 2018, but it reduces the benchmark in 2050 by 6 tCO_2/tCu Eq. (see Figure 5).

Currently six of the ten largest diversified miners produce either thermal or metallurgical coal. Therefore the inclusion of coal in the benchmark is not in question. However, its exceptionally high emissions intensity results in a sector benchmark that is relatively easy for mining companies without coal exposure to be aligned with. If and when further diversified mining companies exit from thermal coal (following Rio Tinto's example), it may become appropriate to exclude it from a diversified mining benchmark. Excluding all energy products, including thermal coal, would substantially lower the proposed benchmark to 22 tCO_2/tCu Eq.

The wide variation in intensity by product highlights the potential for diversified mining companies to align with the benchmarks by shifting their portfolio away from energy products (particularly coal) and iron ore.

Figure 5. The impact of excluding O&G and all energy from the 2 Degrees benchmark (CO_2 only)



* Adjusted removes the impact of non-CO_2 emissions and negative emissions, which are not apportioned by product.

4.2. Estimating company carbon intensity

Choice of companies to profile

We apply our methodology to the world's ten largest publicly listed diversified mining companies measured by market capitalisation of the free float, using data from the FTSE Allcap index (see Table 4). TPI uses market capitalisation as a proxy indicator of the importance of the company to investors.

Table 4. The ten largest diversified mining companies and their disclosure

Company	Sector	Mkt Cap* ($bn) Total	Mkt Cap* ($bn) Freefloat	CP** assessment completed?	Emissions Target?	Data sources
BHP	General Mining	74.6	74.6	Yes	2050+ (Abs.)	• Annual Report 2018, 2017 • Operational report 2018 • CDP Datasets 16-18 • 2018 Sustainability Report
Rio Tinto Ltd.	General Mining	67.6	58.8	Yes	2050 (Abs.)	• Annual Report 2018, 2017 • CDP Datasets 16-18 • 2018 Climate Change Report
Vale SA	Iron & Steel	58.8	39.3	Yes	2050 (Abs.)	• Annual Report 2018, 2017 • CDP Datasets 16-18
Glencore	General Mining	42.5	34.3	Yes	2035 (Abs.)	• Annual Report 2018, 2017 • CDP Datasets 16-18
Anglo American	General Mining	36.5	32.9	Yes	2030 (Abs.)	• Annual Report 2018, 2017 • CDP Datasets 16-18
Freeport-McMoran	Non-ferrous	16.0	15.9	Yes	None	• Annual Report 2018, 2017 • CDP Datasets 16-18
MMC Norilsk Nickel	Non-ferrous	43.7	14.4	No	None	• No CDP responses • No Scope 2 in 2018 Sustainability report
Fortescue Metals	Iron & Steel	19.5	10.1	Yes	FY20 (Int.)	• No CDP responses • Corporate Social Responsibility Report
Grupo Mexico	Non-ferrous	21.2	9.7	Yes	Int. target not usable	• No CDP responses • 2018 Sustainable Development Report
South32	General Mining	9.0	9.0	Yes	FY21 (Abs.)	• Annual Report 2018, 2017 • CDP Datasets 16-18

* Market capitalisation as on the 20th of November 2019. ** CP = Carbon Performance

Data availability: disclosure of historical emissions intensity

TPI is a disclosure-based framework that uses the emissions data companies themselves provide as the basis of the assessment. Whilst the state of disclosure in the diversified mining sector is improving, only nine of the ten companies we assessed currently disclose Scope 1 and 2 emissions. Unless a company discloses Scope 1 and 2 emissions, TPI cannot calculate its Carbon Performance.

While seven companies disclose Scope 3 emissions in some form, the method used to calculate these figures varies significantly. Here are some examples:

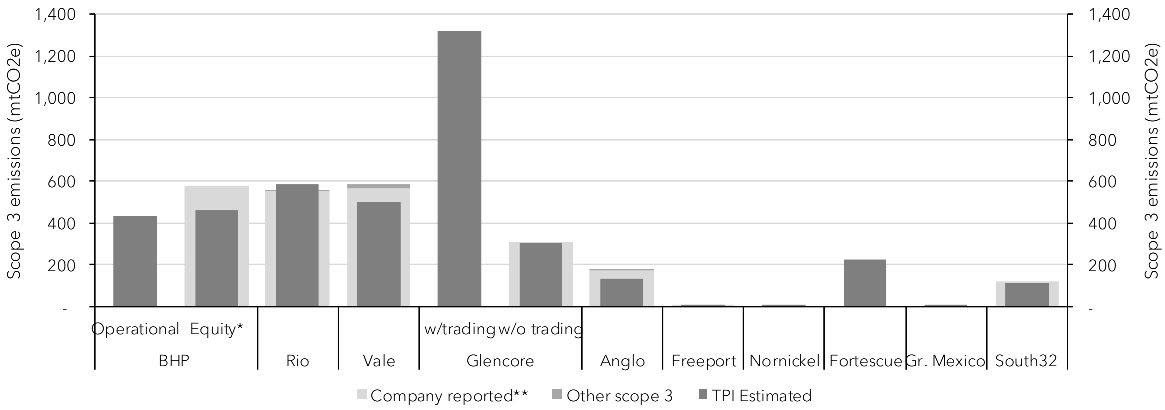
- Freeport discloses a single Scope 3 emission figure covering all categories.
- BHP discloses emissions from the use of energy products separate to emissions from the processing of iron ore and copper (categories 10 and 11 respectively). However, the equity boundary of BHP's disclosure is inconsistent with the boundary it uses to disclose its Scope 1 and 2 emissions.
- Rio Tinto has a broader definition of category 10, which includes "transport of sold product by customer or their representative" and is assumed to be significant for iron ore, given the volumes transported and the distances.
- Anglo American includes processing nickel for production of stainless steel and the processing of refined platinum group metals. It also includes emissions from traded volumes of coal, which are not publicly disclosed.
- Vale has recently expanded the range of activities included in its Scope 3 calculations, from c. 70% to nearly 100%, which has a big impact on its reported estimates.

Calculating Scope 3 is complicated, publishing is voluntary and figures appear to be provided on a "best effort" basis. Disclosure is improving, but in our view published figures do not currently provide a reliable indicator of performance over time, or enable meaningful comparison between companies.

