
Digging deep

Which miners are facing up to the low-carbon challenge?

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Linking climate-related metrics to earnings for diversified miners

This report updates CDP's research and League Table for diversified miners, first published in November 2015. It ranks 12 of the largest publicly listed diversified miners (by market capitalization) on business readiness for a low-carbon economy transition. The companies in aggregate represent 66% of the global seaborne market in iron ore, 53% in copper, 42% in metallurgical coal and 28% in thermal coal.

Mining companies represent the start of the value chain for several sectors set to undergo significant change as part of the transition to a low-carbon economy including utilities, industrials and transport. This economy-wide transition represents opportunities through demand created for materials needed to drive carbon abatement; however, it also poses risks associated with shifts away from some incumbent commodity use.

There are four key areas assessed in the League Table, which are aligned with recommendations for company reporting from the G20 Financial Stability Board's Task Force on Climate-related Financial Disclosures (TCFD):

Transition risks: We assess companies' earnings exposure to various commodities and estimate implied risks from downstream industry carbon regulation and changing demand patterns. We also rank companies on cost efficiency metrics such as energy and emissions intensity.

Physical risks: We map company asset level current and projected future (2030) indicators of water stress risk using WRI's Aqueduct Water Risk Atlas. We compare this water stress exposure with companies' water withdrawal intensity, use of water recycling, and water governance frameworks as a proxy for potential revenue disruption.

Transition opportunities: We assess companies' progress and strategy in shifting towards a low-carbon economy by looking at CAPEX allocation across commodities, capital flexibility and innovative solutions such as smart and renewable energy infrastructure.

Climate governance and strategy: We analyze companies' governance frameworks including emissions reduction targets, alignment of governance and remuneration structures with low-carbon objectives, and actions taken in supporting or opposing policies to achieve a low-carbon transition.

Key findings

- ▼ The mining sector shows **signs of progress** in its operational emissions management, reduced exposure to thermal coal and capital allocation in the context of a low-carbon transition.
- ▼ However, **significant risks remain** for the sector, as a supplier to emissions-intensive industries, from downstream regulation and changing consumption patterns.
- ▼ **Operational emissions are on an improving trend** as the miners come through their recent cost cutting exercise – 9 of 12 companies have taken steps to reduce the emissions intensity of operations.
- ▼ Around **45% of company capital expenditure is being spent on commodities which will benefit from low-carbon technologies** such as copper and nickel; however, this is partially offset by 25% of CAPEX going on fossil fuels particularly oil & gas.
- ▼ The mining industry has **significant potential exposure to carbon emissions regulation in its value chain** where Scope 3 emissions from downstream customers is estimated at an average of 10x and up to 30x higher than operational emissions.
- ▼ Carbon pricing regulation is on the rise with **China's emissions trading scheme (ETS) likely is to be most disruptive to demand patterns of commodities** – Chile introduced carbon pricing this year with Canada and South Africa coming on stream in 2018.
- ▼ China could play a pivotal role in the **demand for "low-carbon" commodities and disrupt demand in the seaborne bulks** as it adopts a leadership role in climate change regulation.
- ▼ **Investor demands for greater transparency on climate risks** will continue to test the sector where scenario planning is in its infancy and requires more standardized reporting against climate constrained pathways.
- ▼ **By 2030, 27% of production and up to US\$50bn of revenues is likely to be exposed to high levels of water stress risk.** Miners are resorting to using greater amounts of seawater, desalination technology and water recycling to hedge against disruption to operations.
- ▼ Highest ranked companies are **Vale, Boliden** and **BHP**. Lowest ranked companies are **Freeport-McMoRan, First Quantum Minerals** and **Vedanta Resources**.
- ▼ **Glencore** was the largest gainer, **Teck** and **Vedanta Resources** had the largest falls in league table rankings relative to 2015.

The summary League Table below presents headline company performance and ranking. It is based on detailed analysis across a range of carbon and water-related indicators which could have a material impact on company performance. The League Table is designed to serve as a proxy for business readiness in an industry which will undergo significant change as governments increase efforts to implement the Paris Agreement. Companies placed towards the bottom are deemed less prepared for a low-carbon transition.

Figure 1: League Table summary

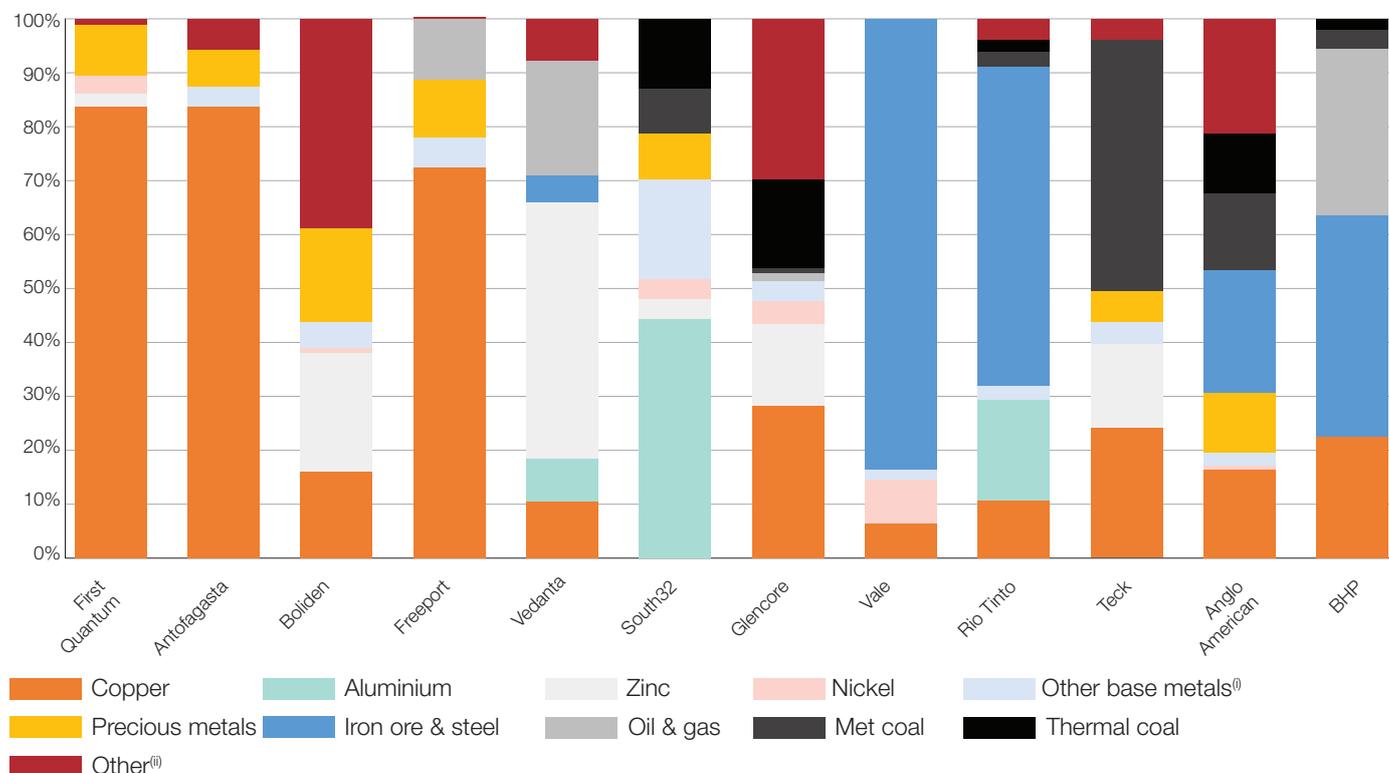
League Table rank	2015 League Table rank	Company	Country	Average market cap Q2 2017 (US\$bn) ⁽ⁱ⁾	2016 Emissions (S1+2 CO ₂ million tonnes)	League Table score	Managing transition risks	Managing physical risks	Transition opportunities	Climate governance & strategy
1	1	Vale	Brazil	31.8	14.7	4.90	A	A	C	D
2	n/a	Boliden	Sweden	6.4	1.0	4.96	A	B	B	C
3	2	BHP	Australia/UK	84.1	18.0	5.28	B	A	C	B
4	4	Rio Tinto	Australia/UK	63.4	32.4	5.82	B	C	A	C
5	11	Glencore	Switzerland	40.6	35.6	5.88	C	B	B	C
6	n/a	South32	Australia	9.3	23.5	6.15	D	B	D	A
7	6	Antofagasta	UK	7.1	2.8	6.29	C	C	B	C
8	5	Teck	Canada	10.8	2.9	6.60	D	B	E	B
9	7	Anglo American	UK	16.0	17.8	7.07	E	B	D	D
10	8	Freeport-McMoRan	USA	16.1	10.3	7.17	C	D	D	D
11	10	First Quantum Minerals	Canada	6.3	1.4	7.79	B	E	C	E
12	9	Vedanta Resources	UK	2.2	53.3	8.02	E	E	D	C

Weighting

(i) Average market cap for last 12 months up to Q2 2017
Source: CDP

30% 30% 20% 20%

Figure 2: Earnings (adjusted EBITDA) split by commodity (2015-2016)



(i) 'Other base metals' includes lead, molybdenum, manganese, titanium, cobalt and vanadium.

(ii) 'Other' includes agriculture and marketing for Glencore, smelting for Boliden and diamonds for Anglo American and Rio Tinto.

Source: CDP, company reports

Key report findings

Earnings risks

- ▼ Miners have **cut operational emissions and energy intensity** in recent years. Nine of the 12 companies featured have taken steps to decarbonize by reducing the emissions intensity of operations. A further seven have also reduced energy use intensity and all 12 have cut costs.
- ▼ Key locations in **Chile, Australia and South Africa exposed to heightened levels of water stress**. Using WRI's Aqeduct tool, we estimate that 27% of the 12 companies' production, equivalent to up to US\$50bn in revenue, will be exposed to high or extremely high baseline water stress risk and arid conditions by 2030.
- ▼ **Water security remains a critical operational issue and costly to rectify**. Increased water efficiency, reduced freshwater usage and higher recycling rates are essential to hedge against some of the physical risks that water poses to business continuity.
- ▼ The 12 companies collectively **produced 20% less thermal coal but over twice as much oil and gas in 2016** compared to 2010. Nine of the 12 companies have exposure to fossil fuel production with varying degrees at a time when prices and demand forecasts are under increasing pressure.
- ▼ Miners' **downstream value chains contain up to 30 times more carbon emissions** than their own operations. Emissions from the use of thermal and metallurgical coal, oil and gas, and the processing of iron ore into steel generate significant downstream emissions in commodity-consuming industries.
- ▼ Carbon pricing and regulation analysis is better focused on **carbon-emitting commodity consumers**. Greater carbon regulation and changing consumption patterns are likely to come from downstream sectors where the vast majority of emissions (Scope 3) arise, impacting demand for commodities.

Opportunities

- ▼ Material recycling and the circular economy could offer a potential medium term **secondary source of commodity market supply**. Pricing dynamics, market fragmentation and commodity substitutability play large roles in determining how much primary production disruption might take place (see box on page 15).
- ▼ **Capital allocation varies across companies**. Copper remains the commodity with the highest share of collective company CAPEX; however, two

companies (Teck and BHP) committed over 40% of 2016 CAPEX to oil and gas projects. Capital allocation decisions, that are coming under greater shareholder scrutiny, made now will impact company production out to 2020–2030 when emissions need to peak.

- ▼ Miners such as Boliden source up to **42% of their energy needs from renewable sources**. However, despite falling renewable energy costs¹, the bulk of mining energy needs and operational emissions come from the use of fossil fuels.
- ▼ Miners are starting to **embrace digital innovation and disruptive technologies**. Automation and intelligent mines that are digitally connected allow for real-time monitoring, optimized logistical efficiency and predictive maintenance and can enhance productivity, safety, energy use and water use.

Long term climate resilience

- ▼ Only one of the companies has a **commitment to reduce its net operational emissions to zero by 2050**. South32 intends to achieve this through wholesale energy switching, intelligent land management and purchasing offsets. Nine other companies have shorter term emissions reduction targets.
- ▼ **Resilience tests through forward-looking climate scenario analysis is yet to become common industry practice**. However, investors are increasingly highlighting scenario analysis as a necessary aspect of company disclosure of planning for a low-carbon transition that would limit global warming to 2°C, as indicated by TCFD recommendations on scenario planning as well as several shareholder resolutions at AGMs requesting such analysis at mining and oil & gas companies.
- ▼ **Governance and remuneration structures lack alignment with a low-carbon transition**. Though seven of the 12 companies detail climate-linked performance metrics in their CEOs' remuneration plan, emissions or climate related compensation typically accounts for 5% or less of total remuneration.
- ▼ InfluenceMap analysis finds some **miners remain opposed to strands of climate policy**. Supportive high-level climate policy statements are, in some cases, paired with engagement through trade associations that oppose progressive climate legislation and advocate continued financial and regulatory support for coal use.

1. IRENA forecast LCOE to reduce a further 59% for solar PV and 26% for onshore wind by 2025.

Company highlights

- #1 Vale** retains the top spot from 2015. It has continued to reduce its emissions, costs and energy significantly from 2010 – an increasingly important cushion against any changes in demand in a low-carbon transition. However, its commodity portfolio is heavily tilted towards iron ore which is reliant on continued Chinese demand and exposed to technological developments (CDP Steel Report - Oct 2016). The company appears to have low asset exposure to water stress and deploys high water recycling rates at its operations.
- #2 Boliden** is a new entrant and utilizes the highest proportion of renewable energy in its operations, resulting in the lowest emissions intensity of production. It uses scrap materials as a secondary supply feedstock in its smelting assets and has exposure to favorable commodities such as copper, zinc and precious metals.
- #3 BHP** was the first company to report to investors on climate scenario analysis in 2015, avoiding a shareholder resolution. It has spun off high Scope 1+2 emitting assets (in the form of South32) to focus on iron ore, copper and energy (fossil fuel) production; its oil & gas assets account for a third of earnings and 40% of CAPEX and have been the focus of activist investor pressure for divestment. The company ranks well in managing physical risks and for its climate governance.
- #4 Rio Tinto** remains unchanged in fourth place. The currently ongoing sale of its last major thermal coal assets will leave its portfolio better positioned for a low-carbon transition and it ranks highest in terms of innovation opportunities. Its balance sheet has strengthened after cutting CAPEX aggressively, giving it flexibility going forward. It sources a third of its energy from renewable sources, helping its emissions intensity. However, its scenario planning remains undeveloped and governance ranking would improve with a climate target KPI in CEO remuneration.
- #5 Glencore** showed the most improvement from the 2015 report. It introduced an emissions reduction target, climate linked pay KPIs and improved water disclosure. Its CAPEX by commodity is among the most favorable and includes exposure to cobalt, copper and nickel; however, it continues to rely on thermal coal for 17% of its EBITDA. The company retains a strategic interest in thermal coal evidenced by its recent bid for Rio Tinto's thermal coal assets and continued support for the energy source through its bullish forecast and scenario planning for thermal coal use globally, which are at odds with the other majors'.
- #6 South32** was born out of the BHP spin off in 2015 and contains energy and emissions intensive assets such as aluminum and zinc. More than half of its annual CAPEX is spent on coal assets, although most is metallurgical and as a result the company has a high Scope 3 footprint of production. However, it ranks first in climate governance and strategy, and is the only company to commit to zero net operational emissions by 2050 through energy use decarbonization, land management and carbon offset purchases.
- #7 Antofagasta** with its pure play copper portfolio is well placed for ongoing demand for copper for electrification in a low-carbon economy and has balance sheet flexibility. However, its emissions and energy intensity of production has increased from 2010-2016. With all its assets in Chile, the company faces significant water stress issues; it is using desalination and water recycling in increasing amounts to hedge against this.
- #8 Teck** drops in ranking from 5th in the 2015 League Table mainly due to its 70% CAPEX spend on fossil fuel development through its oil sands projects. Its Scope 3 emissions are over 28 times its Scope 1+2 emissions, the highest of any of the companies featured. The company benefits from sourcing 28% of energy needs from renewables with a target to build a 100 MW renewable capacity.
- #9 Anglo American** announced far reaching plans in 2016 to focus on three commodities: copper, platinum and diamonds. However, the company's coal business accounts for a quarter of earnings, higher than any other single commodity. A recently announced sale of some South African thermal coal assets will help its ranking going forward. The company has the highest Scope 3 emissions intensity of production, inferring greater risk of downstream carbon regulation. It also opposed the introduction of the South African carbon tax; however, it introduced a CEO pay KPI linked to emissions reduction target.
- #10 Freeport McMoRan** recently completed the sale of its oil & gas assets, following significant write downs and loss in value. The company will have a stronger focus on its core commodity, copper, going forward but faces ongoing legal issues at its Grasberg mine in Indonesia. It ranks poorly in its physical risk exposure and management and in wider climate governance and strategy.
- #11 First Quantum Minerals** has high exposure to copper, a key material needed in a low-carbon transition. However, the company falls short in its management of physical risks and disclosure on its climate governance and strategy. Its emissions and energy intensities have risen over time and the company does not have an emissions reduction target, nor does it independently verify emissions – the only company not to do so. Its operations have a high water withdrawal intensity and the company provides no data on water recycling, or evidence on use of innovative technologies, R&D or renewable energy use.
- #12 Vedanta** has the most energy and emissions intensive operations of the companies, largely down to its significant coal use as an energy feedstock. Its exposure to water stress in India is significant. It recently completed a takeover of Cairn India's oil & gas assets, increasing its exposure to fossil fuel production. However, copper, aluminum and zinc account for 66% of its earnings and 74% of CAPEX, and the company adopted an emissions reduction target in 2017.

