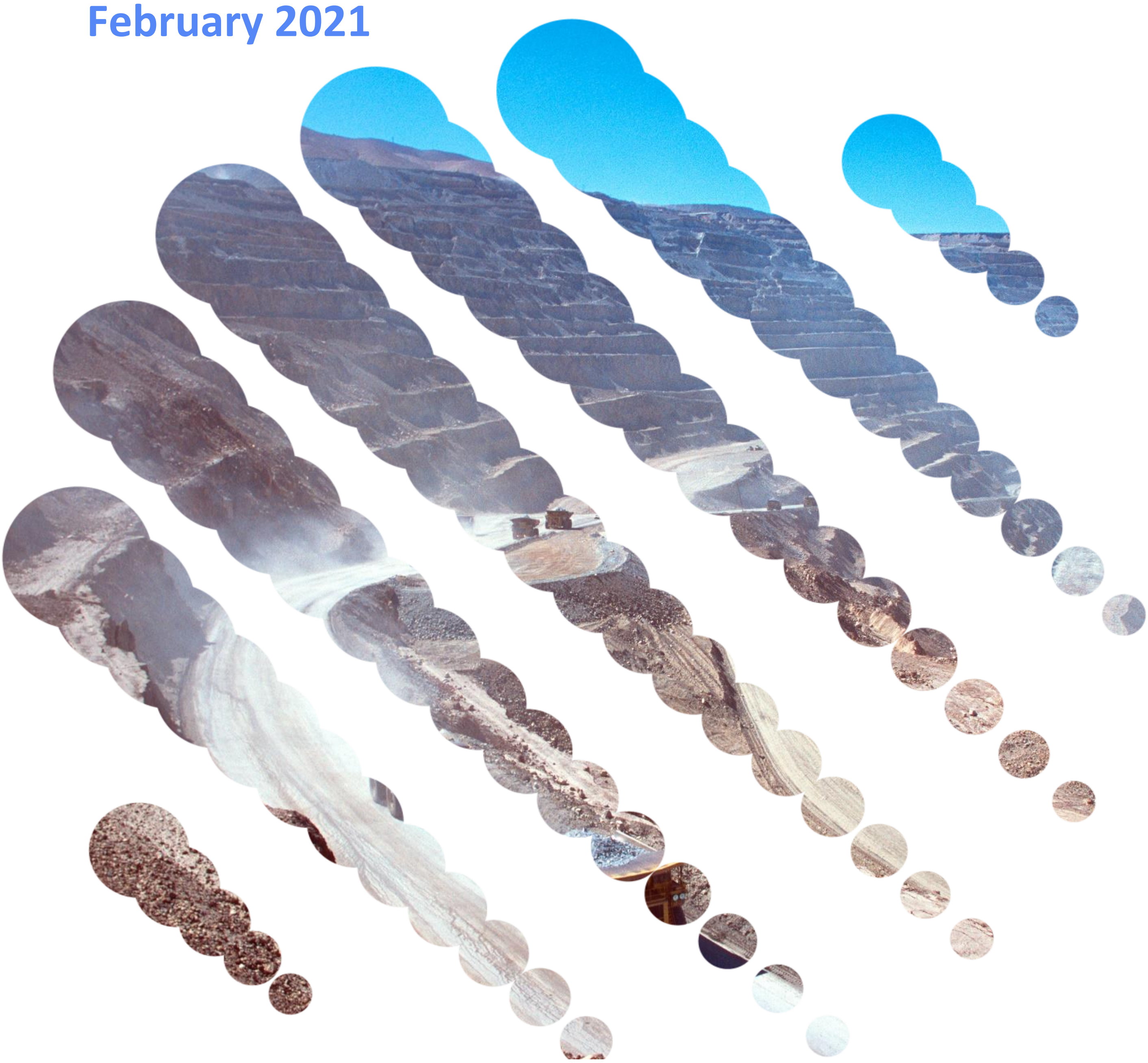
Carbon Performance Assessment in the Diversified Mining Sector:

Methodology

February 2021



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Transition
Pathway
Initiative

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1. INTRODUCTION

The purpose of this note is to provide an overview of the methodology followed by the Transition Pathway Initiative (TPI) in its assessment of the Carbon Performance of diversified mining companies.