In the absence of suitable and consistent Scope 3 disclosure, TPI applies the bottom-up methodology set out above to calculate company emissions. To do so requires disclosure of sales volumes segmented by natural resource (production data can be used where they provide greater granularity). Applying the appropriate emissions factor to these sales data enables emissions from use and processing of sold products (Category 10 and 11 respectively) to be estimated. Where companies publish a Scope 3 breakdown, these categories typically account for over 95% of emissions. Overall, the approach is similar to the one we have developed for the oil and gas production sector [6].

All companies assessed provided sufficient segmentation of sales volumes to make this calculation possible, however the reporting boundary used (equity or operational), the precise nature of the product, and the level of production consumed internally is not always clear. We highlight the impact of reporting boundary in our BHP assessment in Figure 6. In general, we try to ensure consistent boundaries for operational (Scope 1 and 2) and Scope 3 emissions and the Cu Eq. denominator. However, we also prefer our assessments to be as broad as possible, particularly where a narrower consolidation boundary excludes emissions-intensive activities.

Figure 6. A comparison of TPI's Scope 3 estimates with company disclosure



* BHP disclosure of 576mt CO_2e Scope 3 emissions from category 10 and 11 in FY18 but makes no adjustment for emissions from Metallurgical Coal. TPI estimate of emissions without any adjustment is also 576mtCO_2e ** Sum of category 10 and 11 where specified but if no breakdown disclosed just reflects total

As discussed in Section 3.2, we propose to include all natural-resource-related activities within our company assessments. This enables the methodology to include Glencore's Marketing division, which trades third party products and generates 80% of the company's sales, for example. We exclude activities that are not related to natural resources, such as the 25% of Grupo Mexico's revenues generated from its Transportation and Infrastructure divisions.

Data availability: targets

Of the ten largest diversified mining companies, eight have set targets to reduce emissions. Five of these targets are expressed in the form of reductions in absolute emissions by a certain date and three (Glencore, Fortescue and Grupo Mexico) aim to reduce intensity. Disclosure on Grupo Mexico's target and South 32's net zero ambition is not sufficiently detailed to enable a target to be calculated.

These targets typically cover different emissions scopes or have different operational boundaries. While only Glencore has set a target including Scope 3 emissions so far, BHP has indicated it will "set public goals next year on reducing GHG emissions from [their] products even after they have been sold" [22].

Published emissions targets are converted into a company-wide intensity target in the following way:

- **Scope 1 and 2 intensity targets:** the disclosed percentage reduction is applied to Scope 1 and 2 emissions intensity in the elected base year. Scope 3 emissions intensity is assumed to remain flat from the last calculated year.
- **Scope 1 and 2 absolute targets:** emissions within the target are converted to intensity using the Cu Eq. denominator. Production is projected into the future in the same way as the benchmarks, as explained in Section 3.5. Emissions outside the target are assumed to remain at a constant intensity relative to the most recent disclosed data. This approach is consistent with the methodology TPI has adopted in other sectors.

Calculating company-level intensity

Companies' Cu Eq. volumes are calculated using disclosed sales data by raw material (production data can be used where it provides greater detail). Price factors are used to convert these data to Cu Eq. either using global price data or company specific disclosure where available. For a company not reporting on a calendar-year schedule, data from the financial year-end closest to the calendar year-end is used.

Our proposed approach also aims to adjust for internally sold products (the sale of raw material into "downstream" activities owned by the same company) to minimise double-counting. The inclusion of trading and focus on "all externally sold product" is consistent with the approach we use for downstream oil and gas [6].

Total emissions are calculated by adding disclosed Scope 1 and 2 emissions to our estimate of Scope 3 emissions. As with the benchmark calculation, an adjustment is proposed to prevent double-counting of Scope 3 emissions from iron ore and metallurgical coal (see section 3.3). As a default, we include emissions from metallurgical coal production in the company assessment, but believe there is a legitimate argument that, where a company also produces iron ore, a certain proportion of these emissions should be removed. We propose to remove emissions from all metallurgical coal production up to 0.57x the company's iron ore production. This 0.57x factor represents the ratio of metallurgical coal needed to make steel from any given amount of iron ore according to the World Steel Association [14]. For example, 0.8t of metallurgical coal and 1.4t of iron ore are typically required to make 1t of steel (0.8 / 1.4 = 0.57). Table 5 illustrates how this calculation is applied.

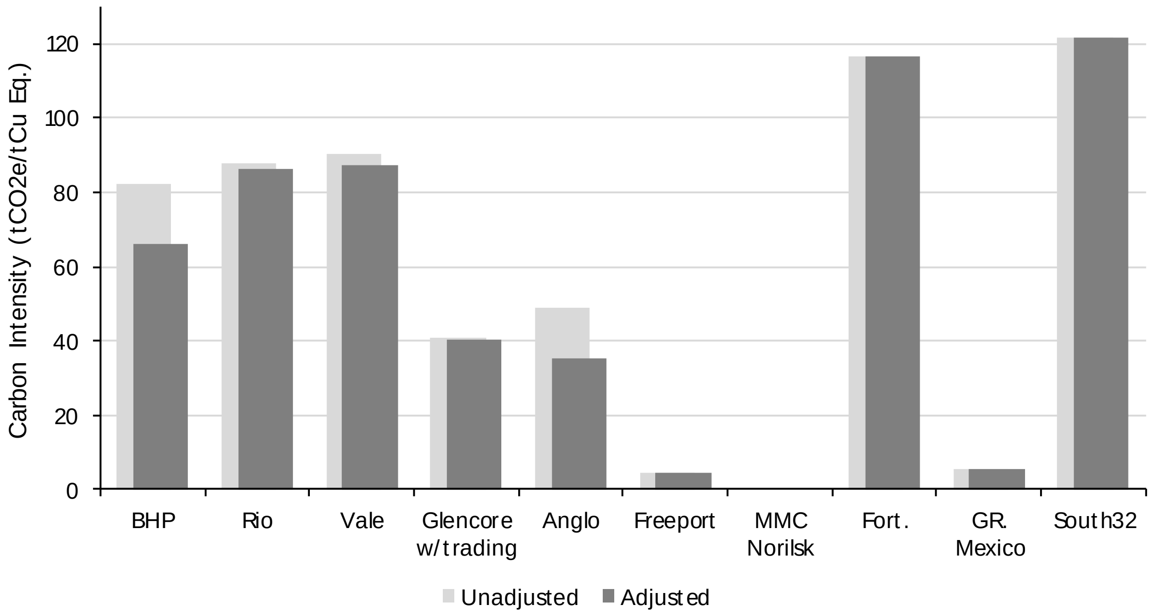
Table 5. The proposed adjustment to Scope 3 emissions from Metallurgical coal and iron ore