Company selection

Companies were selected from the largest publicly listed diversified miners, based on 2016 market capitalization and those that responded to CDP's 2016 and 2017 climate change information request. Ten of the companies that featured in CDP's 2015 mining report are included again. In addition, we have added South32 and Boliden. Several companies that reported to CDP in 2017 were omitted due to incompatible business models or smaller relative size to the companies featured in the League Table.

Linking our findings to investment choices

We recognize that investment decisions are based on a multitude of different factors and that some of these can be misaligned with emissions-reduction efforts. Our League Table identifies company readiness for the transition to a low-carbon economy and the physical impacts of global warming. We would flag that companies towards the bottom of our League Table are higher risk investments from a climate change perspective than those towards the top.

Methodology

We score each company based on a number of metrics which are ranked and then weighted within each key area (see table below for metric weightings within each key area). We then grade each area from A to E based on these weighted ranks. We calculate the overall League Table score by collating the weighted ranks for each key area.

Each of the key areas has a separate section within this report. We disclose the precise methodology for how we rank each metric in an appendix.

Non-responding companies

We highlight the following companies as non-responders to CDP's 2016 climate change questionnaire and are therefore not included in this report. We encourage investors to raise this lack of transparency in discussions with company management.

Figure 3: Non-responders to CDP

Company	Country	Average market cap Q2 2017 (US\$bn) ⁽ⁱ⁾	First approached by CDP	Public disclosure of carbon emissions	Commodities
Norilsk Nickel	Russia	24.2	2006	No	Nickel, palladium, precious metals, base metals
Southern Copper Corporation	USA	21.8	2008	Yes	Copper, zinc, precious metals
Jiangxi Copper	China	6.6	2008	Partial	Copper, precious metals, base metals
KGHM Polska Miedz	Poland	3.9	2010	Yes	Copper, precious metals, base metals

(i) Average market cap for last 12 months up to Q2 2017
Source: CDP

For further study

Areas for further research include:

- ▾ Assessment of the economics of captive renewable plants compared to fossil fuel alternatives in key mining locations.
- ▾ Potential for climatic event disruption to commodity production.
- ▾ Price and demand forecasts for key carbon transition commodities.
- ▾ Enhanced analysis of the impacts disruptive technologies may have on mining sector.

Figure 4: A summary of key areas, associated metrics and weights within the League Table

Key area in League Table	Financial impact	Metrics	Key area weighting	Metric weighting within key area
Transition risks	<ul style="list-style-type: none"> • Operational cost base management against backdrop of depleting ore quality and accessibility. • Commodity demand trends changing due to climate-related action and increasing resource efficiency. • Downstream value chain carbon regulation and wider carbon pricing. 	<ul style="list-style-type: none"> • Emissions intensity of operations • Energy intensity of operations • Value chain exposure to carbon regulation • Production costs • Earnings (EBITDA) split by commodity 	30%	<ul style="list-style-type: none"> 20% 20% 15% 20% 25%
Physical risks	<ul style="list-style-type: none"> • Water scarcity and supply issues currently create supply continuity risks. • Physical risks require increase in capital and operational spend. • Severe water issues can potentially impair asset valuation or reduce useful life. 	<ul style="list-style-type: none"> • Asset exposure to water stress risk • Water withdrawal intensity of operations • Water recycling and water type use • Water governance and policy 	30%	<ul style="list-style-type: none"> 30% 25% 25% 20%
Transition opportunities	<ul style="list-style-type: none"> • Increased demand for commodities needed for a low-carbon transition. • Capital management in potentially structurally changing commodity markets. 	<ul style="list-style-type: none"> • CAPEX split by commodity • CAPEX intensity of operations • Capital (balance sheet) flexibility • R&D spend and technology innovation • Renewable energy use 	20%	<ul style="list-style-type: none"> 35% 20% 20% 10% 15%
Climate governance and strategy	<ul style="list-style-type: none"> • Long term value creation or destruction from climate factors. • Demonstration of business resilience and alignment of business strategy with macro climate trends. 	<ul style="list-style-type: none"> • Carbon regulation supportiveness • Emissions reduction targets • Carbon emissions data verification • Climate-related remuneration • Use of internal carbon price • CDP score 	20%	<ul style="list-style-type: none"> 30% 25% 15% 15% 10% 5%

Source: CDP

Transition risks

- ▼ Company earnings from commodities needed in a low-carbon transition on average exceed EBITDA from fossil fuels. However, nine companies have revenue exposure to oil, gas, metallurgical coal or thermal coal.
- ▼ Operational emissions intensity has come down for ten of the 12 mining companies since 2010, in line with a focus on cost reduction. However, emissions embedded in downstream value chains are up to 30 times higher and these Scope 3 emissions potentially face stricter future climate regulation with structural changes expected in material use and end demand.
- ▼ Vale and Boliden rank highest, Vedanta and Anglo American lowest.

Overview

Miners' earnings are derived from a diverse portfolio of commodities with varying uses², price drivers and risks of substitutability. We seek to identify companies that have greater exposure to commodities conducive to the development of a low-carbon economy and companies that generate earnings today from products potentially at risk in the future.

Energy expenditure accounts for up to 30% of mining cash costs and up to 75% of operational emissions. Operating with the lowest energy intensity offers cost savings potential, especially against the backdrop of falling ore grades and deeper ore bodies requiring more energy. Being a low-cost producer will be an increasing important cushion against any future changes in commodity demand in a low-carbon transition.

As mining is at the beginning of the value chain for several high emitting sectors (including energy generation, industrial processes and manufacturing), global action to curb carbon emissions in downstream value chain industries may pose a greater risk to miners than regulations applied to miners' own operations. To that end we explore the extent to which miners' supply carbon intensive industries and processes with raw materials.

In this section, we assess companies' exposure to low-carbon transition risks using five key metrics:

- ▼ **Metric 1) Emissions intensity³:** This metric focuses on the extent to which companies have reduced their operational emissions intensity over the period 2010-2016 and identifies the companies with the lowest current Scope 1+2 emissions intensity level. We use copper equivalent production to normalize emissions to account for the diverse commodity production mixes of the companies (see page 10 for further info).

- ▼ **Metric 2) Energy intensity³:** This metric focuses on the extent to which companies have reduced the energy intensity of their operations over the period 2010-2016 and highlights the companies with the lowest current energy intensity per unit of copper equivalent production.

- ▼ **Metric 3) Value chain (Scope 3) emissions exposure:** We assess the estimated downstream emissions footprints from the use and processing of companies' sold products, per unit of copper equivalent production. This is used as a proxy for the potential future exposure of each company's commodity mix to downstream carbon regulation, including carbon pricing. Commodities that have significant Scope 3 emissions are viewed less favorably to those which emit less in their use or processing phase.

- ▼ **Metric 4) Production costs:** Companies at the low end of the industry cost curve remain competitive and well placed to navigate through commodity demand shifts and structural changes

- ▼ **Metric 5) EBITDA split:** We analyze companies' earnings to assess exposure to commodities likely to be demanded in greater volumes in a low-carbon environment (e.g. nickel and copper), and those likely to be threatened by substitution (e.g. thermal coal). We use a commodity merit order system to rank companies based on their exposure.

2. See page 38 for global consumption by sector for each commodity.

3. We acknowledge the challenges of comparing a set of diverse mining companies with varying commodity and location mixes and therefore assign a 30% weighting to the emissions intensity level versus a 70% weighting to the trend. Nevertheless, ranking the level accounts for the consideration that companies with lower emissions intensities may find it more difficult to decrease these relative to companies which are reducing their emissions from a higher base.

Figure 5: Transition risks summary

Company	Emissions intensity	Energy intensity	Value chain emissions	Production costs	EBITDA split	Overall weighted rank	Transition risks rank	Transition risks grade
Vale	3	1	6	1	7	3.7	1	A
Boliden	4	4	1	9	3	4.7	2	A
Rio Tinto	2	4	7	3	9	5.3	3	B
BHP	1	2	11	2	12	5.8	4	B
First Quantum Minerals	7	11	1	5	1	5.8	5	B
Freeport-McMoRan	5	7	4	10	4	6.0	6	C
Glencore	10	3	8	4	7	6.4	7	C
Antofagasta	11	9	1	12	2	6.8	8	C
South32	7	10	9	6	6	7.7	9	D
Teck	6	6	10	8	10	8.0	10	D
Vedanta Resources	12	12	5	11	5	8.4	11	E
Anglo American	9	8	12	7	11	8.7	12	E

Weighting **20%** **20%** **15%** **20%** **25%**

Note: In calculating the weighted rank in this table, we use the weighted ranks for each area (where relevant). We display non-weighted ranks in this summary for simplicity only

Source: CDP

Highlights

- ▼ Energy and emission intensity levels of production vary across companies due to commodity mixes; however, nine of the 12 companies have reduced emissions intensity (av. CAGR of -2.3%) and eight have cut energy intensity of production since 2010 (av. CAGR of -1.4%).
- ▼ Nine of the 12 companies derive part of their revenue from fossil fuels. This can translate to significant earnings exposure, e.g. a third of BHP's EBITDA in 2016 came from high carbon emitting commodities such as oil, gas, metallurgical coal and thermal coal.
- ▼ Aggressive operational cost cutting by miners since the commodity market downturn in 2013 has left them more competitive (av. cost reduction CAGR of 10%). This has been mirrored by sharp reductions in company CAPEX (see Transition Opportunities).
- ▼ Vedanta and South32 have significantly higher emissions and energy intensities than peers (see Figures 7 and 8). Vedanta uses coal for over 70% of its energy needs and has energy-intensive zinc smelting operations, whereas South32's energy intense operations include aluminum smelting. This compares with Boliden that sources a significant proportion of its smelting energy requirements from renewables, resulting in a lower emissions intensity.
- ▼ Vale is ranked first due to the low emissions and energy intensity of its operations, as well as its position as a lower cost producer.
- ▼ Most companies featured have downscaled exposure to thermal coal assets since 2014 (of the six companies that produce thermal coal, it accounted for 9% EBITDA on average in 2016). Global consumption for thermal coal has fallen for the second year in a row with total volumes produced by companies in this report falling by 20% from 2010 to 287m tonnes in 2016.
- ▼ Glencore's recent failed bid for Rio Tinto's coal assets in Australia counters this trend. The assets represent the last of Rio Tinto's significant thermal coal assets; we estimate that its earnings exposure to coal will reduce from 4.9% to 2.5% on completion of the sale.
- ▼ By contrast oil and gas production from the 12 companies has more than doubled over the same period. In 2010 only BHP produced oil and gas, whereas in 2016, Vedanta and Glencore hold oil and gas assets and production is due to start at Teck's Forts Hill oil sands project in late 2017. Freeport has recently re-stated its commitment to focus on copper after its divestment of most of its oil and gas assets in 2016, mainly for balance sheet reasons.
- ▼ Large thermal coal, metallurgical coal, oil and gas and iron ore producers such as Glencore, South32, Anglo American, BHP and Teck have the highest Scope 3 emissions intensity of production. Each has over 60t CO₂ emissions per tonne of copper equivalent production in their downstream value chain (see Figure 9 below).
- ▼ Across all 12 companies total operational emissions (Scope 1+2) in 2016 were 225mt CO₂ and total estimated Scope 3 emissions from use and processing of sold goods were 2,365mt CO₂. Pricing the total company Scope 3 emissions at an indicative US\$7 / t CO₂ reveals a potential US\$16bn carbon cost to downstream industries. Teck's estimated 2016 estimated Scope 3 emissions were 80mt CO₂, over 28 times higher than its Scope 1+2 (or operational) emissions of under 3m tonnes.
- ▼ Nine companies have exposure to three countries with recently introduced or incoming carbon pricing schemes - Chile, Canada and South Africa (see page 14 for further discussion). However, due to China's significant consumption of high emitting commodities such as coal and iron ore, the proposed national ETS has the greatest potential (indirect) impact on miners.
- ▼ Copper, a beneficiary of the low-carbon transition, accounts for on average a third of earnings of the companies. Companies such as Glencore also benefit from exposure to cobalt, used in batteries for EVs.

Comparing miners using copper-equivalent production (Cu-eq.)

Comparing a set of diverse mining companies, each with its own unique portfolio of assets and commodities, can be challenging. A measure to normalize production or output of several mined commodities into a single 'copper-equivalent' figure is used by the industry and reported by Freeport McMoRan, BHP, Antofagasta and First Quantum Minerals to measure various intensity-based metrics.

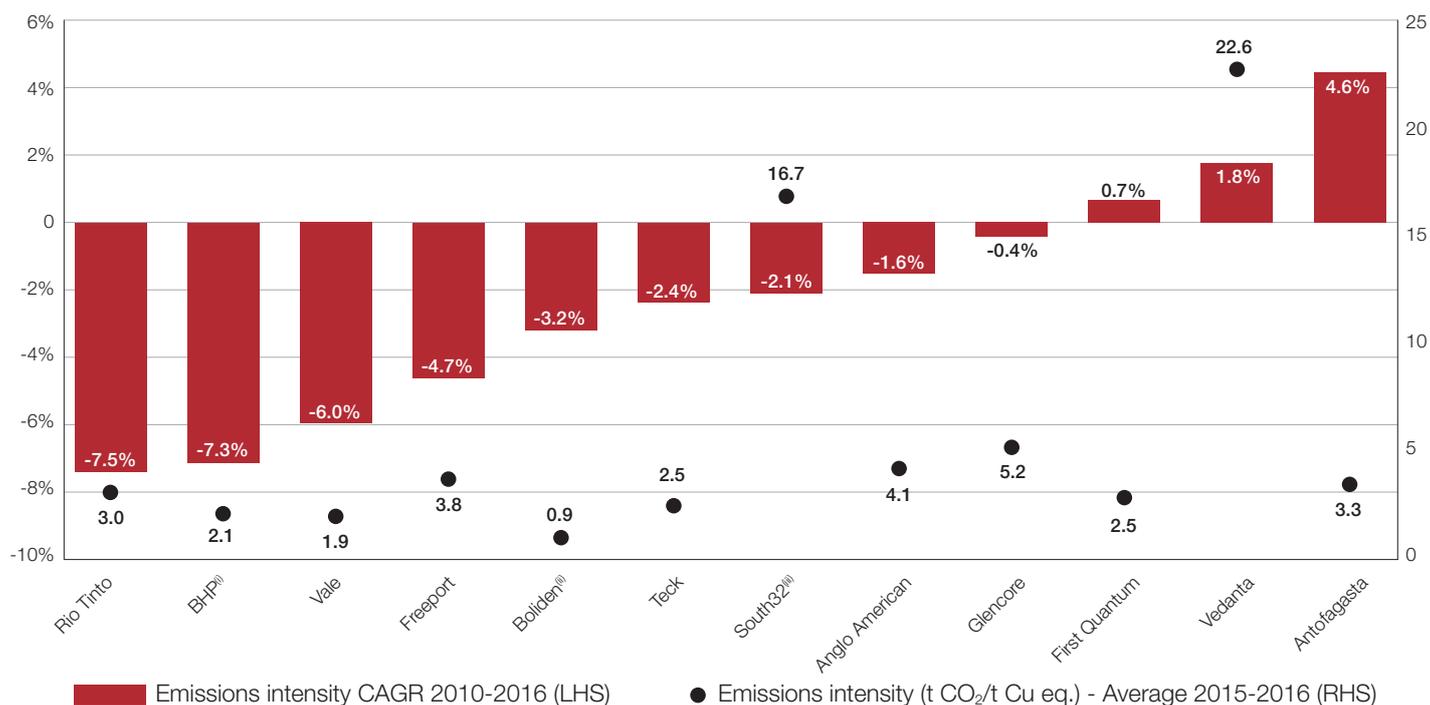
Production of commodities are scaled by the number of 'equivalent' units of copper they represent in value. This is calculated using a relative price for each commodity based on its value relative to copper (price of commodity / price of copper). To avoid potentially volatile year on year price movements skewing levels and trends of copper equivalent production data, relative commodity prices are pegged to either a single point in time or to an average over a period.

In the example below, we show a company that produces 200kt of copper, 5mt of metallurgical coal and 750kt of aluminium. When aggregating this data the company has total copper equivalent production of 523kt.