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 c. US$23 trillion of Assets Under Management and Advice.[1]

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] As of December 2020.

2. TPI'S CARBON PERFORMANCE ASSESSMENT

TPI's Carbon Performance assessment is based on the Sectoral Decarbonization Approach (SDA)[2]. 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 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 they are to reduce. 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.

[2] 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).[3] 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).

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

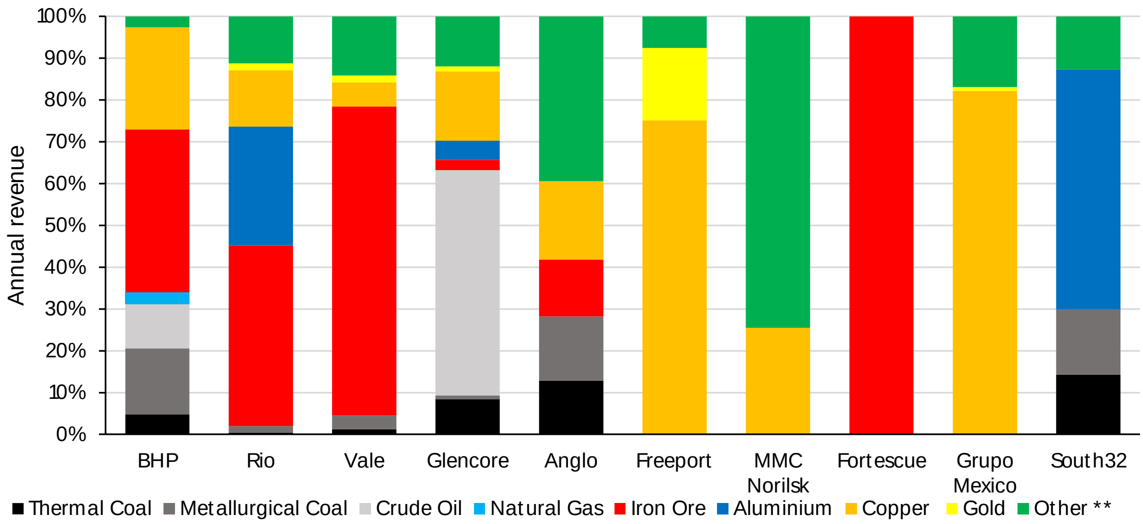
3. APPLYING THE METHOD TO THE DIVERSIFIED MINING SECTOR

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 methodology to ensure the focus is on mining companies. Rio Tinto, Vedanta, Glencore 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 investible market capitalisation. Revenue breakdown 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. For some miners, these activities account for a considerable share of revenues. Whilst they are operationally very different in character to natural resource extraction, trading carbon-intensive products also creates 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 disclose volumes. We continue to solicit feedback on this issue to help develop a consistent approach. We also encourage companies to explicitly disclose financial trading volumes.

Recognising that investors may want to understand the impact of trading, we show the effect of including trading on Glencore's assessment. As Figure 2 highlights, including trading activities increases our estimate of Glencore's absolute emissions nearly fivefold, but cuts intensity by 18 percentage points.

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

* Based on original assessment published in May-2020 (see Carbon Performance Assessment in the Diversified Mining Sector: Discussion document.

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 this data in our company assessments.[4]

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]

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[4] 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 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 4.8 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 this approach. First, revenue is volatile, which exposes the methodology to year-on-year fluctuations in commodity prices. 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).[5]

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.

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

	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 use average price data. Table 1 shows an average over three years and Table 2 shows the impact of extending the average from three years to five years. The current assessments use 10-year averages where consistent price data is available and an average based on the maximum length of consistent data otherwise.