Method	Weight of material (mt)				Ratio of Met. coal to iron ore	Emissions factors			Emissions (mt)				
	Iron ore	Met. Coal	Input total	Steel		Iron ore	Met. Coal	Steel	Iron ore	Met. Coal	Steel	Adjust for double counting	**Total**
#1 Emissions released during steelmaking [8]				100				1.9			185		**185**
#2 Unadjusted. Apply emission factors to raw materials	140	80	220	100	0.57	1.3	2.7		185	213			**398**
#3 Adjusted. Eliminate double counting by removing Met. Coal emissions*	140	80	220	100	0.57	1.3	2.7		185	213		(213)	**185**
#3 Adjusted. Eliminate double counting but include excess coal*	140	100	240	100	0.71	1.3	2.7		185	266		(213)	**238**

* All emissions from Metallurgical coal up to 0.57x iron ore volumes are removed to eliminate double-counting.

Figure 7 shows that this proposed approach has a material impact on the estimated emissions intensity of some companies. We would encourage feedback on this topic. There is a legitimate question as to whether, in the case where metallurgical coal and iron ore are sold to separate customers and are therefore destined not to be combined in the same physical product, it is appropriate to eliminate these emissions. The development of emissions accounting guidelines addressing this specific issue would be helpful. Another solution would be for companies to disclose the volume of metallurgical coal and iron ore sold to the same customer.

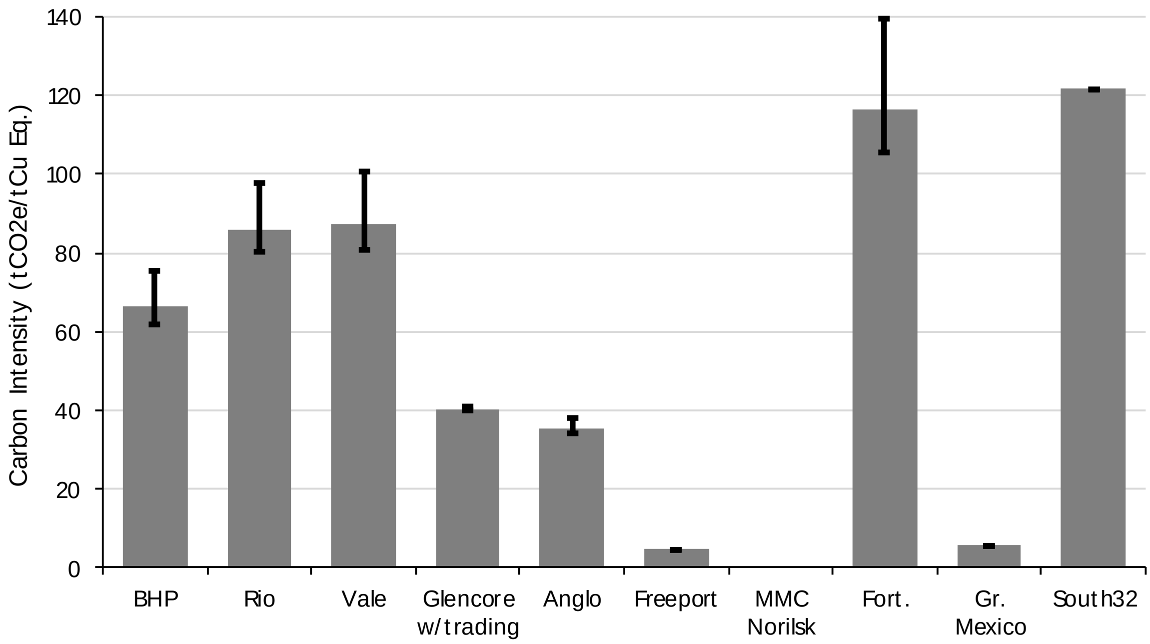
Figure 7. The impact of adjusting for double-counting of Scope 3 emissions from metallurgical coal and iron ore in the provisional company assessments



Emissions factors used

The choice of emissions factors to apply to production is not always straightforward. Following company feedback, we have adjusted the emissions factor we have applied to iron ore from 1.0 tCO_2/t to 1.3 tCO_2/t. This higher figure is based on the WSA [14] estimate of 1.85 tCO_2/t of steel produced and assumes 1.4 tonnes of iron ore per tonne of steel produced. However, it is not clear the extent to which operational emissions from iron ore suppliers are already included in this factor and it may be appropriate to apply lower emissions factors to part-processed products like fines and pellets. Our assessment of steel companies [3] suggests an emissions factor of 1.85 tCO_2/t is an appropriate Scope 3 factor to use for mining, but this does include some production from scrap. The ten most emissions-intensive steelmakers average 2.2 tCO_2/t. Given iron ore is emissions-intensive, the precise factor chosen makes a material difference to overall intensity scores. We highlight this impact in Figure 8 and invite further feedback on this topic.

Figure 8. The impact of different Iron ore emissions factors on overall intensity in 2018*



* Proposed methodology assumes an emissions factor of 1.85tCO_2/t of steel. Error bars show the impact of using 2.2tCO_2/t (the average of the 10 most emission intensive steelmakers assessed by the TPI) [3] and 1.67tCO_2/t factor based on the TPI benchmark for steelmakers.

For Aluminium, the effective downstream emissions factor we apply varies according to the type of product the company sells: bauxite, alumina or aluminium. Diversified mining companies predominantly supply bauxite and alumina but may be involved in all parts of the production process and may sell produce at one stage to its downstream operations. In cases where a company uses its own alumina to produce aluminium internally, the amount of alumina embodied in the aluminium produced is subtracted using a conversion factor of 2 tonnes of alumina per 1 tonne of aluminium.