Figure 6: Copper equivalent production worked example

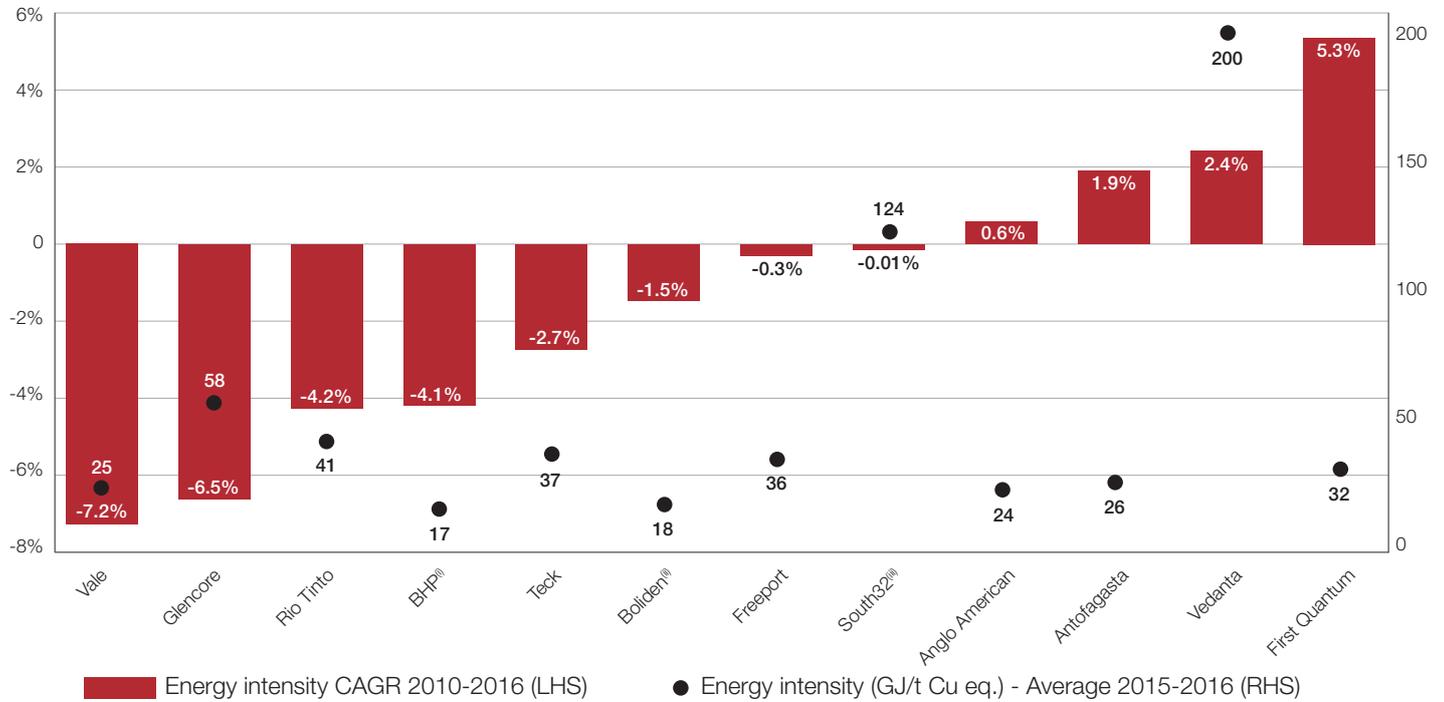
	Average annual price US\$ / t (2010-2016)	Copper equivalent price	Production (kt)	Copper equivalent production (kt)
Copper	7,000	1.00	200	200
Coking coal	161	0.02	5,000	115
Aluminium	1,950	0.28	750	208
Total				523

Figure 7: Emissions intensity (Scope 1+2) of production



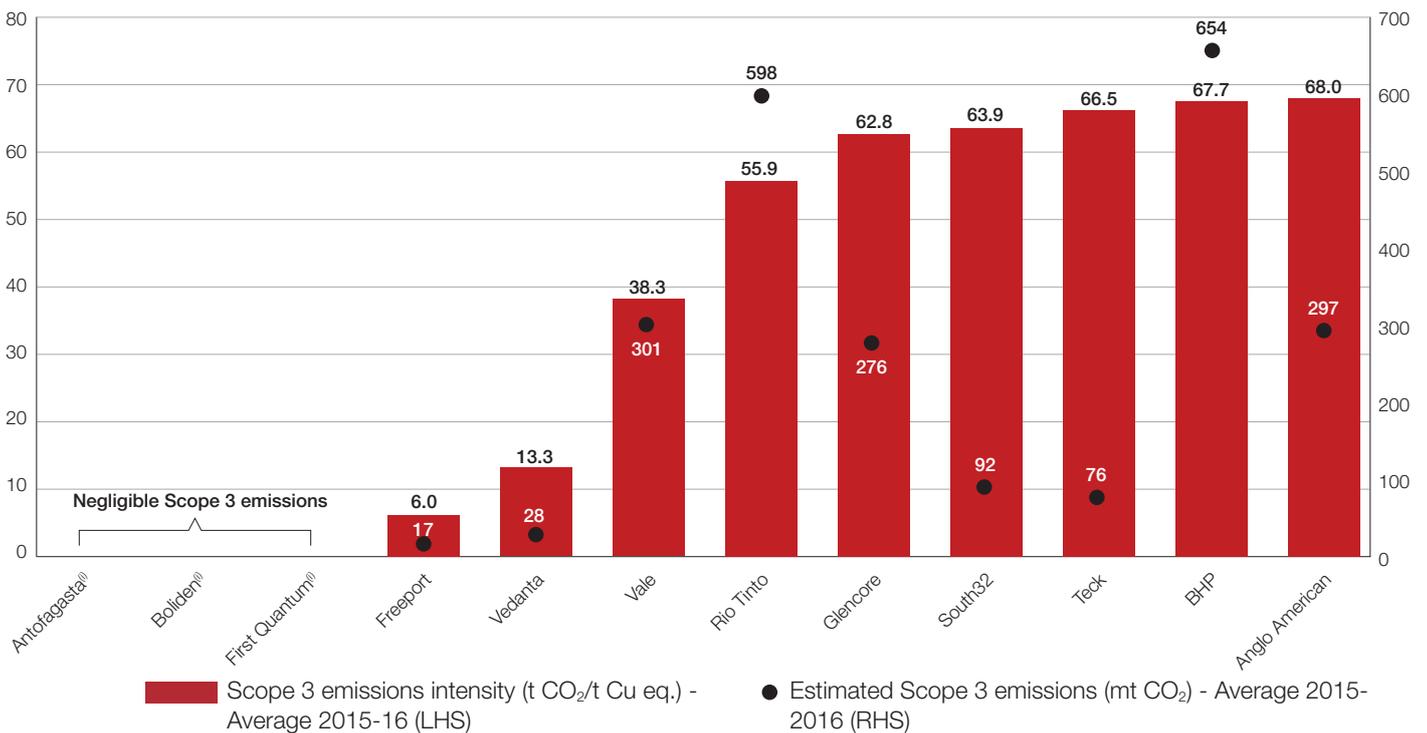
(i) BHP: Emissions intensity for 2016 only
(ii) Boliden: Includes mining and smelting operations
(iii) South32: CAGR 2014-2016
Source: CDP, company reports

Figure 8: Energy intensity of production



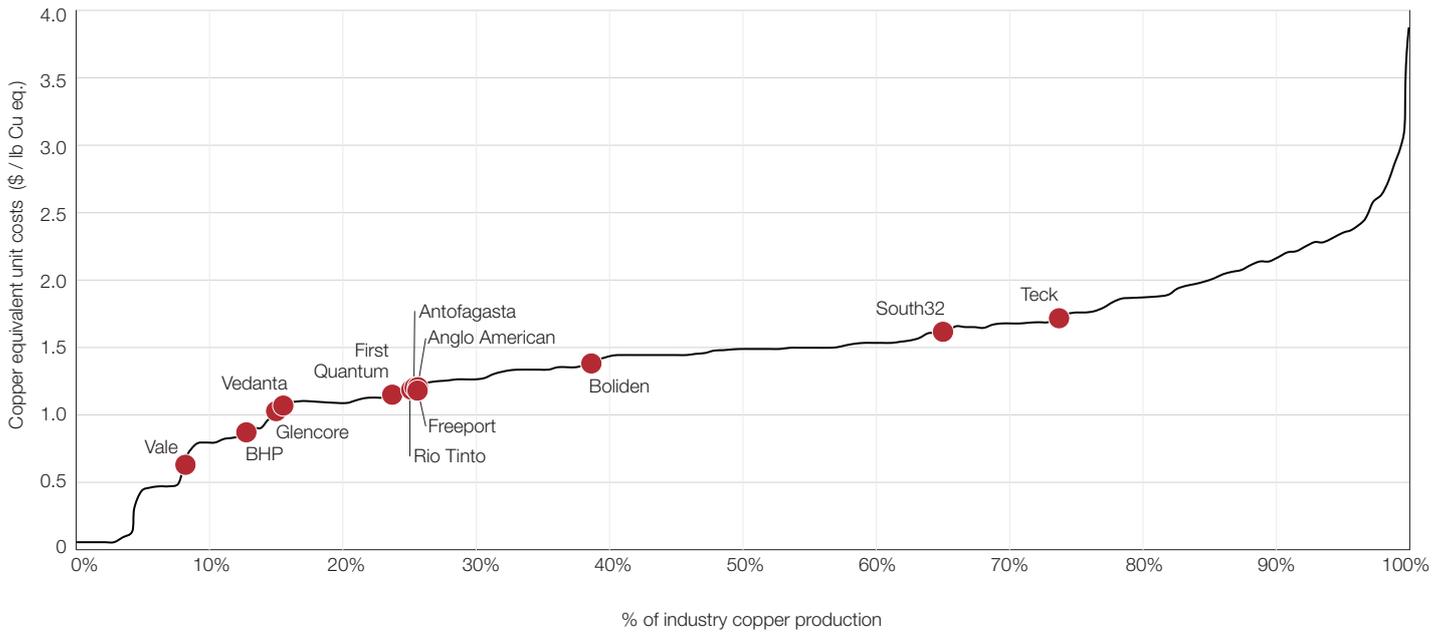
(i) BHP: Energy intensity for 2016 only
 (ii) Boliden: Includes mining and smelting operations
 (iii) South32: CAGR 2014-2016
 Source: CDP, company reports

Figure 9: Scope 3 emissions intensity of production



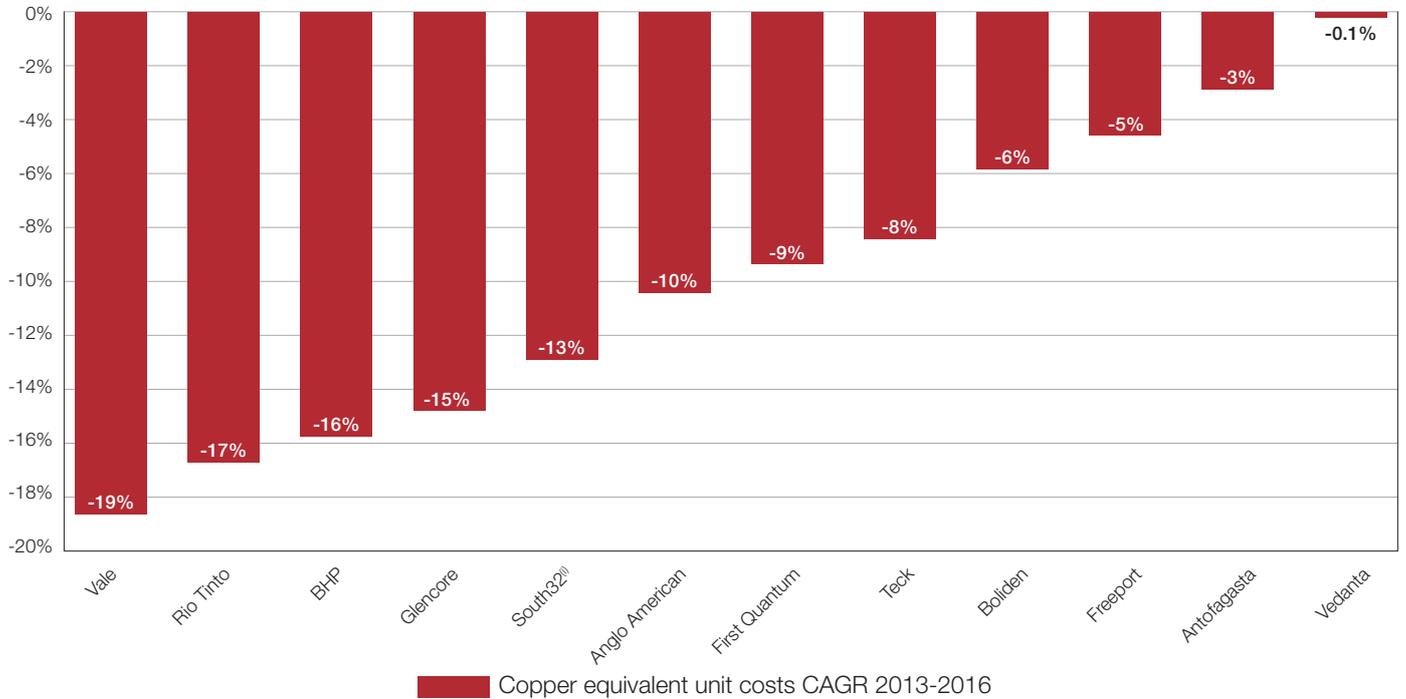
(i) Antofagasta, Boliden and First Quantum do not produce commodities that generate significant Scope 3 emissions such as thermal coal, coking coal, iron ore, natural gas and crude oil. As such these companies have negligible Scope 3 emissions intensities of production.
 Source: CDP data, company data

Figure 10: Copper equivalent unit costs



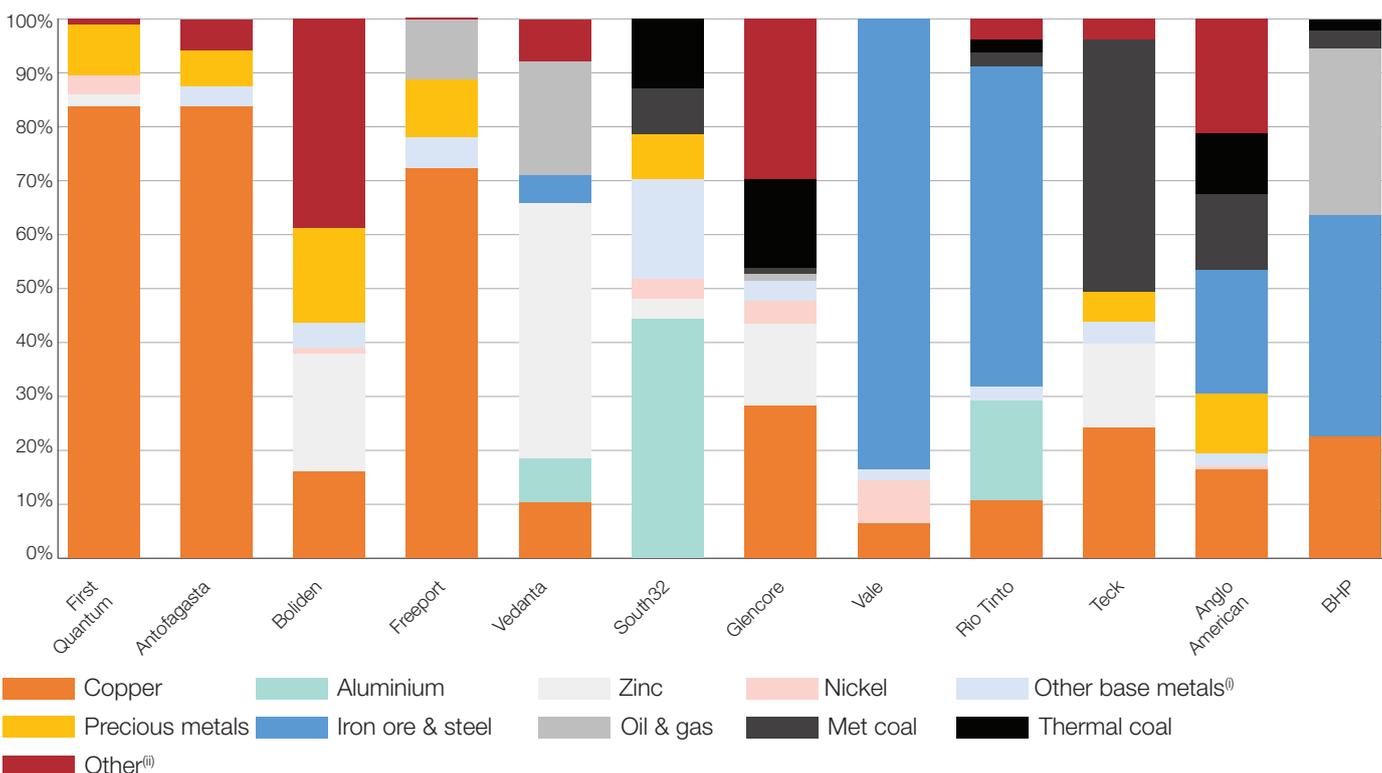
Source: CDP, Wood Mackenzie, company reports

Figure 11: Change in copper equivalent unit costs (2013-2016)



(i) South32: CAGR 2014-2016
Source: CDP, company reports

Figure 12: Earnings (adjusted EBITDA) split by commodity (2015-2016)



(i) 'Other base metals' includes lead, molybdenum, manganese, titanium, cobalt and vanadium.

(ii) 'Other' includes agriculture and marketing for Glencore, smelting for Boliden and diamonds for Anglo American and Rio Tinto.

Source: CDP, company reports

Can miners be carbon neutral?

The mining industry has shown signs of decreasing its operational carbon emissions footprint, but will require further steps to align with a low-carbon future and become 'net' carbon neutral by 2050. Continued future global demand for raw materials favorable to a low-carbon transition will still require energy and emissions intensive extraction processes. It is therefore necessary for companies to explore further ways to reduce their carbon footprint, in addition to greater uptake of renewable energy, such as carbon offsetting and carbon sequestration.

Carbon offsetting can broadly be defined as compensating for one's direct emissions by reducing emissions elsewhere. For the mining industry, this mechanism can lead to a reduced 'net' carbon footprint whilst also rehabilitating environments that have been affected by mining by facilitating the sequestration of greenhouse gases in biological sinks.

Within the companies assessed in this report, South32 have committed to achieving net zero operational emissions by 2050. The companies aim in part to achieve this goal through its "Intelligent Land Management" (ILM) scheme. The initiative intends to turn land holdings, which are otherwise unused, into areas that support climate resilience. This approach uses the principle of carbon sequestration, whereby greenhouse gases are absorbed and stored in biological sinks, with the co-benefit of rehabilitating and conserving land disturbed by mining operations. Under the ILM initiative, South32 were able to rehabilitate 60% of the land it had disturbed through mining. This compares to a mining industry average of 8%⁴.

Similarly, BHP aims to generate 800kt of carbon offset credits through the Reducing Emissions from Deforestation and Degradation (REDD+) carbon offsetting scheme⁵. The company provided US\$5m to the Alto Mayo REDD+ project in Peru which protects approximately 182 thousand hectares of threatened forest⁶.