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.

[5] 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.

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.

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

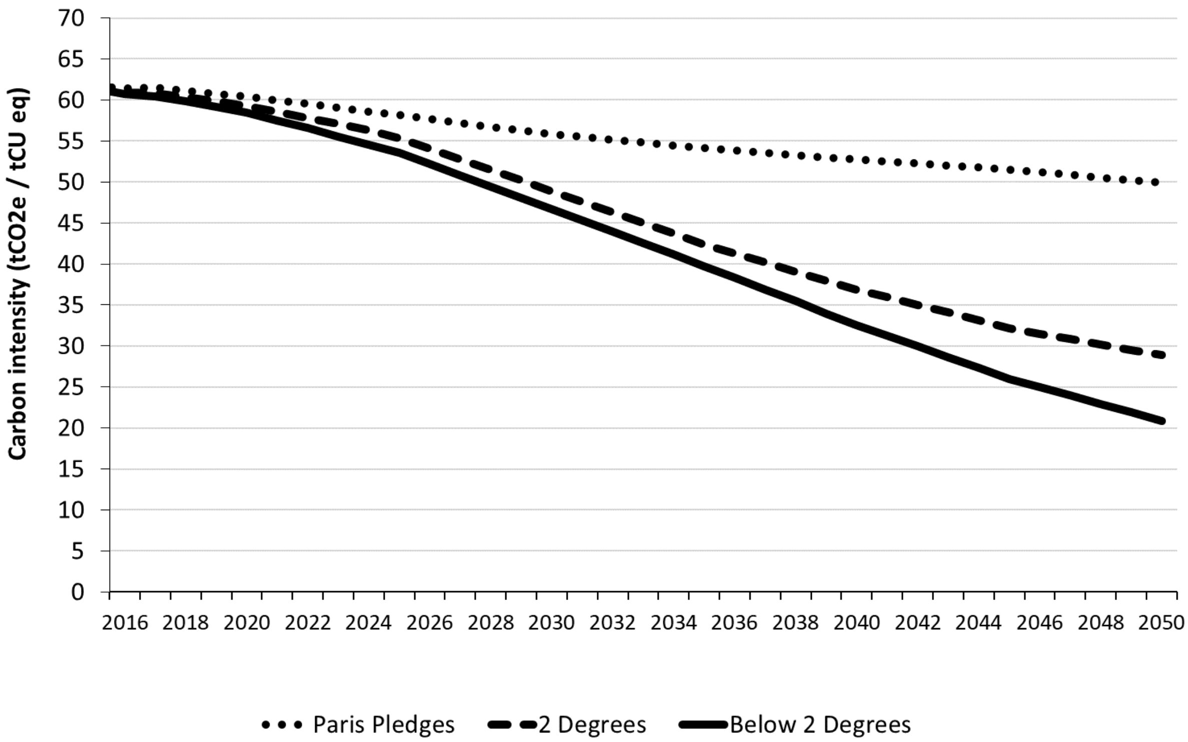


Table 3. Production, emissions and method of calculation for our diversified mining benchmark, based on a 2C scenario