We assume a lifecycle factor of 14.4 tCO_2e/t primary aluminium [21] with emissions predominantly released at two main stages of the production process: alumina refining and aluminium smelting. If a company produces a (finished) aluminium product, all processing emissions will be reported in the company's Scope 1 or 2 disclosure and no Scope 3 emissions factor is applied. However, smelting consumes significant energy and hence generates c. 90% of the emissions. Assuming two tonnes of alumina are needed to make one tonne of aluminium, the effective downstream Scope 3 "processing of sold products" emissions factor we use for alumina is 6.5 tCO_2/t (90% x 14.4 $tCO_2e/2t$). If the mining company sells bauxite, all 14.4tCO_2e are effectively Scope 3. Assuming five tonnes of bauxite are converted to a tonne of aluminium, the effective emissions factor for bauxite is therefore 2.9tCO_2e/t.

We apply similar adjustments to copper output. Several companies remarked that a 4.2 tCO_2/t lifecycle factor was too high for processed copper concentrate. Based on ECI [8], we have adjusted the emissions factor applied to copper concentrate where it is specified. We will look to refine our emissions factors and extend them to other products where material.

Reflecting improvements in the efficiency of customers' production

Using industry-wide emissions factors improves comparability of our intensity estimates for the sector. However, a potential limitation of this approach is that it does not encourage diversified mining companies to focus on selling to customers deploying the best available technologies or offsetting to improve efficiency and reduce emissions. We see this as a legitimate decarbonisation strategy and arguably the only one that will enable diversified miners to retain a significant iron ore business while claiming alignment with climate goals. Given the limited variation in the emissions intensity of listed steel manufacturers at present [3], we do not see this as a significant issue at this point but believe it will become so over time. We welcome feedback on how emissions factors that reflect the efficiency of a customers' production could be reliably calculated.

Treatment of carbon capture and offsets

Our benchmark includes the impact of negative emissions (carbon capture and offsets), as we believe these are in general a legitimate path to decarbonisation for some sectors. As such, we also aim to include them in our company assessments and understand that some companies already factor them into their emissions disclosure and expect to make use of them to meet long-term targets. However, not all offsets are equally valid and company disclosure in this area varies [23]. As with our assessment of the oil and gas sector, we believe companies should publish the impact of carbon capture and offsets on their disclosed figures and an indication of the extent to which they intend to rely on them to meet emissions reduction targets.

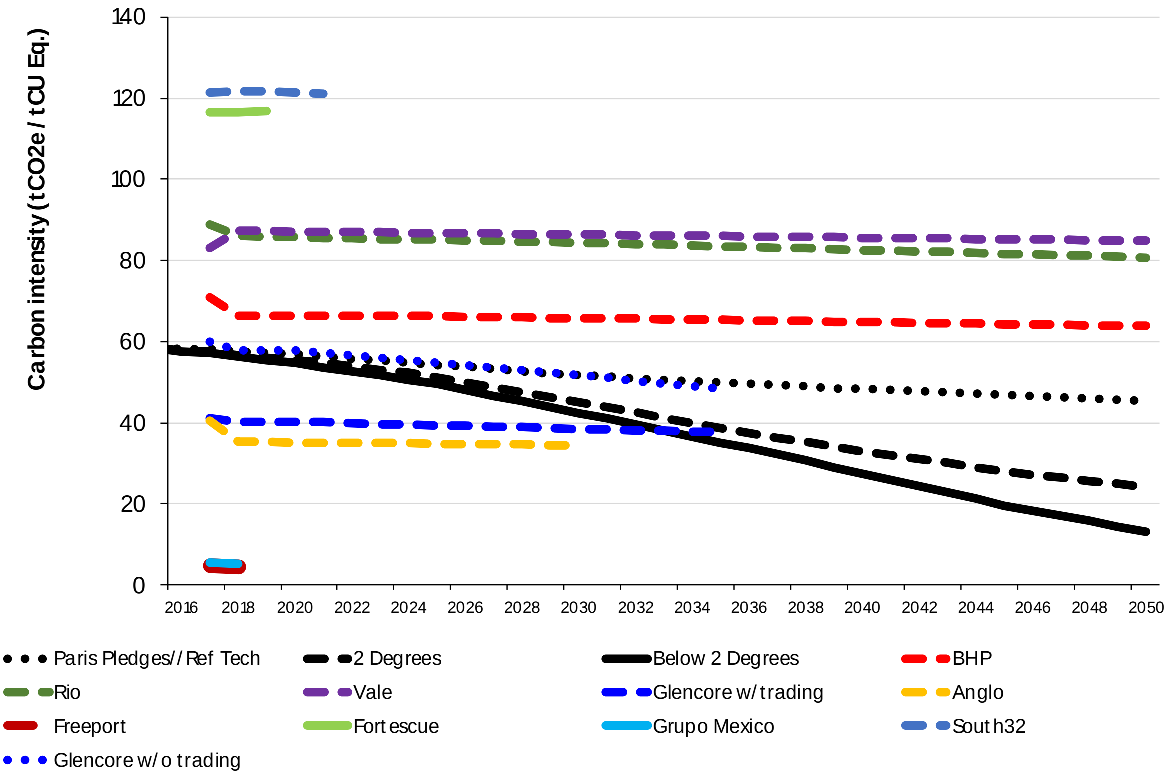
5. RESULTS FROM APPLYING THE METHOD TO THE DIVERSIFIED MINING SECTOR

5.1. Benchmarking diversified mining companies

We applied the methodology outlined in Section 3 to the 10 largest diversified miners as measured by market capitalisation on 20 November 2019. Provisional assessments were sent to assessed companies alongside a copy of the proposed methodology in February 2020 and feedback was solicited. The results after incorporating this feedback and additional freshly disclosed targets are shown in Figure 9. Of the ten largest diversified miners:

- Two companies (Grupo Mexico and Freeport) are aligned in all scenarios in 2050;
- Two companies (Glencore including its trading business and Anglo American) are currently aligned with all scenarios, but by 2050 are only aligned with the Paris Pledges;
- Three companies (BHP, Rio Tinto and Vale) are above the benchmarks currently and, with long term targets only pledging to address Scope 1 and 2 emissions, remain above the benchmarks in 2050;
- Fortescue and South 32 are substantially above the benchmarks and do not currently have credible long-term targets to substantially reduce emissions intensity;
- One company (MMC Norilsk) provides insufficient disclosure to make an assessment.