De Beers, the world's largest diamond company, 85% owned by Anglo American, announced in 2017 that it will be able to operate a carbon neutral mine within the next 5 years⁷. The company plans to capture and store CO₂ in kimberlite rock, a waste product from the diamond mining process that naturally reacts with carbon, removing it from the atmosphere. By accelerating this process and using readily available waste rock, De Beers will be able to offset the emissions it generates from its mines.

Carbon emissions are an inevitable part of a mining company's business. Carbon offsetting and innovative approaches to carbon storage provide additional avenues for miners to reduce emissions elsewhere. It is unlikely to be enough to reduce miners' emissions sufficiently in isolation, but is part of the suite of actions available to companies in the sector.

4. Intelligent Land Management at South32, 2016

5. REDD+ is an international mechanism established under the UNFCCC that provides economic, social and environmental incentives for developing countries to reduce GHG emissions from deforestation and related activities through the creation of carbon credits.

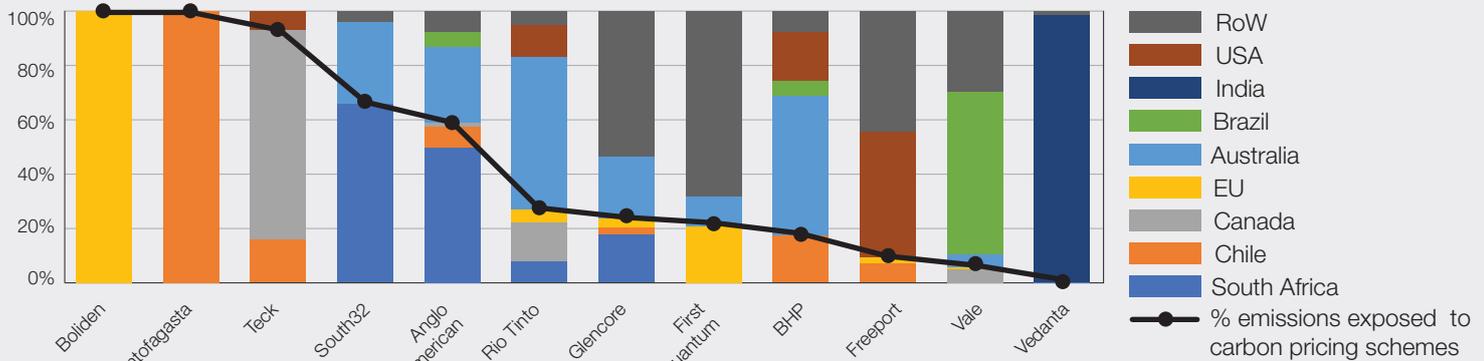
6. BHP annual report, 2017

7. Anglo American – Futuresmart mining, 2017

Carbon Pricing - it may all depend on China's incoming ETS

The companies featured in this report operate across a number of geographies that regulate and price operational carbon emissions differently. Direct emissions pricing at source has been proposed in Canada and South Africa and indirectly occurs through the application of a carbon price to emissions from electricity generation in Chile or to coal as a feedstock in India. Currently, implemented global carbon pricing schemes cover around 13%⁸ of global greenhouse gas emissions, whereas the companies in our study have, on average, over 25% of operational emissions exposed to existing and announced, direct or indirect, carbon pricing schemes (see Figure 13 below).

Figure 13: Emissions split by geography and % exposure to key carbon pricing schemes



Source: CDP, company reports

As highlighted in this section, mining company Scope 3 emissions footprints from use and processing of commodities can be up to 30 times higher than in the extraction, exposing companies indirectly to significant potential carbon regulation risk in downstream value chains. This exposure differs across mining companies and is largely dependent on which commodities they produce. For example, some bulk commodities such as thermal and metallurgical coal and iron ore are produced in large quantities, have relatively low prices and have higher embedded carbon in their downstream value chains relative to their emissions during extraction. In contrast, while copper emits significantly more carbon during its extraction and refinement, its higher value and price inelastic demand (due to lack of substitutes) means that it is potentially less sensitive to carbon pricing – i.e. the cost of its emissions represent a lower proportion of its value. In the example below, a US\$25/t CO₂ price is used to compare three commodities' potential sensitivity to carbon pricing:

Figure 14: Carbon price sensitivity across iron ore, thermal coal and copper

	Miner emissions (t CO ₂ /t product)	% commodity lifecycle CO ₂ emissions	Carbon cost of miner emissions (US\$ per t product)	Value chain emissions (t CO ₂ /t product)	% commodity lifecycle CO ₂ emissions	Carbon cost of value chain emissions (US\$ per t product)	Average commodity price (US\$/t product)	Lifecycle carbon cost as % of selling price	Miner's CO ₂ cost as % of price	Consumer's CO ₂ cost as % of price	Carbon price needed for 10% commodity price increase (US\$/t CO ₂)
Iron ore	0.03	2%	0.75	1.46	98%	36.5	95	39%	0.8%	38.4%	6
Thermal coal	0.09	4%	2.25	2.10	96%	52.5	75	73%	3.0%	70.0%	3
Copper	4	96%	100	0.15	4%	3.75	6500	2%	1.5%	0.1%	157

Source: CDP

As shown above, iron ore and thermal coal emit relatively little in the extraction phase but have significant downstream emissions (and associated carbon costs) as a proportion of its selling price. Such carbon costs would be incurred at the point of use in downstream industries, where the ability to pass on costs vary according to the competitive nature of markets. Copper on the other hand, whilst emitting more per tonne, has a noticeably smaller 'carbon emissions cost' relative to its sale value, making it less sensitive to carbon pricing.

Existing or announced carbon price levels are not currently being considered at levels that would materially impact miners' earnings. The cost of current or announced carbon pricing schemes would represent at maximum 13% of 2016 EBITDA in the case of South32 (if full South Africa price was applied at ZAR120 to its operations⁹). However, the potential impact of China's ETS may be significant - the country consumes 67% of seaborne iron ore in its heavy industry and steel mills.

Figure 15: Incoming carbon pricing schemes affecting mining companies

Country	Policy + date	Price level	Major commodities
Canada	Country wide emissions tax, 2018	CAD10 (US\$7.5)/t, rising to CAD50 (US\$38)/t in 2022	Copper, coal, zinc
Chile	Electricity generation emissions tax, 2017	US\$5/t	Copper, gold, nickel, lithium
South Africa	Country wide emissions tax, 2018	ZAR120/t (US\$9.5/t)	Coal, iron ore, gold, PGMs
China	Country ETS, 2017	Unclear	Coal, iron ore, copper

Source: CDP

8. World Bank, State and Trends of Carbon Pricing, 2016

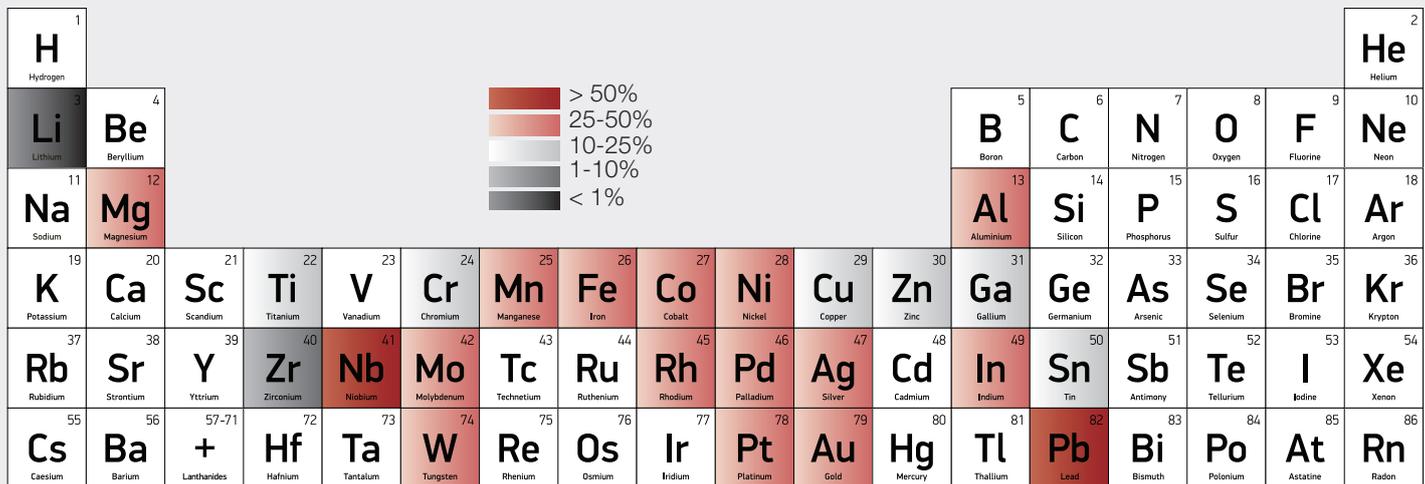
9. We note that currently free allowances or tax credits exist for metals and mining companies in most schemes to prevent carbon leakage. In South Africa a price of ZAR48/tonne CO₂ is expected to be paid after tax breaks are taken into account.

Recycling – the potential for “urban” mining

Recycling or production from secondary material has to date been a marginal issue for the large miners and the commodities market. The focus of miners has been to deliver high margins from extracting primary ore in the most economical way against a backdrop where externalities such as carbon emissions from energy use, water use and the disposal of waste are not fully priced. Recycling is seen as a “downstream” issue, divorced from upstream business models and a fragmented market. Could this change and how could it impact future supply?

The answer is not straightforward and depends on the commodity, what the end use of the product is and how it enters the waste stream. Figure 16 below shows estimates of recycled content for various metals – the range estimates reflect the difficulty in estimating these numbers.

Figure 16: Periodic table, ranges for recycled content



Source: CDP, UNEP

The scale of their use makes steel, aluminum and copper more ready candidates for recycling – iron ore and metallurgical coal are the main bulk commodities going into steel production and into urban environments with copper use driven by electrification and aluminum as a light weight metal which improves energy efficiency in autos and airplanes¹⁰.

For iron ore and metallurgical coal – interesting trends and drivers include the higher emissions efficiency of steel production from electric arc furnaces (EAF) which use scrap against blast furnaces (BF-BOF) using mainly iron ore and metallurgical coal. As pointed out in our steel report¹¹, EAF offers up to 75% emission reductions versus the BF-BOF route. One key limitation of capturing this has been the shortage of supply from scrap metal.

China could hold the key here – China has been the main driver of demand for raw materials into steel production and for the last decade has been the biggest producer and consumer of steel and could potentially be the largest source of scrap. As the country’s products and infrastructure enter the replacement phase, they could be the source of scrap to facilitate a shift from BOF to EAF technology¹². McKinsey estimate in 2015, obsolete scrap (end of life scrap) accounted for 35% of total scrap available in China and this could grow by 9% p.a. over the next 15 years as steel is recovered from old products, buildings, infrastructure and machinery. However, availability is only one part of the story – any material shift in scrap use and a shift from BOF to EAF technology depends on a number of factors – the transformation of the scrap industry from a fragmented, informal industry to a formal consolidated sector, the economics of scrap (sustained at US\$210-240/t using a LT price for iron ore of US\$60-80/t, metallurgical coal of US\$110-130/t) and government policy to shut BOF plants and invest in EAF plants as a clean-up and restructuring program and aligned to commitments to reduce GHG emissions.

EAF global capacity was 25% in 2015 (35% in 2000) driven by China’s dominance in steel production from BOF. Assuming China takes up domestic scrap availability, EAF’s share of domestic steel production could rise from 6% to 22% in 2025 and 33% in 2030 implying a reduction in BOF capacity of 130 Mt and 265 Mt respectively. The McKinsey analysis points to an interesting demand dynamic for iron ore and metallurgical coal in the seaborne market in the next 10 to 15 years

Key policy drivers for increasing recycling content for metals include the End of Life Vehicles (ELV) Directive in the EU (2000) setting stringent recycled content for the auto industry – a regulatory review in 2014 showed benefits outweighed the cost to the auto industry. Challenges remain – the collection and treatment by illegal operators and illegal shipment of ELVs to developing countries. ELV policy has been particularly effective in countries with high landfill taxes such as Germany, Spain, Finland and Italy (EC, 2014). The introduction of complex electronic systems and composite materials in new cars also poses a challenge in terms of high recovery targets set by the ELV policy (95% by 2015) with reuse and recycling of 85% by 2015.

One key benefit of the ELV Directive cited is its success in driving innovation in the auto sector with major auto companies investing in technology to meet higher recycling and recovery rates. Thinking around innovation leads directives such as the Eco-Design directive (2009) targeting energy related products where reduction of life cycle (including disposal) environmental impacts and energy savings are being sought at the design stage. While regulatory moves for downstream sectors remain remote to upstream mining companies in the short term – trends in regulation point to recycling becoming more important in the medium term.

10. See page 38 for global consumption by sector for each commodity.

11. CDP – Nerves of Steel – Oct 2016

12. McKinsey & Co – The growing importance of steel scrap in China – March 2017

Physical risks: Water resilience

- Key mining locations such as Chile, South Africa and Australia are exposed to heightened levels of water stress. Companies with mining operations in Brazil, northern Europe and Canada, are less exposed to the physical risks of water stress.
- 27% of company production, representing up to US\$50bn in revenue, will be exposed to high or extremely high baseline water stress or arid conditions¹³ by 2030.
- Water security remains a critical operational issue. Increased water efficiency, reduced freshwater usage and enhanced recycling rates are essential to hedge against the physical risks that water poses to business continuity.
- Vale and BHP rank highest, First Quantum and Vedanta rank lowest.

Overview

Access to and availability of water is fundamental to the continuity of mining operations. With global demand growth for water set to exceed supply by 40% by 2030¹⁴, a good-quality supply of freshwater can no longer be guaranteed in many regions of the world.

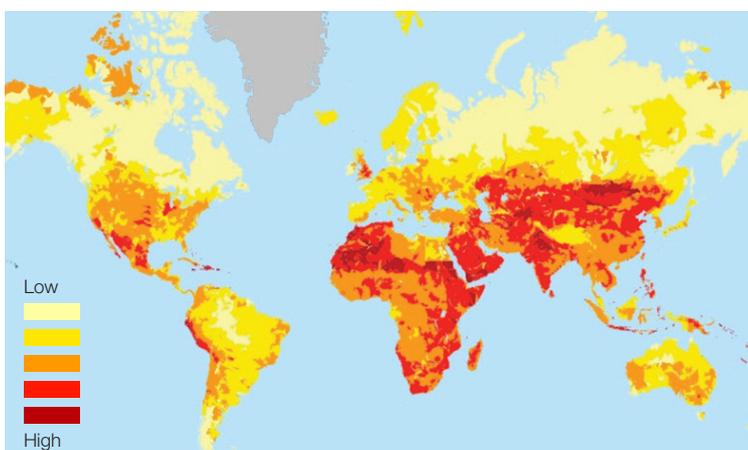
In water scarce regions, miners face a new business reality of weighing up the economics of large-scale capital investments in alternative water resourcing (e.g. desalination plants) against the value of ore reserves for greenfield projects, or the prospect of extending and securing existing mines' useful lifetimes. Companies with water efficient mining operations are better placed to manage operating costs and secure water supply, essential to mitigate risks of accelerated asset value depreciation or potential asset stranding.

In its 2017 CDP water response, Antofagasta states that "the use of surface water will generally no longer be

feasible for new greenfield projects in Chile." Evidenced by the company's investment in a desalination plant and pipeline at its Los Pelambres mine in Chile costing approximately US\$470m. At the Escondida copper mine in Chile, majority owned by BHP and part owned by Rio Tinto, a new desalination facility is set to provide long-term water supply security – at a cost of a US\$3.4bn capital investment.

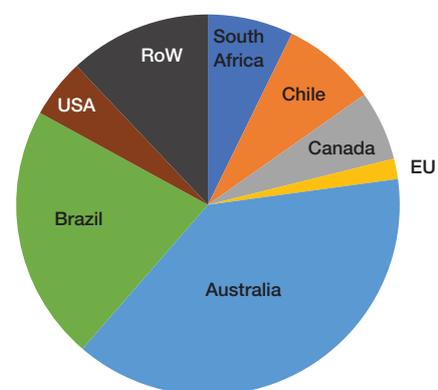
Conversely, the Tia Maria copper mine in Peru, owned by Southern Copper (a non-responder to CDP), appears stranded over water conflicts. This partially stems from a proposal to use surface and groundwater instead of an expensive capital commitment to desalination. The resulting conflict with the community resulted in the company having to revise its environmental impact report to include water supply infrastructure. Concerns remain for the business case for this mine rendering it currently untenable.

Figure 17: Water stress relative to mining sector in 2016



Source: WRI

Figure 18: Company mining production split by geography (on copper equivalent basis)



Source: CDP, company reports, GlobalData

13. Arid conditions defined by WRI as less than 0.03 m³/m²/year of available blue water. See: WRI – Aqueduct Global Maps 2.1: Constructing decision-relevant global water risk indicators

14. Morgan Stanley Research: Metals & Mining in SRI – Insight: Copper & Water – expensive solutions

In this section, we assess companies' water resilience. Taken in aggregate, we believe the below metrics give an overall indication of companies' exposure to and management of water related issues and their resilience to the physical risks of water stress.

▼ **Metric 1) Asset water stress exposure:** We assess localized water stress on a mine by mine basis using the World Resource Institute (WRI) Aqueduct global water-stress risk mapping tool¹⁵. It assesses current water stress conditions based on physical water quantity and quality indicators and regulatory and reputational risks¹⁶. Future water exposure is based on baseline water stress, calculated by the ratio of water use to supply. A company's water stress exposure is scaled by asset level production relative to total output, to capture its relative materiality within a portfolio.

▼ **Metric 2) Water withdrawal intensity:** Water withdrawal intensity is used to evaluate companies' dependency on water supply and the associated risk of business disruption in the event of increased supply strain. This metric focuses on current water withdrawal intensity per unit of copper equivalent and the extent in which companies' have reduced this over the period 2012-2016.