Classifi-cation	Product	2018 Global production				2018 Global emissions (CO_2)				2018 - 2050 Forecast methodology	
	Raw Material	Mt	Price factor	Cu Eq. (mt)	Source	Scope 1 & 2	Scope 3	Emission Factor	Metric and source	Production	Emissions
Energy products	Metallurgical Coal *	1,204.3	0.02	28.9	IEA ETP 2017 primary energy demand module	Scope 1 & 2 emissions estimate: 1623 mt. Calculated from average operation intensity of top ten miners of 2.46 tCO2e/t Cu Eq.)	3,219	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 **	5,104.1	0.01	62.1			10,457	94.6-101	tCO_2/TJ [10]		
	Crude Oil	4,126.5	0.08	341.8			12,245	73.3	tCO_2/TJ [10]		
	Natural Gas	2,825.5	0.03	70.9			6,811	56.1	tCO_2/TJ [10]		
ETP Metals	Iron Ore	2,199.4	0.02	34.8	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	0.32	19.3			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	0.0	6,072.7	21.3	WGC [16]		82	23,435	tCO_2/tAU [9]		
	Cobalt	0.1	6.4	0.7	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 by the IEA ETP. Scope 3 emission factors assumed to be immaterial
	Ferroalloys	13.6	0.3	4.3	USGS [17]		-				
	Lead	4.9	0.3	1.5	ILZSG [18]		-				
	Manganese	16.7	0.0	0.0	USGS [17]		-				
	Molybdenum	0.3	3.8	1.2	USGS [17]		-				
	Nickel	2.2	2.4	5.2	USGS [17]		-				
	Palladium	0.0	4,586	1.0	USGS [17]		-				
	Platinum	0.0	4,939	1.0	USGS [17]		-				
	Salt	291.8	0.0	2.4	USGS [17]		-				
	Silver	0.0	98.0	2.6	USGS [17]		-				
	Titanium Dioxide	7.4	0.0	0.2	USGS [17]		-				
	Uranium	0.1	9.6	0.6	WNO [19]		-				
	Zinc	13.2	0.3	4.2	ILZSG [18]		-				
	Diamonds****				Bain [20]		-				
Total		**15,895**	**0.04**	**624.6**		**38,015**					
	Elimination of Scope 3 CO_2 emissions (see text)					-3,659					
	Other GHGs (Methane + PFC) CO_2e					2,943					
	Captured Emissions					-46					
Adj Total		**15,895**	**0.04**	**624.6**		**37,252**					

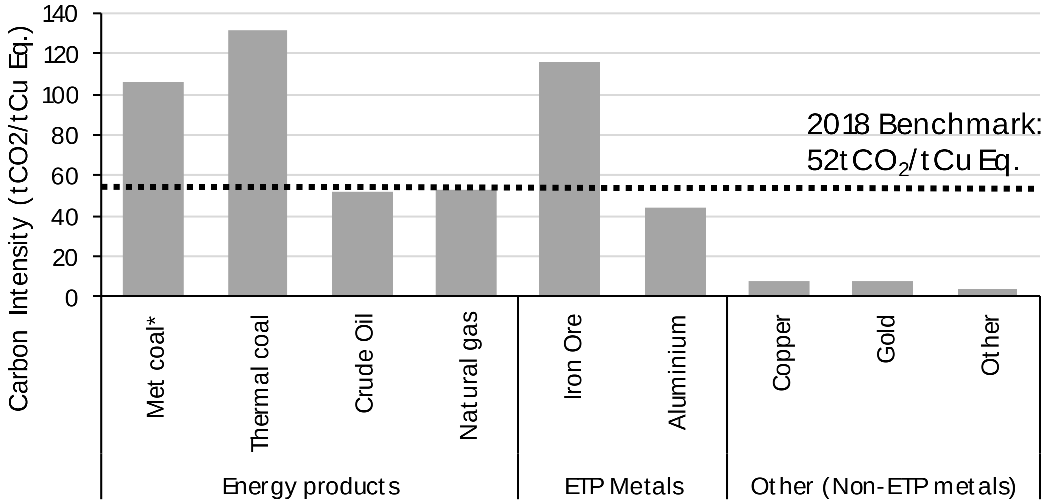
* Coal primarily used for steelmaking ** A range of coal grades modelled separately *** Lifecycle emissions factor of 14.4 tCO_2e/t primary aluminium, 90% of emissions released converting alumina into aluminium with c.80% occurring outside the mining industry (incurring Scope 3 emissions) **** Cu Eq.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



* Based on original assessment published in May-2020 (see Carbon Performance Assessment in the Diversified Mining Sector: Discussion document). Emission factors used in company assessments will vary according to grade. 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 shown for illustrative purposes (see text).