Figure 9. The Carbon Performance of the ten largest diversified mining companies



5.2. Variation in companies' carbon intensity

The carbon intensity of the ten largest diversified mining companies in 2018 varies widely from 4.6 tCO_2e/tCu Eq. (Freeport) to 121.7 tCO_2e/tCu Eq. (South32). The weighted average (excluding trading activities to minimise double-counting) of the nine companies assessed is 66.5 tCO_2e/tCu Eq., 20% above the 2C benchmark.

As highlighted in Figure 4, carbon intensity varies significantly by commodity. To test the influence of production mix, company carbon intensity was assessed against:

1) the proportion of iron ore in the mix (measured in Cu Eq.);

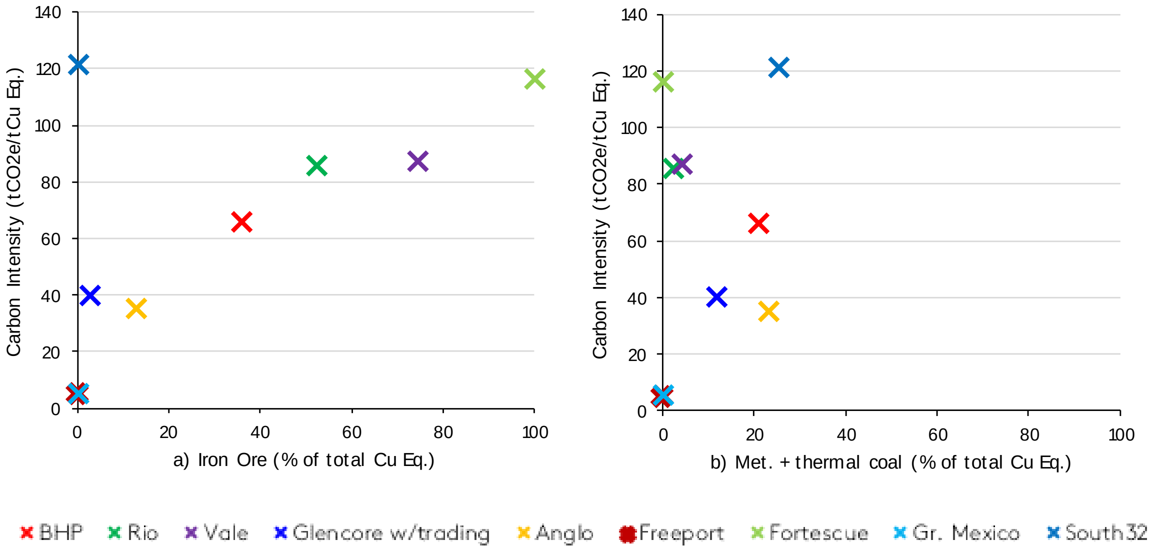
2) the proportion of coal (both thermal and metallurgical) in the mix;

3) the proportion of copper, gold and other metals in the mix;

Figure 10a suggests that the proportion of iron ore production significant influences variation in carbon intensity across the sector. Iron ore's Scope 3 emissions intensity of 112 tCO_2e/tCu Eq. is double that of the benchmark and it is extensively produced across the sector (five of the nine companies assessed mine iron ore and it accounts for 35% of total Cu Eq.). However, the share of production varies widely by company, ranging from 0% for South32, Freeport and Grupo Mexico to 100% for Fortescue.

The notable outlier in Figure 10a is South32, which, despite no iron ore production, has an emissions intensity of 121.7 tCO_2e/tCu Eq. This reflects both a high share of coal in its mix and high operational emissions. Figure 10b shows that South32 has the biggest share of coal production (25% of Cu Eq.). Unlike BHP and Anglo, which also mine metallurgical coal, it does not produce iron ore and hence its emissions are not adjusted to avoid double-counting. Furthermore, its domestic thermal coal (5% of total Cu Eq.) is sold at a quarter of the export price of its thermal coal and consequently it has a tCO_2e/tCu Eq. of 669. Figure 11b shows that South32 also has the highest operational emissions intensity in the sector by a considerable margin. Highly energy intensive aluminium production accounts for 54% of Cu Eq.

Figure 10. Variation in 2018 carbon intensity by a) the proportion of iron ore in the mix, b) the proportion of coal (both metallurgical and thermal) in the mix*



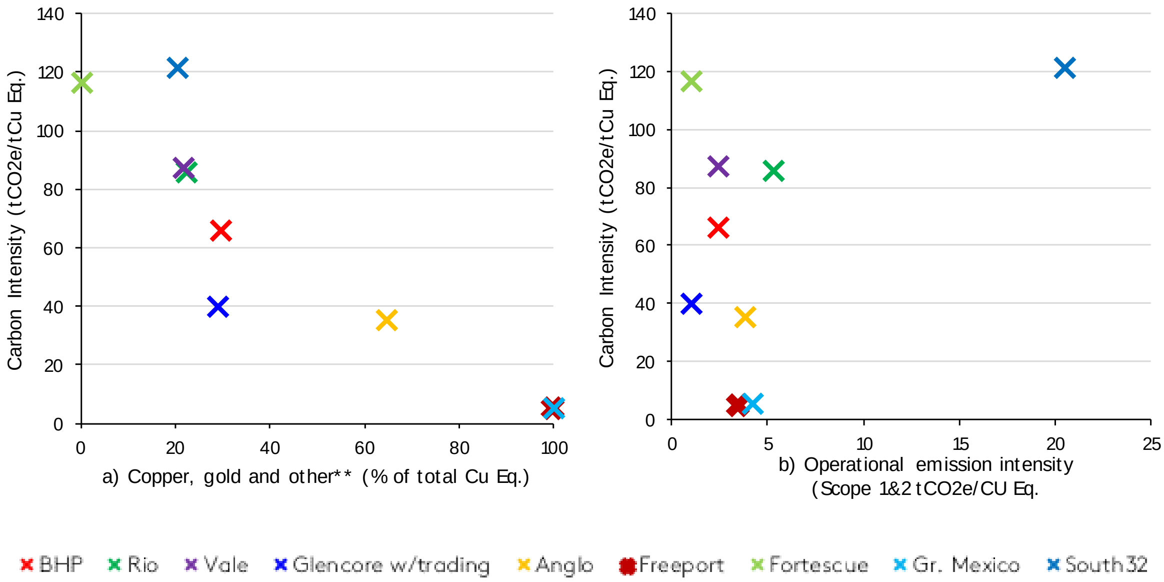
* MMC Norilsk did not disclose sufficient information to enable an assessment to be completed

Figure 10b shows that, aside from the notable exception of South32, the relationship between the amount of coal produced and company intensity is unclear. BHP and Anglo American mine only slightly lower amounts of coal than South32 (21% and 23% of Cu Eq. respectively), but their emissions intensity is much lower. These companies both benefit from the adjustment to metallurgical coal emissions due to iron ore production and diverse portfolios of products that have low Scope 3 emissions.