▼ **Metric 3) Water recycling and fresh surface water use:** This metric builds on the water stress exposure analysis to identify companies with low levels of freshwater withdrawal and high water recycling rates (both favorable).

▼ **Metric 4) Water governance and policy:** We form a ranking based on a range of indicators relating to companies' water risk assessment, policies and governance frameworks based on responses to the 2017 CDP water questionnaire and public company disclosures. The scorecard includes: Disclosure to CDP, water risk assessment metrics, data verification, water consumption targets, and adoption of the ICMM framework. Companies are scored out of 50, with high scores indicating better placed companies.

Figure 19: Water resilience summary

Company	Asset exposure to water stress	Water withdrawal intensity	Water recycling and fresh surface water use	Water governance and policy	Overall weighted rank	Water resilience rank	Water resilience grade
Vale	1	4	3	5	3.6	1	A
BHP	4	1	6	3	4.3	2	A
Boliden	2	4	2	12	5.0	3	B
Anglo American	7	7	4	1	5.3	4	B
Teck	3	4	9	6	5.4	5	B
Glencore	5	10	7	2	5.7	6	B
South32	6	3	8	4	5.7	7	B
Antofagasta	12	7	1	8	7.2	8	C
Rio Tinto	9	1	10	10	7.8	9	C
Freeport-McMoRan	11	10	5	9	8.4	10	D
First Quantum Minerals	8	12	12	7	9.3	11	E
Vedanta Resources	10	9	11	11	9.4	12	E

Weighting **30%** **25%** **25%** **20%**

Note: In calculating the weighted rank in this table, we use the weighted ranks for each area (where relevant). We display non-weighted ranks in this summary for simplicity only

Source: CDP

15. World Resource Institute Aqueduct tool: <http://www.wri.org/our-work/project/aqueduct>. Mine data is sourced from GlobalData and company reports. GlobalData is a provider of asset level data of facilities for high emitting sectors. Details at: <https://www.globaldata.com/>

16. Physical water quantity is based on baseline water stress, inter-annual and seasonal variability, flood occurrence and drought severity.

Highlights

- ▼ The mining industry is highly water intensive; however, depending on ore grade, commodity type and mine accessibility, intensities can vary significantly. Figure 24 highlights the difference between highly water efficient companies such as BHP and South32 and water inefficient companies such as Glencore and Vedanta.
- ▼ There have been minimal reductions in water withdrawal intensities from 2012-2016. With the exception of Boliden which has reduced withdrawal intensity by 9.8% annually, Figure 24 shows that half of the companies have only achieved marginal reductions in water withdrawal intensities. While companies have attempted to reduce water withdrawals over time, increasingly low ore grades and deeper ore bodies have required more intensive water use, likely counteracting water efficiency practices.
- ▼ High recycling rates are key to reducing dependency on water supplies in water scarce areas. Figure 25 shows that three of the 14 companies have recycling rates of over 80%, and three-quarters of the companies have recycling rates of 50% or greater.
- ▼ With large investments in desalination plants and water processing, companies such as BHP, Boliden and Antofagasta have been able to reduce exposure to water supply risks and conflicts associated with fresh surface water competition by utilizing greater withdrawals from brackish surface water and seawater (see Figure 25).
- ▼ Ten of the 12 companies assessed show relatively advanced levels of water governance. Multiple stakeholders are factored into companies' water risk assessments and all companies monitor and measure water withdrawal, consumption and discharge at their operations.
- ▼ Boliden and Rio Tinto were the only two companies not to respond to the 2017 water questionnaire. Of the total diversified miners targeted by CDP in 2017, 53% responded. While this is a higher response rate than other industries, there will be an increased demand for better disclosure, in order to facilitate integration of water risk analysis into the investment process.
- ▼ Vale rank first for water resilience. On a company-wide basis, Vale recycles the most water and in 2017, 95% of Vale's production is located in areas of low to medium water stress risk. In 2030, Vale's exposure to baseline water stress is negligible, with 99% of production located in low water stressed areas, mitigating the fact that its operations withdraw a high proportion of fresh surface water.
- ▼ BHP ranks second overall. The company has by far the lowest water withdrawal intensity and scores highly in water governance. By 2030, the company's Australian assets are in areas where baseline water stress is expected to be low, despite nearby areas forecast to experience major reductions in water availability.
- ▼ Boliden is exposed to low water stress exposure in 2017 and 2030. The company's mines are based in the Nordic region, and in 2017, all of its production is located in low or low to medium water stress risk areas. Despite this, the company has reduced its water withdrawal intensity and has a water recycling rate of 75%. However, the company's ranking is impacted by its poor water governance score from a lack of disclosure.
- ▼ Glencore and Anglo American score the highest for water governance, conducting advanced water risk assessments. Glencore is one of only three companies to set forward-looking quantitative targets, and aims to cut freshwater intensity at its Australian operations by 28% by 2019. Anglo American has the most comprehensive company-wide water policy. It is also targeting a reduction in water consumption of 19% against a business as usual forecast.
- ▼ In 2017, all of Antofagasta's production in Chile is exposed to medium to high water stress risk. By 2030, half of its production will be exposed to extremely high baseline water stress and the remaining output will be located in arid regions, the highest of any company. Antofagasta has taken steps to mitigate this risk by using high-levels of seawater and recycling over 80% of water withdrawn, though it will continue to be exposed to significant water challenges in the future.
- ▼ Freeport and Vedanta rank in the bottom three. By 2030, 78% of Freeport's production, predominately based in the US, is set to be exposed to extremely high baseline water stress risk or to arid conditions. The company also has a relatively high water withdrawal intensity that has increased over time. Vedanta has the lowest water recycling rate and performs poorly relative to peers in relation to water governance, despite producing a publicly available water policy. Vedanta's mining operations in India are already exposed to high water stress risk.
- ▼ First Quantum ranks second last for water resilience. The company has the highest water withdrawal intensity that has increased from 2012-2016¹⁷. It does not disclose a water recycling rate and uses a high proportion of freshwater. Going forward, the company is likely to have polarized exposure to baseline water stress. By 2030, the company's Zambian and European mines (67% of production) have reduced exposure to baseline water stress, whereas the remaining 33% of its production is exposed to extremely high stress and arid conditions.

Physical risks of climate change

The physical risks of climate change represent challenges to miners beyond reductions in water supply. The TCFD categorize physical impacts as acute near-term weather events, such as storms, floods and drought, and chronic long-term climatic changes, including sea-level rise or sustained heat-waves. Shifts in seasonal variability and an increase in the frequency and severity of extreme weather events has the potential to cause major disruptions directly to mining operations, its wider transportation infrastructure and distribution networks.

In recent years, the north-eastern region of Australia has been hit with several weather events that have caused disruption to mining operations:

- ▼ In 2011, Cyclone Yasi caused torrential rain in the Bowen Basin of Queensland where BHP, Glencore, Anglo American and Rio Tinto operate. Severe flooding disrupted production for over six months, causing output from the region to fall by a third¹⁸.
- ▼ In 2013, Cyclone Oswald hit the region, causing long-term damage to roads and rail networks. As a result, miners were forced to look for alternative ways to export coal from the southern part of the Bowen Basin¹⁹.
- ▼ In March 2017, BHP and Glencore ceased production as Cyclone Debbie hit the region. BHP, along with four other companies declared force majeure, and was unable to meet its contracted export commitments. It was estimated that about 13mt of coking coal production from Australia was lost due to damage to rail links²⁰.

Figure 20: Flood occurrence in Australia - 2017

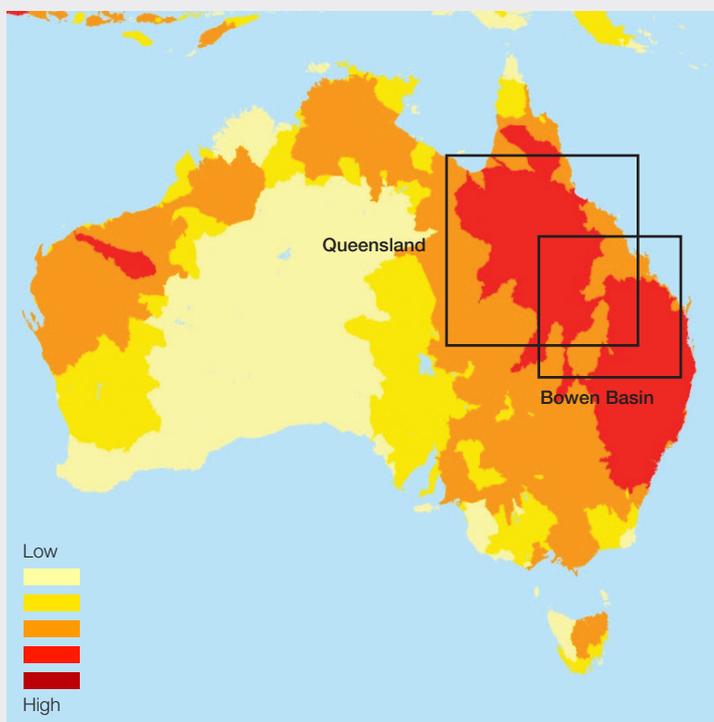
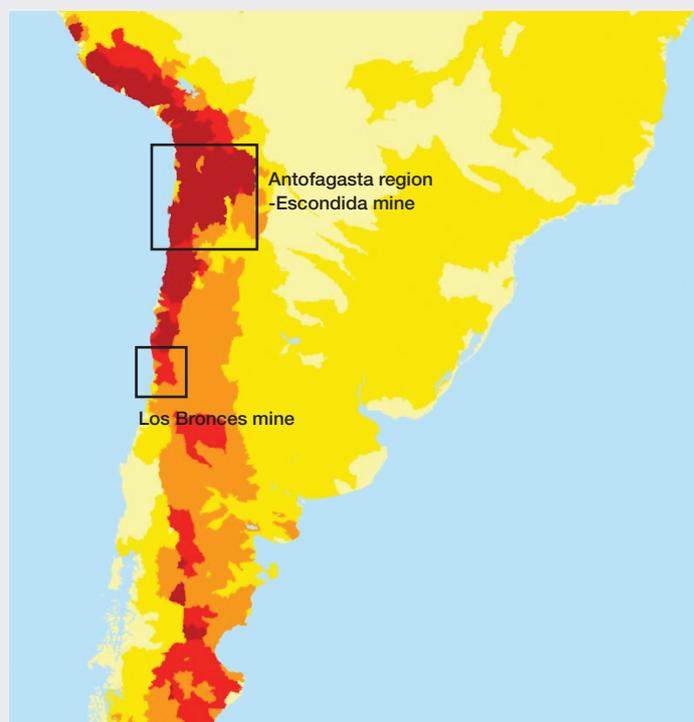


Figure 21: Drought severity in Chile - 2017



Source: WRI

Central and northern regions of Chile are particularly prone to drought due to the La Niña phase of the El Niño Southern Oscillation. In 2014, Anglo American lost 30kt of copper production, equivalent to approximately US\$170m in revenue or 4% of company-wide copper output at its Los Bronces mine in Chile²¹. In 2015, drought conditions also led to a 2% downturn in output at the Escondida in the Antofagasta region, a catalyst for investment in the desalination plant at the mine.

Heightened levels of heat stress can also impact mining. Bulk commodities are transported via large-scale rail freight networks and during periods of extended high temperatures tracks can buckle, causing delays in shipments. Heat stress is also an ongoing concern for the health and safety of on-site workers and for heat sensitive equipment.

As part of their CDP 2017 climate change questionnaire responses, all companies acknowledge that some form of physical climate impact will potentially cause increased CAPEX or OPEX, a reduction in production capacity or an inability to conduct operations as normal. Physical impacts of climate change must therefore be factored into companies' forward-looking business planning and in the design of new infrastructure. BHP ensure that all new projects assess risks associated with the forecasted impacts of climate change, such as cyclones or storm surges and invested US\$100m in infrastructure to buffer against wet weather in Queensland after the 2011 cyclone. Rio Tinto use scenarios to conduct climate change risk assessments for proposed new investments and to strengthen business resilience and recovery in the event of extreme weather events.

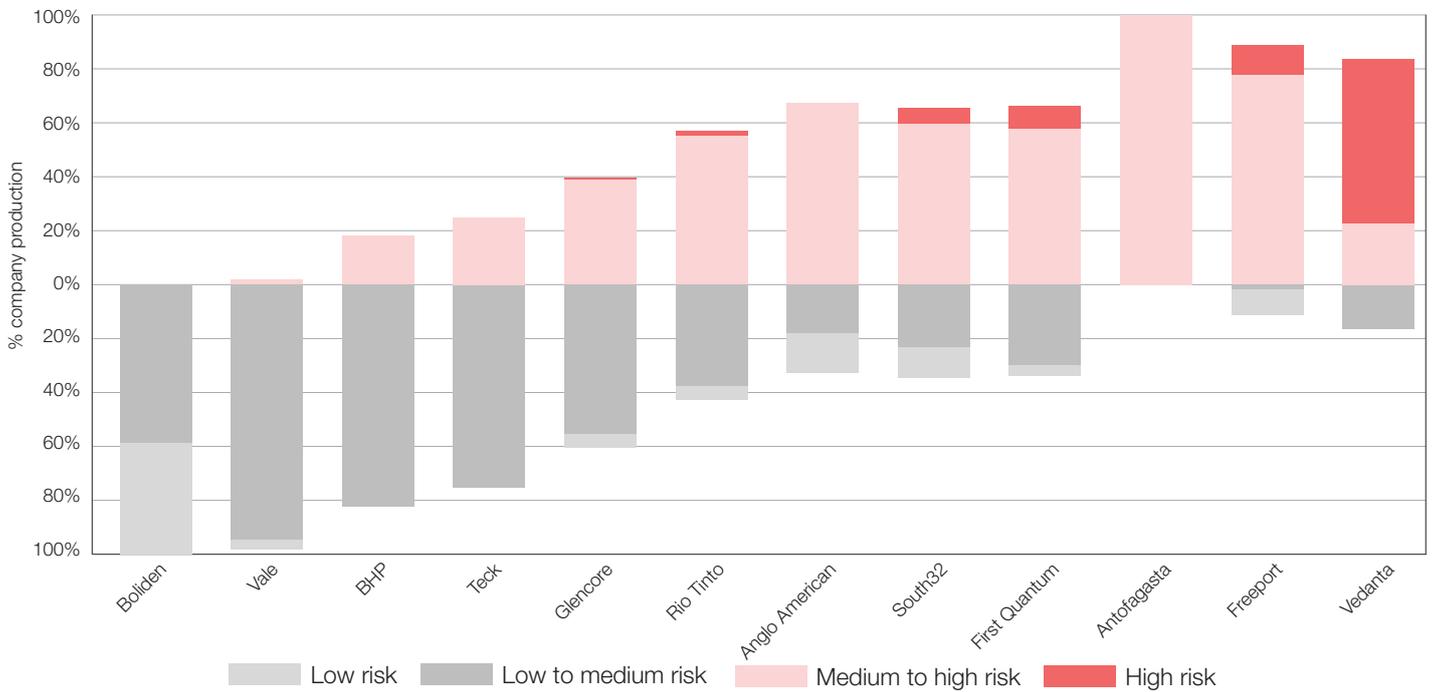
18. ABC news: Cyclone Debbie threatens coal exports from Queensland, 29/02/2017