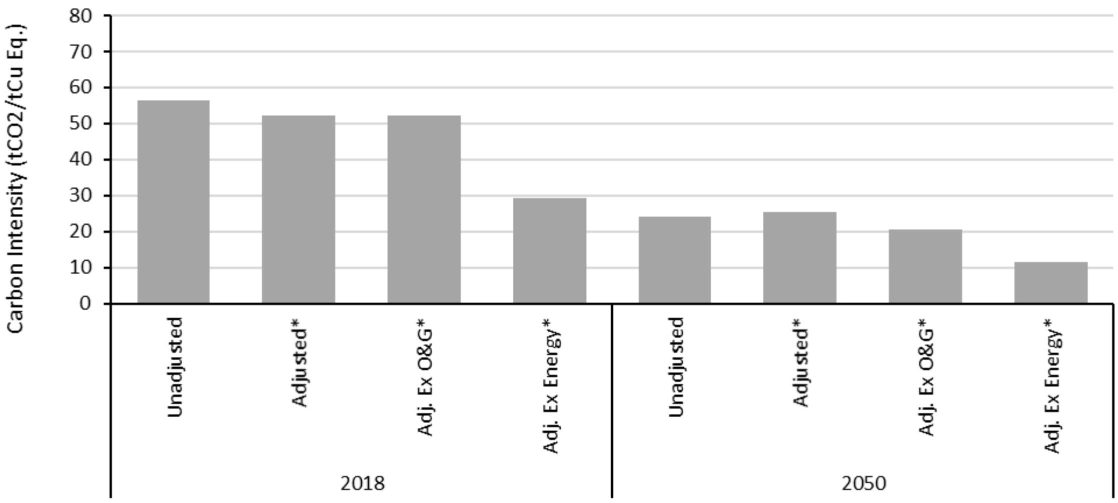
As a result of their high intensity, energy products (thermal coal, oil and gas) account for 89% of CO_2 emissions in the sector benchmark, but just 81% of Cu Eq. production (an average emissions intensity of 58 tCO_2/tCu Eq. vs. 52 tCO_2/tCu Eq. for the benchmark). Oil and gas is broadly neutral for 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 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. Diversified mining companies by free float capitalisation assessed by the TPI

Company	ICB code	Sector	Mkt Cap ($bn)*
BHP Group Plc	1775	General Mining	40.7
Vale SA	1757	Iron & Steel	32.1
Anglo American	1775	General Mining	26.0
Rio Tinto Ltd.	1775	General Mining	23.1
Glencore	1775	General Mining	21.0
MMC NORILSK	1755	Nonferrous Metals	16.6
Fortescue Metals Group	1757	Iron & Steel	14.3
Freeport-McMoRan	1755	Nonferrous Metals	13.1
Grupo Mexico	1755	Nonferrous Metals	7.9
South32	1775	General Mining	6.4
Teck Resources Ltd	1755	Nonferrous Metals	4.6
Southern Copper Corp.	1755	Nonferrous Metals	3.0
Vedanta Resources	1775	General Mining	NL**

* Market capitalisation as on the 22nd of May 2020. ** NL = Equity not listed but has publicly traded debt

Data availability: disclosure of historical emissions intensity

TPI is a disclosure-based framework that uses the emissions data companies publish as the basis of the assessment. Whilst the state of disclosure in the diversified mining sector is improving, only eleven of the thirteen 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 nine companies disclose Scope 3 emissions in some form, the method used to calculate these figures varies significantly. Here are some examples:

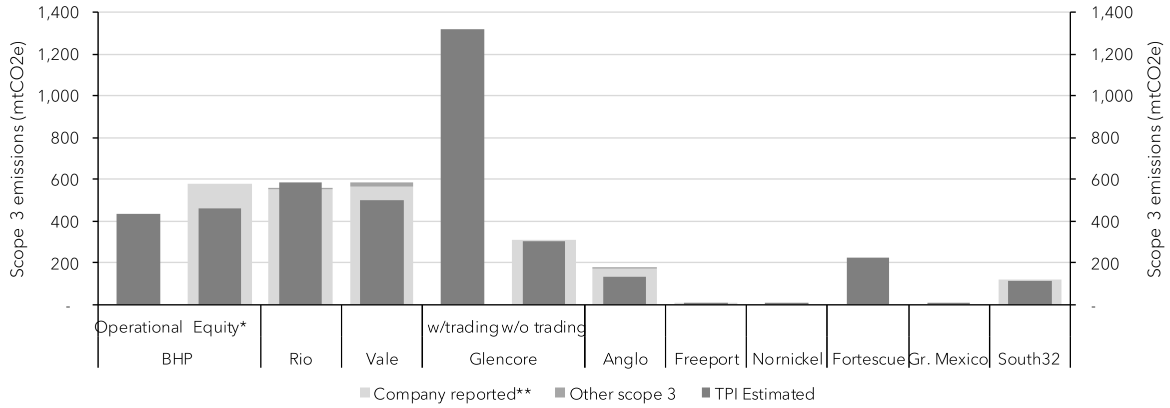
- Freeport discloses a single Scope 3 emission figure covering all categories.
- BHP discloses emissions from the use of energy products separate to emissions from the processing of iron ore and copper (categories 10 and 11 respectively). However, the equity boundary of BHP's disclosure is inconsistent 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.
- 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 captured in 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



* Based on original assessments published in May-2020. 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 thirteen largest diversified mining companies eleven have set long term targets to cut emissions. Seven of these targets are expressed in the form of net zero or carbon neutral ambitions, with intermediate targets expressed as reductions in intensity or absolute emissions. Glencore has set an absolute target while Freeport aims to reduce intensity. Disclosure on targets set by Vedanta and Grupo Mexico was not sufficiently detailed to enable a target to be calculated.

These targets typically cover different emissions scopes or have different operational boundaries. Only Glencore had set a target including Scope 3 emissions at the time the assessments were made. BHP has subsequently set Scope 3 emission goals but these look insufficiently detailed to enable a target to be calculated [22].

Emissions targets are converted into a company-wide intensity targets:

- **Intensity targets:** the percentage reduction is applied to emissions intensity within the target (typically Scope 1 and 2) in the elected base year. Scope 3 emissions intensity is assumed to remain flat from the last calculated year.
- **Absolute targets:** emissions within the target (typically Scope 1 and 2) 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 remove emissions from metallurgical coal 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.

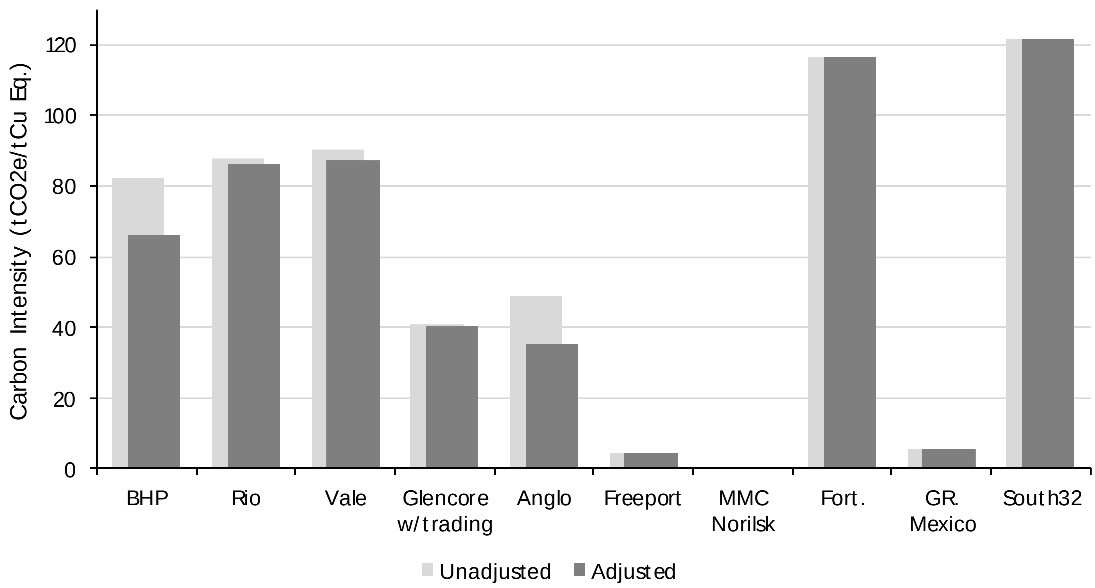
Table 5. The proposed adjustment to Scope 3 emissions from Metallurgical coal and iron ore