Figure 11a helps explain the low emissions intensity of companies like Freeport and Grupo Mexico. These companies focus on commodities (mostly copper), which have very low or zero Scope 3 emissions and consequently have very low emissions intensities overall.

Finally Figure 11b compares total company intensity with operational (Scope 1 & 2) emissions intensity. Average operational emissions intensity for the nine companies assessed (excluding Glencore's trading business) is 4.3 tCO_2e/tCu Eq. (6% of emissions), with South32 a notable outlier (see above). Excluding South32, operational emissions intensity is tightly clustered around 3.8 tCO_2e/tCu Eq.

Figure 11. Variation in 2018 carbon intensity by a) the proportion of copper, gold and other in the mix and b) operational emission (Scope 1 & 2) intensity*



* MMC Norilsk did not disclose sufficient information to enable an assessment to be completed ** All non-energy commodities excluding iron ore and aluminium. For a full list, see page 10.

6. DISCUSSION: STRATEGIC OPTIONS FOR DIVERSIFIED MINERS SEEKING TO DECARBONISE

This discussion paper presents a methodology enabling investors to assess the Carbon Performance of the diversified mining sector. We have collected feedback on both the overall methodology and the individual company assessments we have undertaken. We are publishing the paper now to solicit additional feedback from interested parties, with the aim of further improving the methodology ahead of the publication of formal assessments later in 2020.

The sector has made significant progress over the last six months. Several companies (e.g. Rio Tinto, Vale and Glencore) have announced new, more ambitious emissions targets. However, our results suggest further progress is needed. Companies' net zero ambitions only cover operational emissions which typically account for just 6% of their total emissions. Consequently BHP, Rio Tinto and Vale are in fact further away from alignment in 2050 than they are today. Introducing targets that include Scope 3 emissions will therefore be critical. Glencore's plans to cut Scope 3 emissions by c. 30% by 2035 are promising, but do not include its marketing activities. Unless Anglo American also begins reducing Scope 3 emissions, it risks not being aligned with 2C by 2040. Fortescue and South32 need to set credible long-term targets to cut carbon intensity by nearly 80% by 2050 to claim alignment with 2C.

With carbon intensity varying widely between commodities, the most obvious decarbonisation strategy miners can adopt is reducing production of the commodities with the highest emissions intensity. With an emissions intensity over double that of the current benchmark, coal, particularly thermal coal, presents the biggest opportunity to decarbonise. Coal production at South32 and Anglo American accounts for 25% and 23% of their Cu Eq. output respectively. We estimate that stopping this production would cut emissions intensity by 45% for South32 and 31% for Anglo.

Reducing iron ore production presents another potential opportunity to decarbonise. Iron ore is a significant commodity for a number of the companies we assess (five of the nine companies assessed mine iron ore and it accounts for 35% of total Cu Eq.), plus its Scope 3 emissions intensity is double that of the benchmark. If all iron ore production ceased overnight, we estimate the average intensity of production for the nine players assessed would fall from 65.5 tCO_2e/tCu Eq. to 40.7 tCO_2e/tCu Eq. and the sector would be aligned.

However, aside from being impractical in the near term (Fortescue produces only iron ore, for example), this response is unlikely to deliver the decarbonisation that investors ultimately seek. Unlike coal, there is no direct low-carbon substitute for steel. Reduced supply from large miners may simply lead to higher prices and increased supply from smaller (potentially less efficient) players. Cutting emissions from the steel sector is likely to require a combination of reducing end demand, greater recycling, improving technology, offsets, and carbon capture and storage. We believe there is scope for miners to play a proactive role, helping to accelerate these initiatives and preferentially supplying efficient (lower-carbon) producers. TPI currently assesses the emissions intensity of 24 steel-makers. Theoretically these assessments could be used to adjust the emissions factors we apply to miners' iron ore output. How this could be done reliably using public disclosure is not clear currently.