19. The Australian: BHP's Bowen Basin coalmines hit by floods, Aurizon warns on rail lines, 29/01/2013

20. Reuters: BHP declares force majeure on cyclone-hit Australian coal exports, 05/04/2017

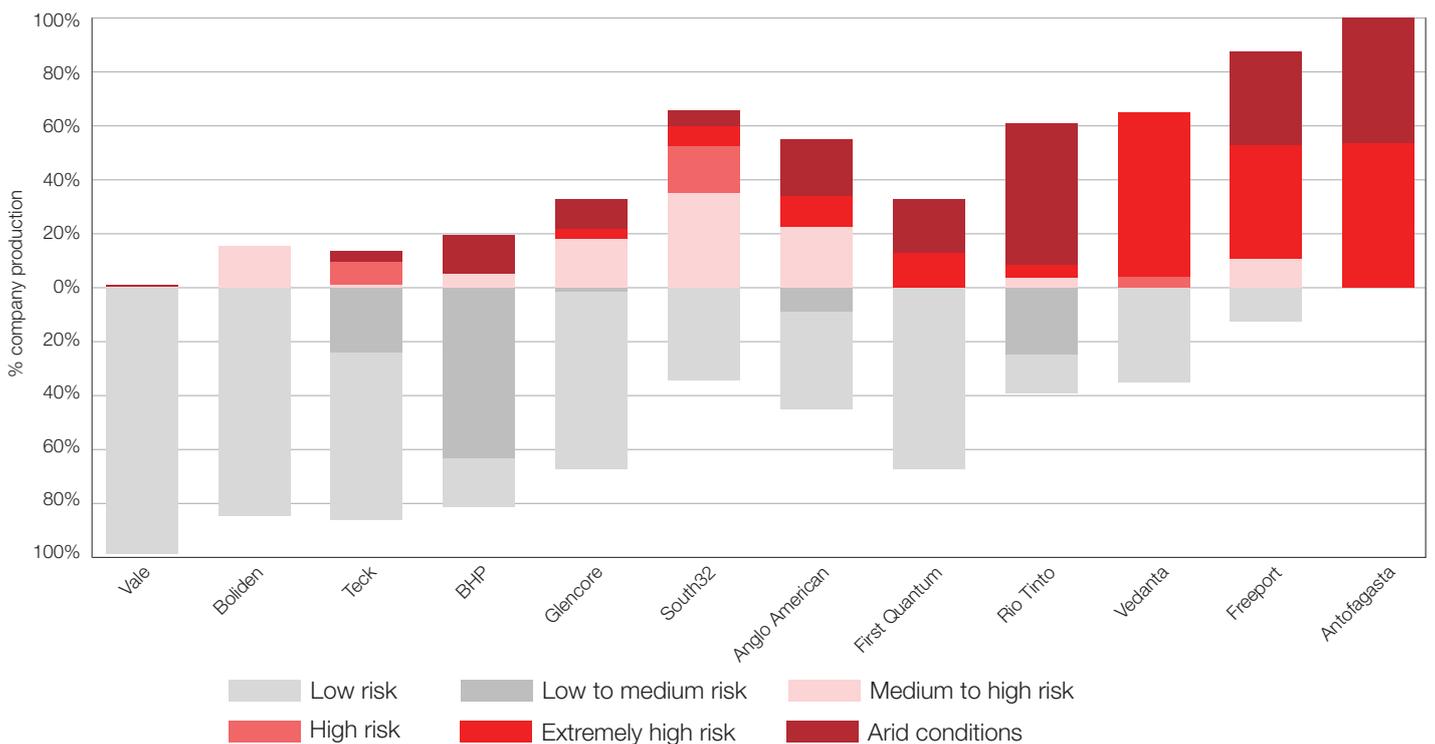
21. Anglo American annual report 2015

Figure 22: Current water stress exposure



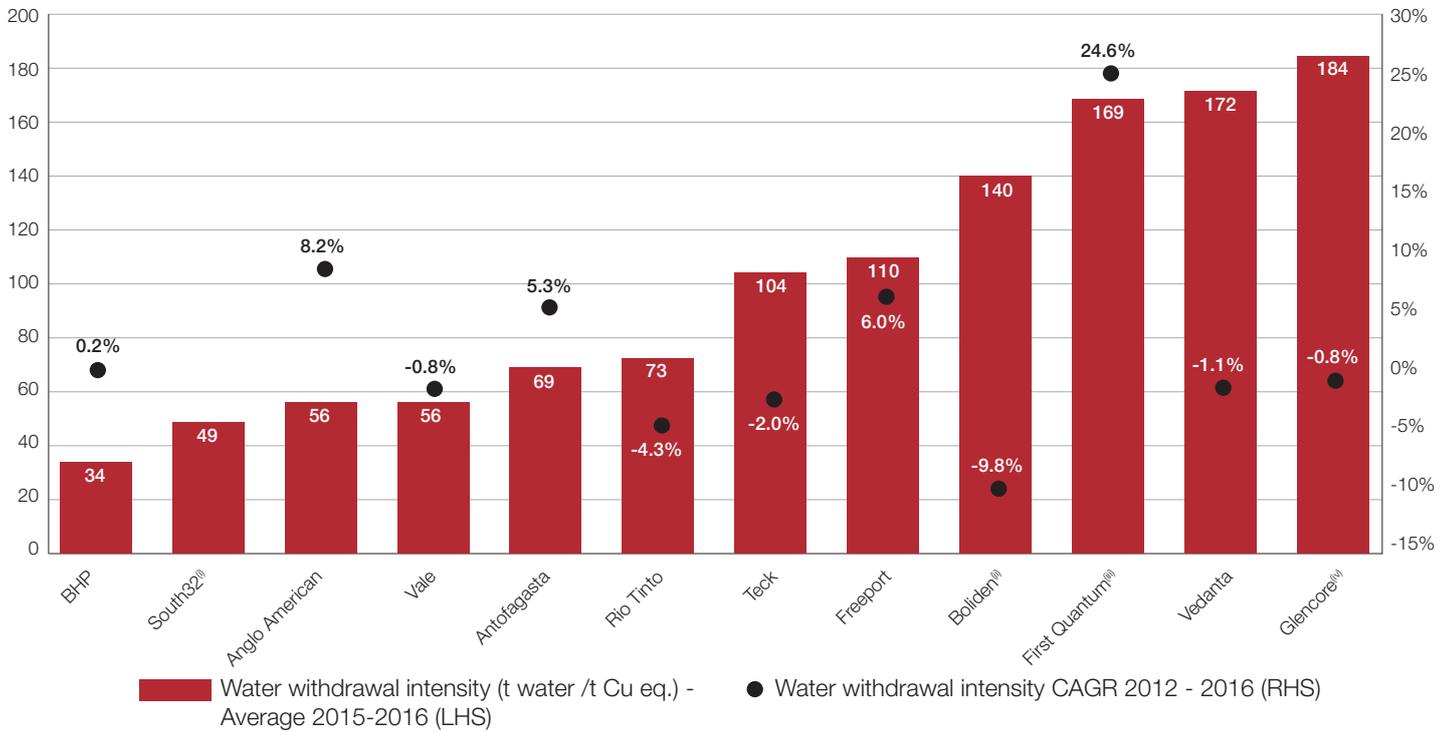
Source: CDP, WRI, company reports, GlobalData

Figure 23: Future baseline water stress exposure



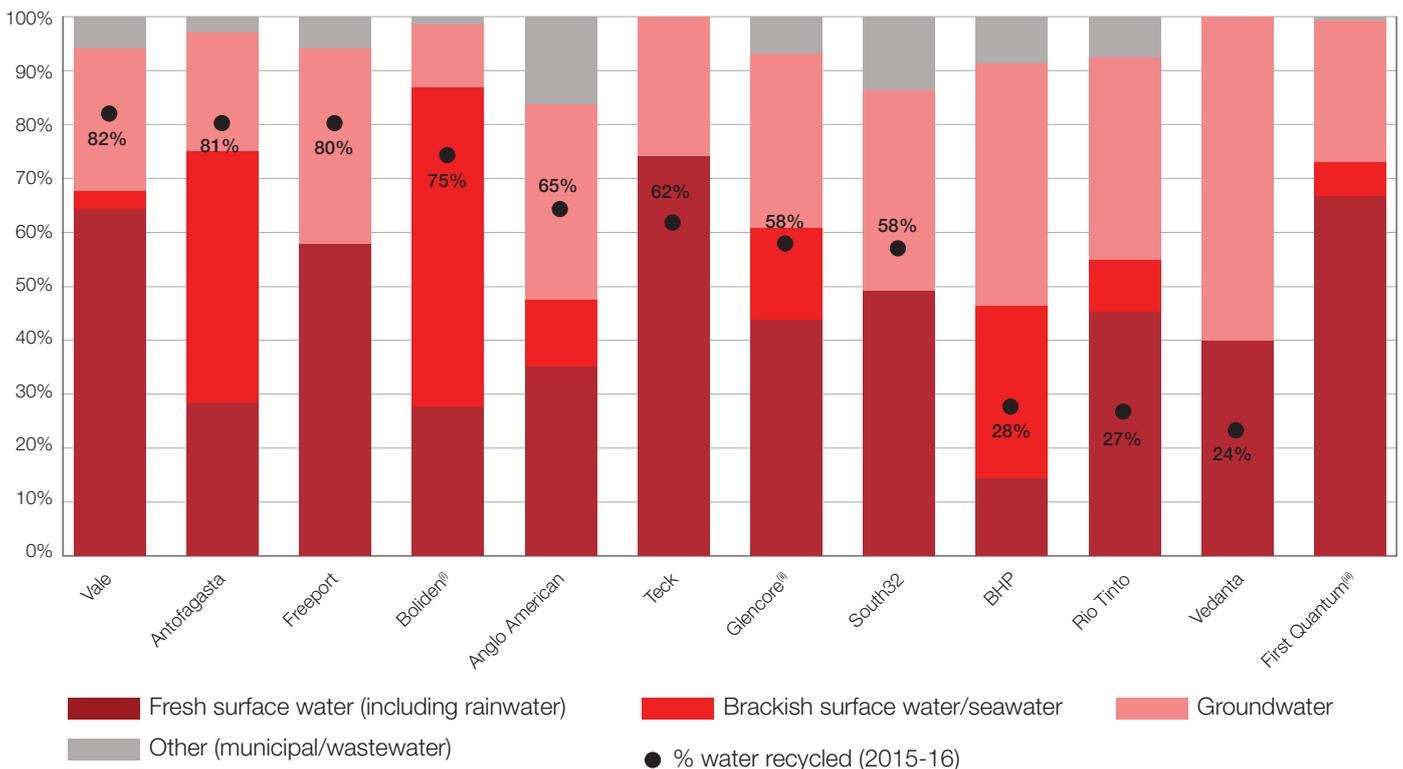
Source: CDP, WRI, company reports, GlobalData

Figure 24: Water withdrawal intensity



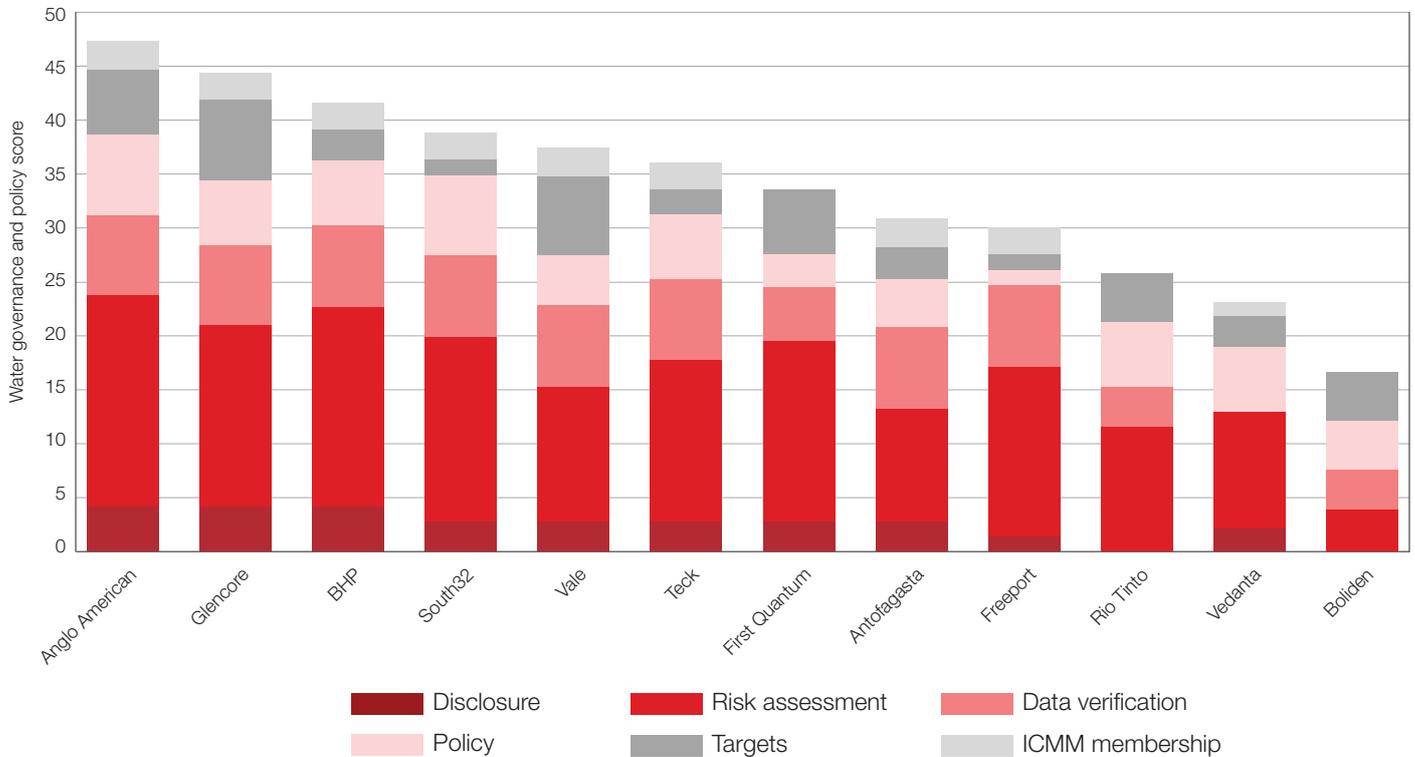
(i) South32: CAGR not calculated, only 2015-16 data available
 (ii) Boliden: production and smelting operations
 (iii) First Quantum Minerals: CAGR 2013-2016
 (iv) Glencore: mining operations only (excludes agriculture)
 Source: CDP, company reports, Bloomberg

Figure 25: Water recycling and fresh surface water use



(i) Boliden: production and smelting operations
 (ii) Glencore: includes water for agriculture
 (iii) First Quantum Minerals: no data on water recycling
 Source: CDP, company reports, Bloomberg

Figure 26: Water governance and policy score



Source: CDP, company reports

Waterless mining

Increasing pressure for water resources in industry and agriculture, coupled with the physical risk of higher water scarcity within prominent mining regions, has presented opportunities for research and development of technologies where water is removed from the mining process. Upscaling of innovative waterless technologies has the potential to significantly reduce water withdrawals, consumption and discharge, as well as improving efficiency and bringing down operational costs. A number of companies have begun exploring the feasibility of introducing new technologies and increasing recycling rates to reach a point where the water demands of mining are significantly reduced.

Due to a high proportion of mines being located in water stressed areas, Anglo American is looking to eliminate freshwater from its mining operations, through the implementation of closed loop-water recycling, evaporation control and dry tailings disposal. Currently it has been able to increase the recycling rate at its Los Bronces mine to 78%, up from 25% five years ago with the goal of increasing this to 80%²².

By 2025, Vale intends to reduce tailings by 700 million m³ by increasing the use of dry processing. Combining dry processing with reduced investments in tailing dams is predicted to create a net gain of US\$2bn for the company. At its new S11D Eliezer Batista Complex, the introduction of the process, whereby natural moisture stored within iron ore is used to remove impurities, has reduced water consumption by 93%²³.

Where large quantities of water are normally required for magnetite processing and beneficiation of iron ore, IMP Technologies, a South Australian company has developed a system called “Cyclomag” (cyclonic magnetic separator), a further waterless process that negates the need for tailing dams and can increase iron ore content by up to 70%²⁴. While only a demonstration system at present, the process may receive significant global interest once it has been upscaled and made commercially viable.

With average R&D spend at 0.4% of sales, it is clear that innovation and wide-spread investment of existing waterless mining technologies has not gained significant traction in the sector, despite compelling opportunities demonstrated by Vale.

22. Anglo American – Futuresmart mining, 2017

23. Vale – Dry processing and the reduced use of dams, 8/9/2016

24. The Lead – Waterless ore processor improves mining efficiency, 13/06/2017

Transition opportunities

- ▶ Around 45% of total company CAPEX is spent on commodities conducive to a low-carbon transition such as copper and nickel; however, over a quarter goes on fossil fuel development.
- ▶ Rio Tinto is ranked first. Its Mine of the Future™ program is pushing technological applications in mining. The company has cut CAPEX intensity the most since 2013, has one of the lowest levels of financial gearing and is shifting away from thermal coal²⁵.
- ▶ Boliden and Antofagasta rank second and third respectively. Capital spending is focused on metals with positive demand outlooks and both have relatively low levels of gearing.
- ▶ Teck is ranked last. Around 70% of its capital expenditure is allocated to fossil fuel development (50% to its Fort Hills oil sands project) and it cut CAPEX intensity the least between 2013-2016.

Overview

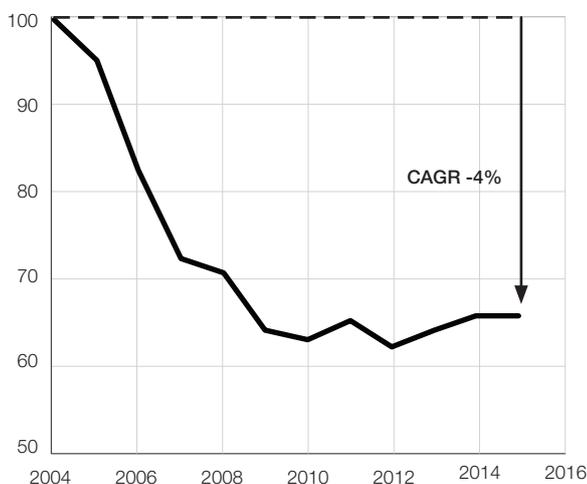
Due to the long lived and capital intensive nature of mining projects, capital allocation decisions made today will shape a company's portfolio of assets at a time when emissions need to peak globally, i.e. 2020-2030. Balance sheet flexibility, efficient spending and commodity investment choices are central to determining the direction of a company asset base going forward.

In the low-carbon transition, certain metals will be necessary ingredients for the expansion of clean-tech industries and products²⁶. Greater deployment of renewable energy infrastructure, battery technology and electric vehicles (EVs) are set to drive demand for underlying commodities such as nickel, copper, cobalt, manganese and lithium²⁷.

Investors have asked companies to align their medium-term strategies with these trends and conduct scenario analysis to ensure portfolio resilience. Accordingly, large capital commitments and decisions are coming under increasing scrutiny in an industry that has in the past been characterized by significant, debt-funded, acquisitions during times of buoyant commodity prices.

For many commodities ore grades are in decline and productivity across the mining sector has significantly fallen over the last 10 years (Figure 27). However, miners are beginning to focus more attention on innovative technologies and there is broad consensus that innovation will play an important role in delivering future productivity gains and sustainable growth²⁸. As costs for renewables and battery storage continue to fall, miners have greater optionality to utilize smart energy solutions and reduce reliance on on-site fossil fuel combustion and electricity grid access.