Method	Weight of material (mt) Iron ore	Met. Coal	Input total	Steel	Ratio of Met. coal to iron ore	Emissions factors Iron ore	Met. Coal	Steel	Emissions (mt) 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. 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

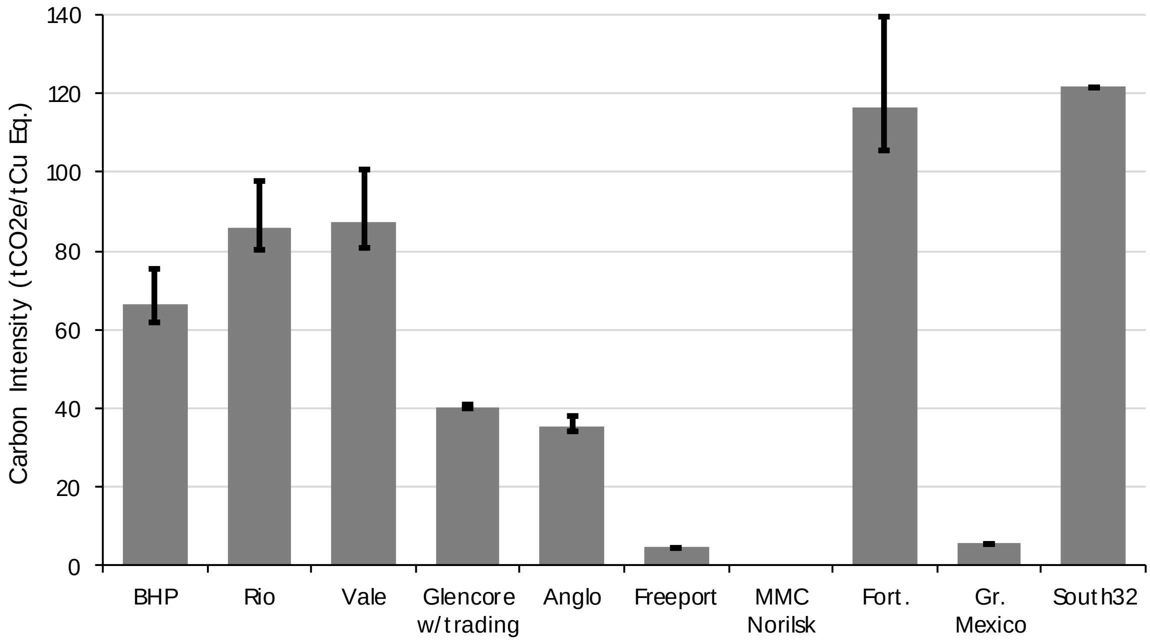


* Based on original assessment published in May-2020 (see Carbon Performance Assessment in the Diversified Mining Sector: Discussion document)

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. This impact is highlighted in Figure 8.

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 to improve efficiency or using offsetting to 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 continue to 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.

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6. 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] BHP 2020. Value chain emissions reductions. https://www.bhp.com/sustainability/climate-change/value-chain-emissions-reductions/ [Accessed: 03-Oct-2020]

[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].