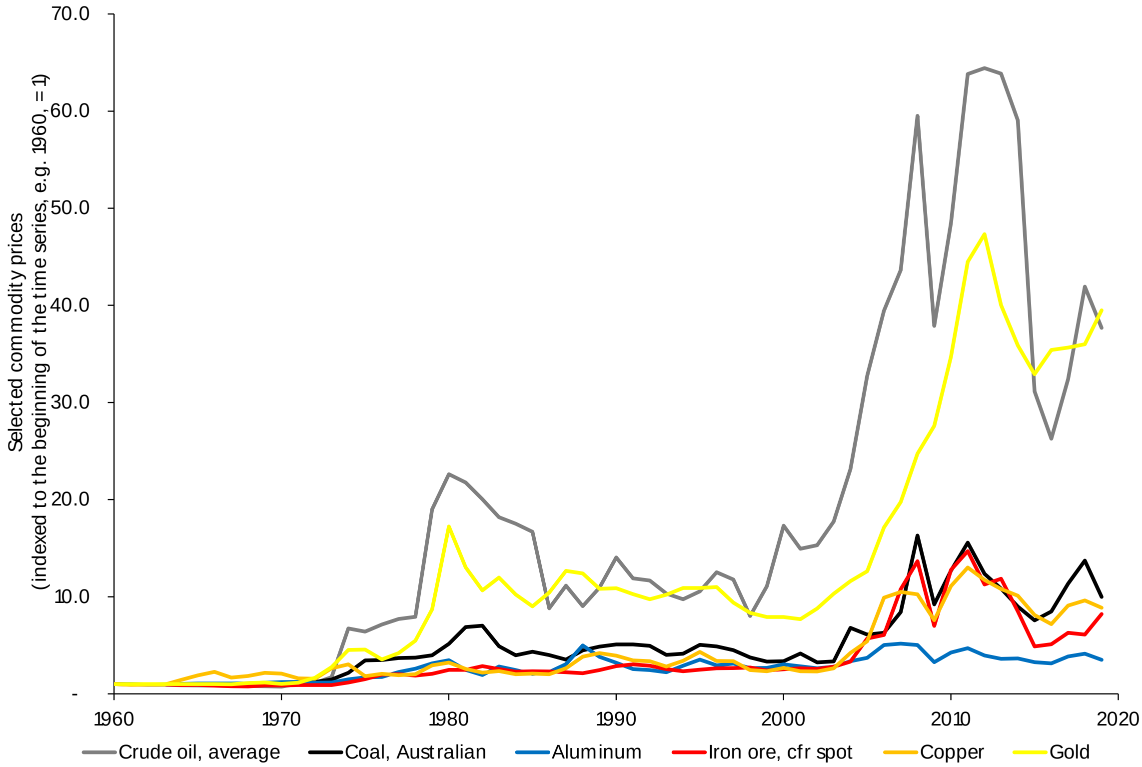
7. APPENDIX

Table 6. Cu Eq. conversion price factors

Classification	Raw Material	Commodity prices ($/tonne*) 2016	2017	2018	CU Eq price factor 2016	2017	2018	2018 3-yr av	Method and Source of price data
Energy products	Metallurgical Coal**	141	168	205	0.03	0.03	0.03	0.03	S&P Global Platts (hard coking coal) [24]
	Thermal Coal ***	94	89	107	0.02	0.01	0.02	0.02	World Bank Commodity Market Outlook [7]
	Crude Oil	43	50	64	0.01	0.01	0.01	0.01	US$/bbl /US$/t, S&P Global Platts (Dated Brent) [25]
	Natural Gas	8	9	10	0.00	0.00	0.00	0.00	US$/bbtu /US$/t, S&P Global Platts (Natural Gas Japan) [25]
ETP Metals	Iron Ore	58	72	69	0.01	0.01	0.01	0.01	World Bank Commodity Market Outlook [7]
	Aluminium	1,604	1,968	2,122	0.33	0.32	0.33	0.32	World Bank Commodity Market Outlook [7]
Other (non-ETP metals)	Copper	4,868	6,170	6,500	1.00	1.00	1.00	1.00	World Bank Commodity Market Outlook [7]
	Gold	40,155,877	40,431,436	40,477,760	8,249.12	6,552.97	6,227.35	7,009.81	World Bank Commodity Market Outlook [7]
	Cobalt	26,455	55,116	72,753	5.43	8.93	11.19	8.52	Metal Bulletin [26]
	Ferroalloys	1,984	2,227	1,984	0.41	0.36	0.31	0.36	Metal Bulletin [26]
	Lead	1,867	2,315	2,242	0.38	0.38	0.34	0.37	World Bank Commodity Market Outlook [7]
	Manganese		591	724	-	0.10	0.11	0.07	Metal Bulletin [26]
	Molybdenum			25,640	-	-	3.94	1.31	London Metal Exchange [26]
	Nickel	9,595	10,410	13,344	1.97	1.69	2.05	1.90	World Bank Commodity Market Outlook [7]
	Palladium	23,633,580	37,284,618	44,551,062	4,854.99	6,042.95	6,854.01	5,917.31	London Metal Exchange [26]
	Platinum	31,676,052	32,628,450	28,007,556	6,507.13	5,288.29	4,308.85	5,368.09	London Metal Exchange [26]
	Salt	55	55	55	0.01	0.01	0.01	0.01	United States Geological Survey [11]
	Silver	551,280	548,690	501,551	113.25	88.93	77.16	93.11	World Bank Commodity Market Outlook [7]
	Titanium Dioxide	64,700	66,050	70,500	13.29	10.71	10.85	11.61	United States Geological Survey [11]
	Uranium	57,998	50,012	57,982	11.91	8.11	8.92	9.65	London Metal Exchange [26]
	Zinc	2,094	2,893	2,919	0.43	0.47	0.45	0.45	London Metal Exchange [26]
	Diamonds****								Market value into Cu Eq [14]

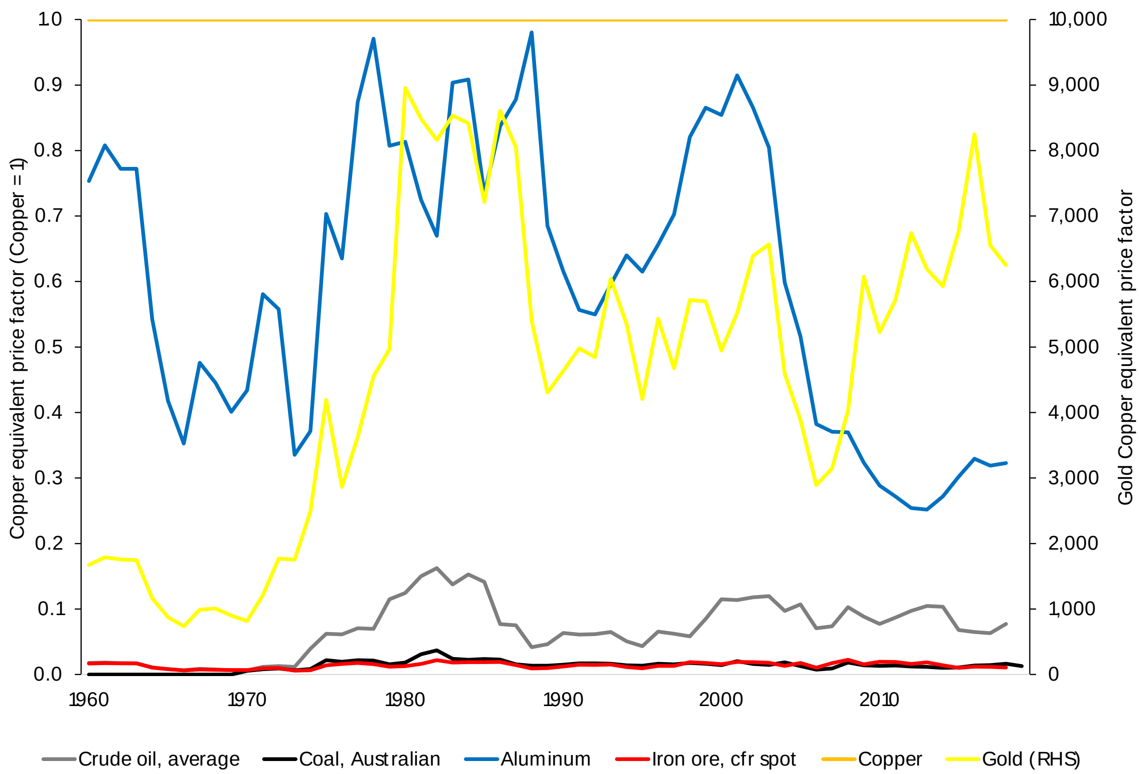
* Energy products crude oil and natural gas are priced per barrel or per million British Thermal Unit respectively
** Average of coking coal and coke oven coke
*** Thermal coal includes anthracite, bituminous coal and lignite. Price shown here are averages
**** Diamonds calculated from an estimate of market value.