Figure 27: Mining productivity index



Source: McKinsey MineLens^{5x}

25. Highlighted by decision to sell Coal & Allied assets

26. See Figure 48 in the 'Supplementary figures' section for commodity demand scenario.

27. See box "Low-carbon transition metals" on page 25 for further discussion.

28. See box "Mining the future" on page 29 for further discussion.

29. McKinsey "Beyond the Supercycle", MineLens productivity index (indexed to 2004).

In this section we assess the extent to which companies are capturing these transition opportunities in their allocation of capital, and their advancement in innovative solutions at the mine site:

- ▼ **Metric 1): CAPEX split:** We look at company capital spending allocation across commodities to assess which ones are investing in commodities geared to higher demand in a low-carbon environment (e.g. nickel and copper), and those likely to be threatened by substitution (e.g. thermal coal). We use a commodity merit order system to rank companies.
- ▼ **Metric 2): CAPEX intensity:** This metric focuses on the extent to which companies have reduced their CAPEX intensity (per unit of copper equivalent production) over the period 2013-2016 and identifies the companies with the lowest current sustaining CAPEX intensity.
- ▼ **Metric 3): Capital flexibility:** Companies with lower levels of gearing have greater financial flexibility to withstand commodity price and demand level fluctuations. It is also an indicator of balance sheet management and company optionality to shape future investment decisions.
- ▼ **Metric 4): R&D and innovation:** This metric identifies innovative companies taking the lead in applying new technologies at the mine site. We also rank companies on their average R&D expense to sales ratio over the period 2014-2016, providing an indication of companies' focus on innovation.
- ▼ **Metric 5): Renewable energy:** We look at how companies are meeting their energy needs and rank them based on the renewable share of their total energy use.

Highlights

- ▼ Figure 31 illustrates the different approaches companies have in their allocation of capital. Companies to the left have higher shares of CAPEX spent on materials conducive to a low-carbon transition whilst those to the right continue to focus on fossil fuels³⁰.
- ▼ Allocation of capital to fossil fuel projects remained high across the company sample in 2016: South32 had more than 50% of CAPEX spent on coal, Teck approx. 50% on oil sands, and Freeport and BHP more than 40% on oil and gas projects³¹. Due to the long-lived nature of projects companies are in danger of 'locking-in' the emissions associated with these commodities.
- ▼ Rio Tinto continues to shift its focus away from thermal coal, highlighted by its decision to sell its Coal & Allied operations. Glencore's rejected bid of US\$2.675bn for these assets highlights a very different approach (Glencore's 2016 total CAPEX spend was US\$3.5bn).
- ▼ All companies have cut total CAPEX intensity (on average reduced by 25% p.a. across the company sample since 2013.) The focus is now on maintaining low levels of sustaining spend for existing operations and being selective on growth spends.
- ▼ Figure 34 shows the relative leverage of the companies. South32, a relatively young company, is currently cash positive and is looking to utilize this capital flexibility to facilitate growth.
- ▼ Miners are beginning to focus more attention on innovative technologies and the role they can play in driving productivity gains and sustainable growth³². Figure 35 summarizes progress in this area – Rio Tinto, Vale and Boliden are leading the industry, with Vale and Boliden also having the highest R&D expense as a proportion of sales (Figure 36). However, with average R&D expense to sales of 0.4%, the sector collectively invests very little in research and development.

Figure 28: Transition opportunities summary

Company	CAPEX split	CAPEX intensity	Capital flexibility	R&D / Innovation	Renewable energy	Overall weighted rank	Transition opportunities rank	Transition opportunities grade
Rio Tinto	5	2	3	2	2	3.4	1	A
Boliden	4	9	4	3	1	4.4	2	B
Antofagasta	2	10	2	9	9	5.0	3	B
Glencore	3	4	7	8	8	5.5	4	B
First Quantum Minerals	1	7	10	12	n/a	5.9	5	C
Vale	8	6	9	1	4	6.7	6	C
BHP	9	1	5	7	12	6.8	7	C
Freeport-McMoRan	6	8	10	11	5	7.5	8	D
Anglo American	10	5	6	4	10	7.7	9	D
Vedanta Resources	7	3	12	10	11	7.8	10	D
South32	12	12	1	6	6	7.9	11	D
Teck	11	11	8	5	3	8.2	12	E

Weighting **35%** **20%** **20%** **10%** **15%**

Note: In calculating the weighted rank in this table, we use the weighted ranks for each area (where relevant).

We display non-weighted ranks in this summary for simplicity only

Source: CDP

30. See box "Low-carbon transition metals" on page 25 for further discussion and Appendix II: Methodology and limitations for detail on ranking of companies by capital allocation.

31. We note that Freeport completed the sale of its Deepwater GOM and onshore California oil and gas assets in December 2016.

32. See box "Mining the Future" on page 29 for further discussion.

Figure 37 shows the different sources of energy used by companies in their operations. Six companies source at least 20% of energy from renewables, with Boliden having the highest share of renewable energy consumption. With energy accounting for up to 75% of a miner's emissions and up to 30% of its operational cost base, smart energy solutions offer an opportunity to optimize cost, security of energy supply and emissions intensity concerns. Synergies exist in setting renewable energy targets in combination with emissions, cost, productivity and other operational targets.

With new technologies emerging and increasing focus from companies on smart solutions to optimize operations, companies need to highlight the actions taken in these growth areas and present clear indicators of performance to investors. Companies should use scenario analysis to assess the potential opportunities available, as recommended by the TCFD.

Low-carbon “transition” metals

Certain metals will prove vital in the low-carbon transition, acting as key ingredients for clean-tech industries and products. Renewable energy, batteries and electric vehicles (EVs) are set to drive demand for underlying commodities such as nickel, copper, cobalt, manganese and lithium.

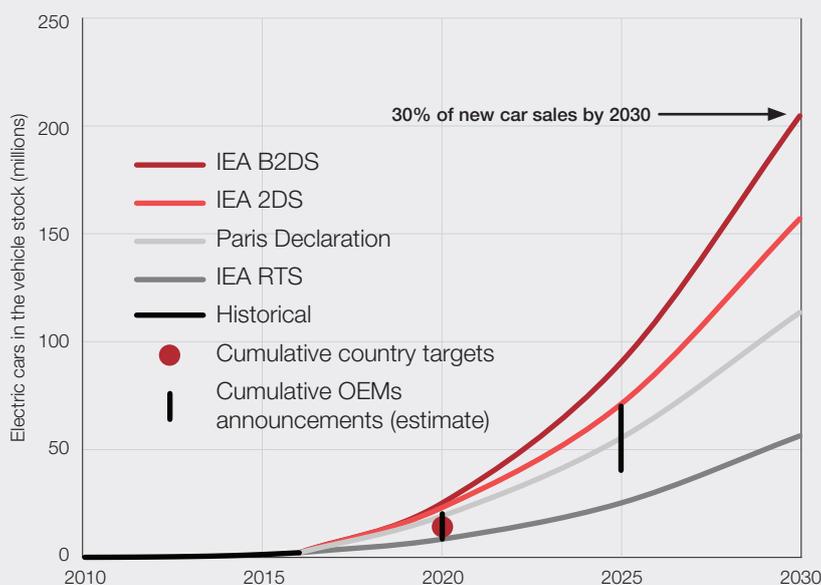
Renewable energy growth will fuel demand for particular commodities. Bloomberg New Energy Finance (BNEF) predict that 72% (US\$7.4 trillion) of global investment in new generating capacity to 2040 will go to renewables³³. Solar PV cells currently use around 120 – 150 milligrams of silver (approx. 20% of the total cost for a solar cell³⁴) and account for approximately 6% of global silver demand³⁵. Conventional power generation uses around one tonne of copper per installed MW whereas renewable generation ranges from being four to twelve times more copper intensive.²⁷

Figure 29 illustrates deployment scenarios for EVs, with the IEA B2DS scenario projecting more than 200 million EVs by 2030 (approx. 13% of total vehicle stock, and 30% of new car sales³⁶). There is already strong consumer demand; the Tesla Model 3 received more than 325,000 reservations in under a week and the global number of EVs exceeded 2 million in 2016 (a 60% increase from 2015). BNEF forecast that growth of EVs could reduce the cost of lithium-ion batteries by 73% by 2030 and expect lithium-ion batteries for energy storage to be a US\$20bn per year market by 2040³⁷.

Figure 30 provides a breakdown by type for Lithium-ion batteries in 2015, illustrating some of the commodities which are crucial to this battery technology. The International Copper Association estimates that for every kWh of a lithium ion battery, 1.2 kg of copper is used. UBS' recent analysis of the Chevrolet Bolt found it to contain 140kg of battery materials (such as lithium, nickel, cobalt and manganese) and around 80% more copper than a conventional fuel car. (BHP's analysis estimates EVs will use up to four times as much copper as today's conventional fuel cars.)

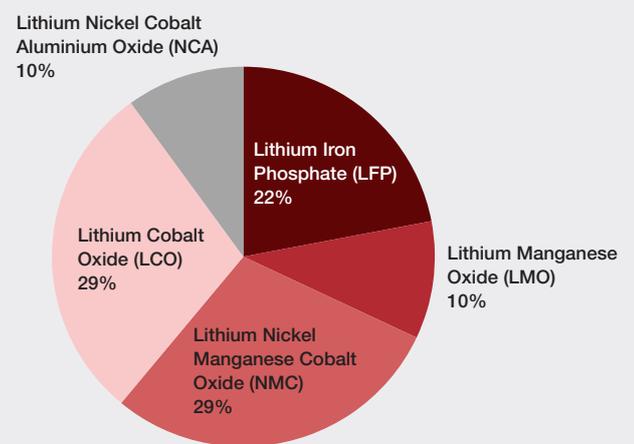
Declining ore grades and increasingly difficult mining conditions may result in supply constraints for many of these commodities. With demand expected to increase, companies should look to capitalize on the opportunities that are present.

Figure 29: Deployment scenarios for electric cars to 2030



Source: IEA Global EV Outlook 2017

Figure 30: Lithium-ion batteries⁽ⁱ⁾



(i) Global demand breakdown by type – 2015
Source: ResearchInChina

33. Bloomberg New Energy Finance (BNEF), New Energy Outlook 2017

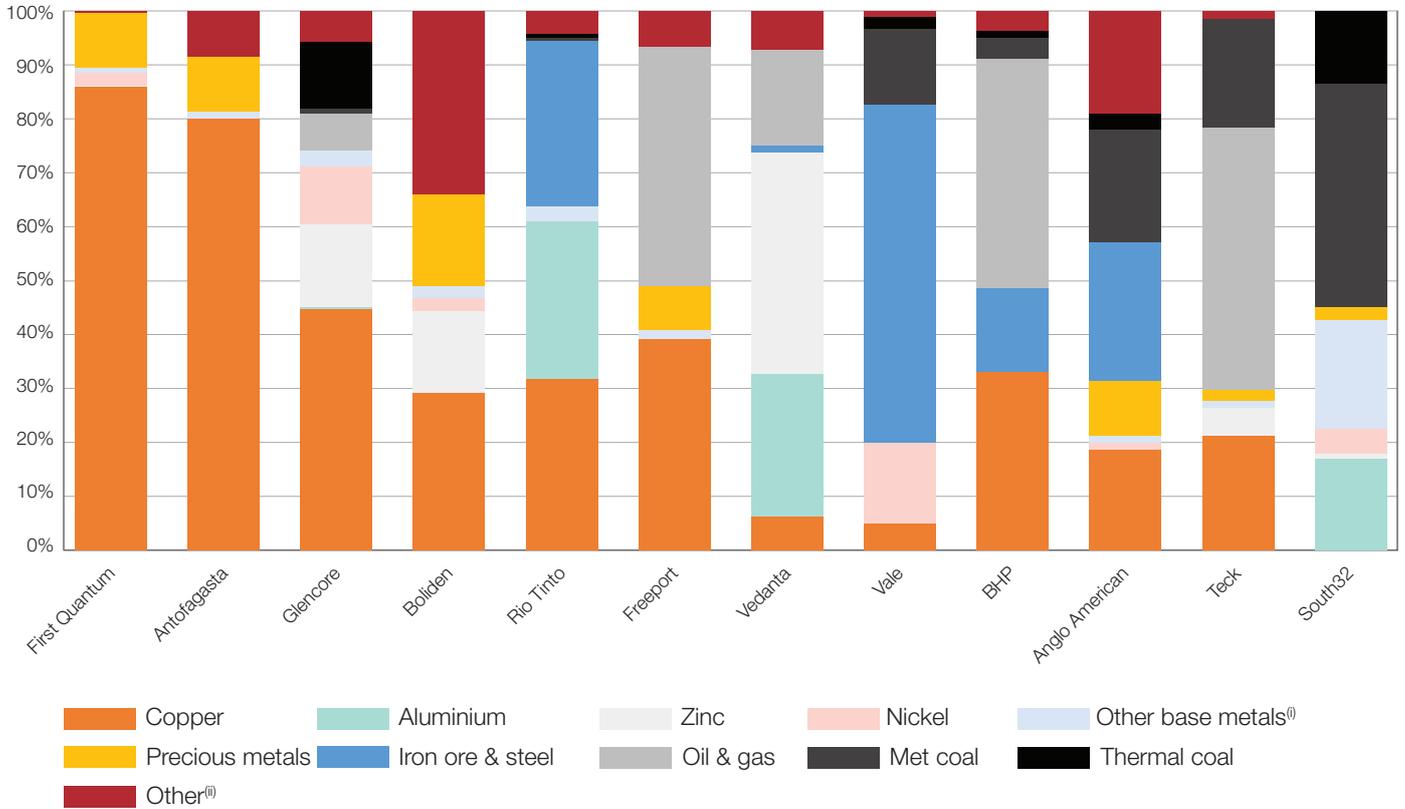
34. Meyer Berger estimate

35. See page 38 for global consumption by sector for each commodity.

36. The Copper Technology Roadmap 2030, The Warren Centre

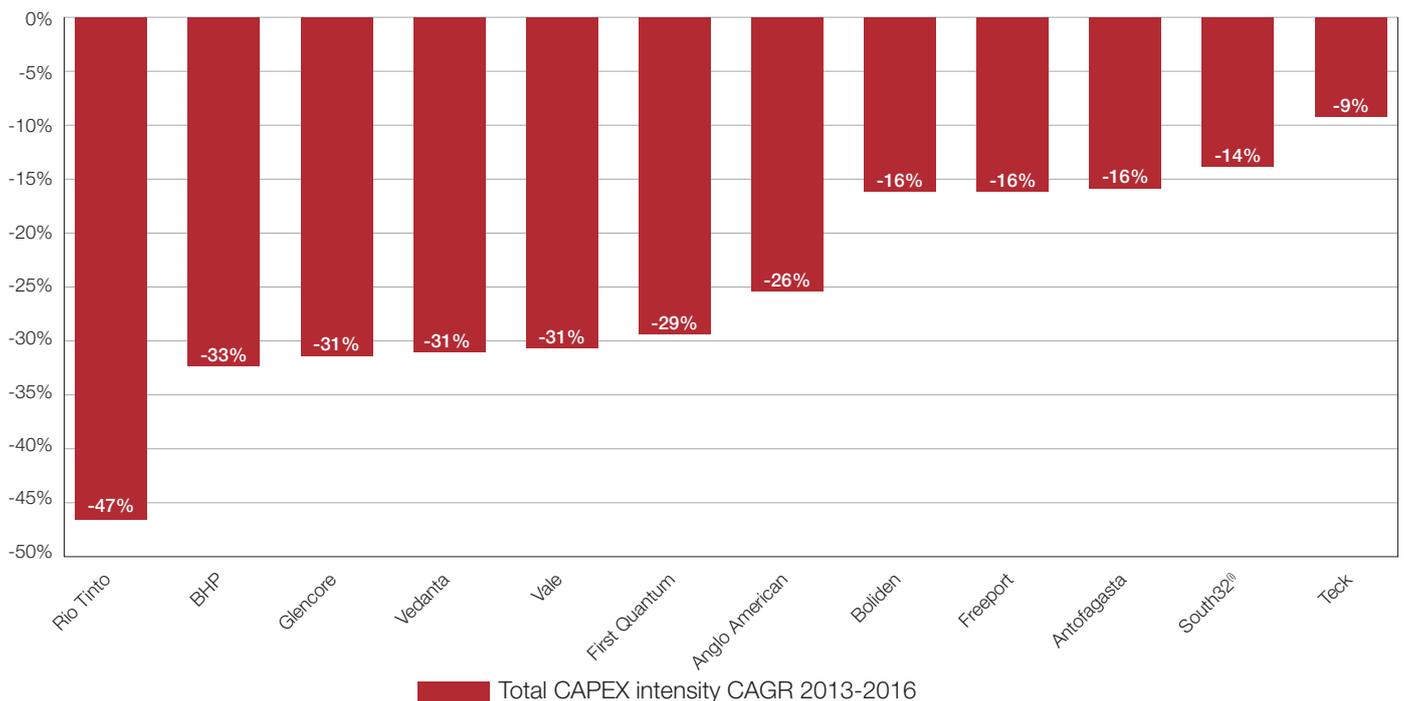
37. Consistent with the Electric Vehicles Initiative (EVI) ambition, EV30@30 campaign (Clean Energy Ministerial).