Figure 12. Changes in key commodity prices over time



Source: World Bank Commodity Market Outlook [7].

Figure 13. Changes in Cu Eq for key commodities over time



8. BIBLIOGRAPHY

[1] RANDERS J, “Greenhouse gas emissions per unit of value added (‘GEVA’): a corporate guide to voluntary climate action”, Energy Policy, vol. 48, pp. 46– 55, 2012

[2] International Energy Agency, Energy Technology Perspectives 2017, Paris, 2017.

[3] DIETZ, S. & GARDINER, D. Carbon performance assessment of steel makers: note on methodology, Updated version, July 2018. Transition Pathway Initiative.

[4] DIETZ, S, JAHN, V., NACHMANY, M., NOELS, J. SULLIVAN, R. Carbon Performance assessment methodology for the aluminium sector. February 2019. Transition Pathway Initiative.

[5] ICMM 2010. Measurement, reporting and verification and the mining and metals industry. *In:* ICMM (ed.) *In Brief - Climate Change*.

[6] DIETZ, S. & GARDINER, D. Carbon performance assessment in Oil and Gas: Discussion paper, November 2018. Transition Pathway Initiative.

[7] SOLIMAN, T., FLETCHER, L. & CROCKER, T. 2017. Digging deep: Which miners are facing up to the low-carbon challenge? *In:* CDP (ed.). London.

[8] EUROPEAN COPPER INSTITUTE 2012. The Environmental Profile of Copper Products – A ‘cradle-togate’ life-cycle assessment for copper tube, sheet and wire produced in Europe. In: EUROPEAN COPPER INSTITUTE (ed.). Europe.

[9] NUSS, P. & ECKELMAN, M. J. 2014. Life cycle assessment of metals: a scientific synthesis. PLoS One, 9, e101298.

[10] IPCC, 2019. IPCC Emissions Factor Database 2002-today. *In:* PROTOCOL, I. A. G. G. (ed.) *IPCC Emissions Factor Database*.

[11] JANSSENS-MAENHOUT, G. et al., 2017. “EDGAR - Global Greenhouse Gases Emissions EDGAR v4.3.2,” Global Atlas of the three major Greenhouse Gas Emissions for the period 1970-2012, Earth System Science Data, [Online]. Available: http://edgar.jrc.ec.europa.eu/overview.php?v=432_GHG&SECURE=123. [Accessed: 17-Apr-2019].

[12] INTERNATIONAL ALUMINIUM INSTITUTE 2018. perfluorocarbon-pfc-emissions (CSV Dataset)

[13] WORLD BANK GROUP. 2019. *Commodity Markets Outlook, April 2019* [Online]. World Bank, Washington, DC. Available: https://openknowledge.worldbank.org/handle/10986/31549 [Accessed].

[14] WORLD STEEL ASSOCIATION 2017. STEEL’S CONTRIBUTION TO A LOW CARBON FUTURE AND CLIMATE RESILIENT SOCIETIES worldsteel position paper

[15] ICSG (International Copper Study Group), https://www.icsg.org/index.php/component/jdownloads/finish/165/871. [Accessed: 17-Jan-2020]

[16] WORLD GOLD COUNCIL: https://www.gold.org/goldhub/data/historical-mine-production

[17] UNITED STATES GEOLOGICAL SURVEY 2019. Mineral Commodity Summaries 2019. Reston, Virginia: 2019: U.S. Government

[18] INTERNATIONAL LEAD AND ZINC STUDY GROUP: https://www.statista.com/statistics/264871/production-of-lead-worldwide/ [Accessed: 17-Jan-2020]

[19] WORLD NUCLEAR ORGANISATION: https://www.world-nuclear.org/information-library/nuclear-fuel-cycle/mining-of-uranium/world-uranium-mining-production.aspx [Accessed: 17-Jan-2020]

[20] BAIN & COMPANY 2019. Global rough diamond production 2005 2018. In: STATISTICA (ed.).

[21] INTERNATIONAL ALUMINIUM INSTITUTE 2009. Aluminium for future generations. http://www.world-aluminium.org/media/filer_public/2013/01/15/fl0000329.pdf [Accessed: 17-Jan-2020]

[22] HUME, N. 2019. BHP to set targets for reducing customers' carbon emissions. *Financial Times*, 2019-07-22.

[23] DIETZ, S., BYRNE, R., GARDINER, D., GOSTLOW, G., JAHN, V., NACHMANY, M., NOELS, J., SULLIVAN, R. TPI State of Transition Report 2020. March 2020. Transition Pathway Initiative.

[24] S&P GLOBAL PLATTS. 2019. *IODEX Iron Ore: metals price assessment | S&P Global Platts* [Online]. Available: https://www.spglobal.com/platts/en/our-methodology/price-assessments/metals/iodex-iron-ore-metals-price-assessment [Accessed].

[25] METAL BULLETIN. 2019. *Leading provider of global metal & steel prices | Metal Bulletin* [Online]. Available: https://www.metalbulletin.com/ [Accessed].

[26] LONDON METAL EXCHANGE. 2019. London Metal Exchange [Online]. Available: https://www.lme.com/ [Accessed 29/07/2019].