Figure 31: CAPEX split by commodity (2015-2016)



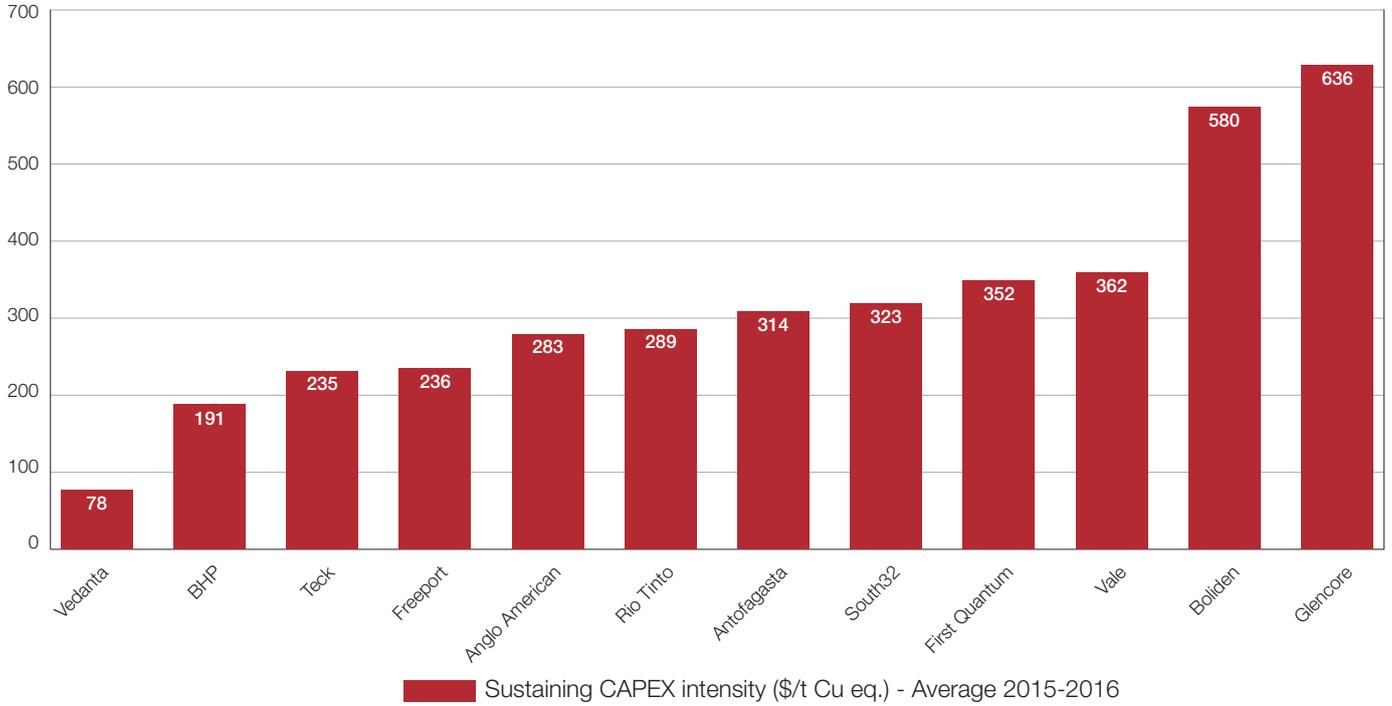
(i) 'Other base metals' includes lead, molybdenum, manganese, titanium, cobalt and vanadium.
 (ii) 'Other' includes agriculture and marketing for Glencore, smelting for Boliden and diamonds for Anglo American and Rio Tinto.
 Source: CDP, company reports

Figure 32: Change in total CAPEX intensity (2013 – 2016)



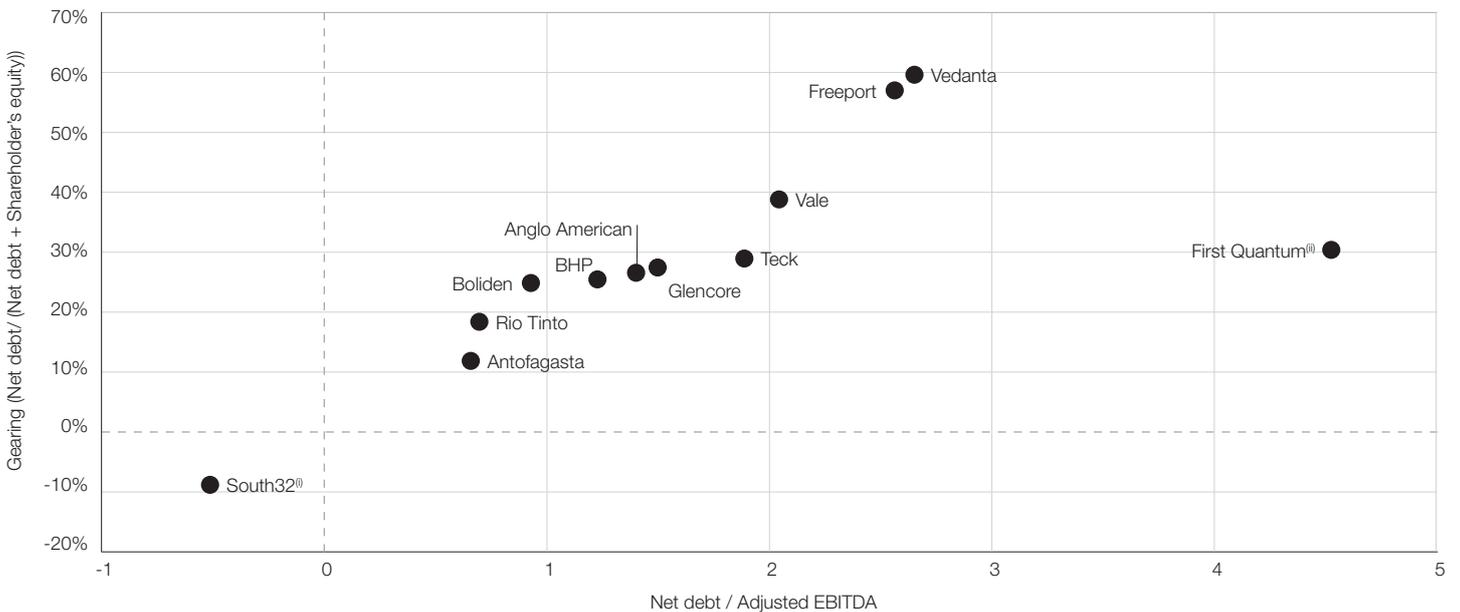
(i) South32: CAGR 2014-2016
 Source: CDP, company reports

Figure 33: Sustaining CAPEX intensity



Source: CDP, company reports

Figure 34: Capital flexibility



(i) South32 currently cash positive

(ii) First Quantum Minerals – Net debt / EBITDA ratio expected to reduce to 3.25 in 2019 in line with Cobre Panama commissioning schedule (ramp-up scheduled for 2019)

Source: CDP, company reports

Figure 35: Innovation & Technology summary

Company	Innovation / technology rank	Comments
Rio Tinto	1	Mine of the Future™ program. Autonomous haulage systems (AHS), Mine Automation System (MAS), RTVis™ technologies (3D visualisatoin tool) - evaluate mine info in real time (now used at over 95% of open cut mines). Growth & Innovation group. Technology centres in Canada & Sydney. Analytics Excellence Centre to assess data.
Vale	1	Vale Institute of Technology (ITV). Mineral Development Centre (CDM). Ferrous Technology Center (FTC). Implementing truckless systems. Processing copper waste using bacteria. Natural humidity processing to reduce water consumption. Automation networks. Use of drones and simulators. Many new technologies are being implemented at the new S11D iron ore project.
Boliden	3	Mine Automation program. Early adopter of mine automation and first to install wireless networks, IP telephony and positioning within mine. Autonomous trucks, remote-controlled loaders. Use of drones to inspect mine faces safely. Leader in recycling at smelting plants.
Anglo American	4	FutureSmart Mining™ program. Advanced drilling and cutting systems - Rapid Mine Development System. Object detection and auto-braking system for trucks. Mineralisation of kimberlite to store carbon. Advancing evaporation measurement. Member of Hydrogen council - advancing hydrogen fuel cell technology.
BHP	5	Global technology team - expanding function and integrating IT and operational technology. Trialing driverless trucks. Using sensors for predictive maintenance. Online shipping auction platform. CC(US) research.
South32	5	Technology roadmap - partnering with General Electric to roll-out Internet of Things platform Predix - allowing connection of industrial equipment, real-time data analysis, predictive maintenance and optimisation of operations. Intelligent land mangement (ILM) - transforming land holdings to increase climate resilience and protect biodiversity.
Teck	5	Technology Group. Product Technology Centre (PTC). Applied Research and Technology (ART). CESL - development of hydrometallurgical technology. Use of surveillance technology such as GPS, piezometers, inclinometers and remote sensing. Replacing diesel in haul trucks with LNG to reduce emissions.
Glencore	8	Glencore Technology subsidiary. Develops technology for mineral processing, refining and smelting e.g. ISASMELT™ which is a clean and cost effective lance smelting process, and IsaMil™ which is highly energy efficient large scale grinding technology.
Antofagasta	9	Leader in utilization of seawater / desalination e.g. Esperanza mine. Collision Alert Systems in mining trucks. Thickened tailings technology used at Centinela mine - greater water efficiency & stability and better dust control. Looking to increase use of renewable energy sources in operations.
Vedanta Resources	10	Innovation Task Force chaired by CEO aims to drive down production costs using disruptive technologies. HZL Research & Development lab exploring mine waste minimisation. 'Eureka' in-house web platform to encourage innovation and technology development.
Freeport-McMoRan	11	Utility demand side efficiency programs. Climax Technology Center - advanced technologies for molybdenum. Use of drones to monitor and evaluate rock face. Collaboration with universities to improve biodiversity with copper flora conservation activities.
First Quantum Minerals	12	No significant data found

Source: CDP, company reports

Figure 36: Research and development expense as a proportion of sales

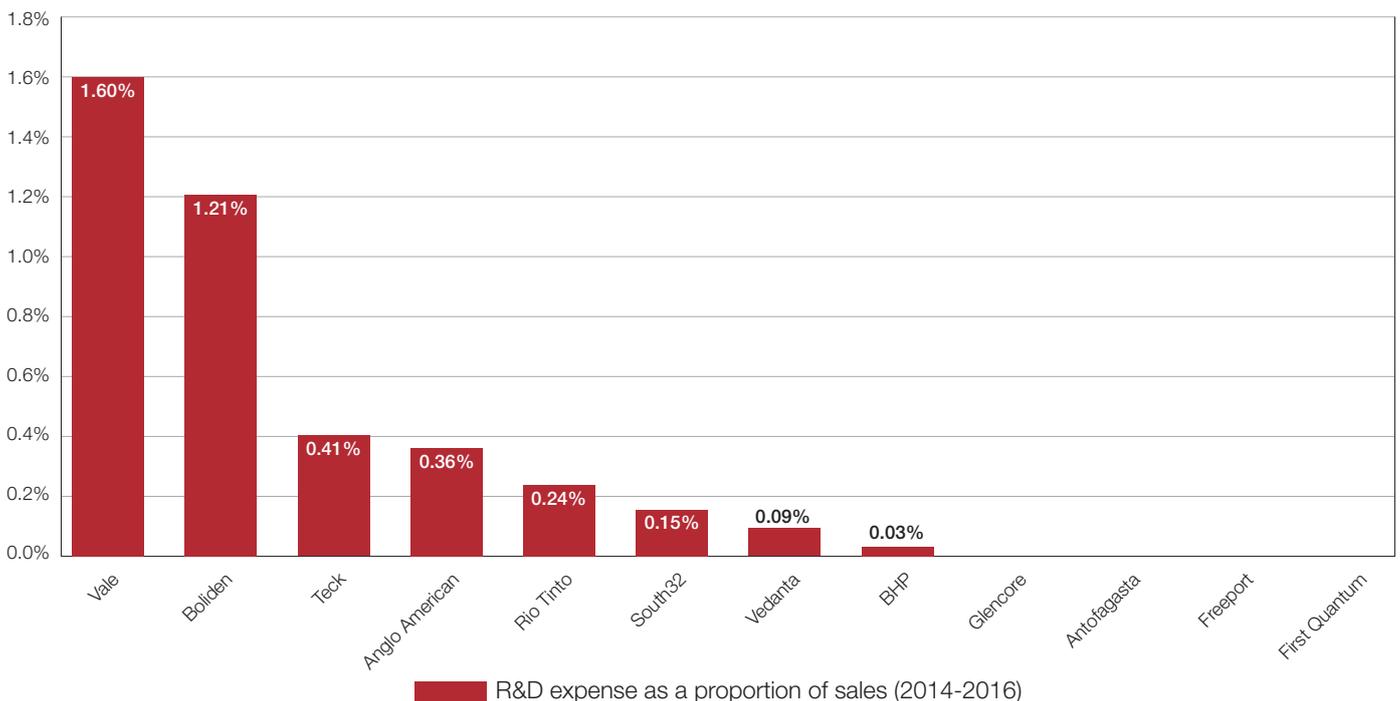
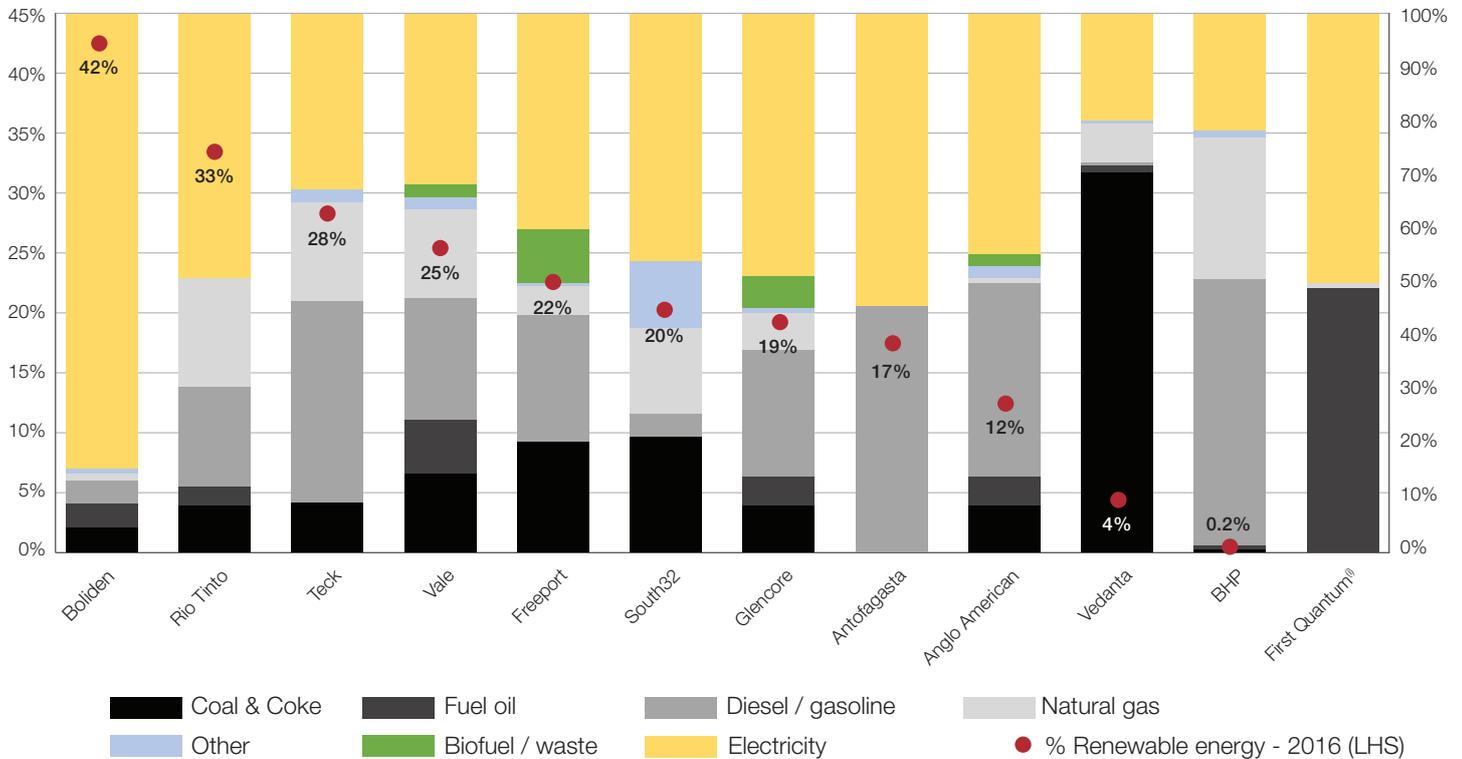


Figure 37: Energy consumption split by resource type (2016)



(i) First Quantum Minerals: no data on renewable energy use
 Source: CDP, company reports

Mining the future

Disruptive technologies and digital innovations will transform the mining sector; enhancing productivity, safety, energy use and water use. Intelligent mines that are digitally connected allow for real-time monitoring, optimized logistical efficiency and predictive maintenance. Improved data analysis and modelling can advance understanding of the resource base and increased automation can improve safety and reduce operating costs.

Historically miners have lagged behind other extractive industries in application of technology and overall equipment effectiveness³⁸. However, miners are beginning to focus more attention on innovative technologies and there is broad consensus that innovation will play a crucial role in driving future productivity gains and sustainable growth³⁹.

Energy requirements represent a significant proportion of a company's operating costs (we estimate this to be up to 30% for our sample of companies). As the global energy mix evolves miners should look to take advantage of advancing technologies to reduce their energy costs and reliance on fossil fuels – costs for renewables and battery storage have significantly decreased since 2010 and are forecast to fall further⁴⁰.

Solar and wind power underpinned by localized battery storage can provide off-grid solutions for inaccessible regions where grid supply can be unreliable. New engine technology enables fuel substitution (replacing diesel with alternative fuels such as LNG) and demand response will allow miners to optimize their energy use.

38. McKinsey list average overall equipment effectiveness (OEE) at 27% for underground mining, 39% for open-pit mining, and 69% for crushing and grinding – compared to 88% for upstream oil and gas, 90% for steel, and 92% for oil refining.

39. Innovation in Mining series, Deloitte

40. IRENA forecast LCOE to reduce a further 59% for solar PV and 26% for onshore wind by 2025. BNEF forecast the cost of Li-ion batteries to reduce a further 73% by 2030.

Climate governance & strategy

- 2016 'Aiming for A' shareholder resolutions filed at three mining companies have increased focus on climate governance in the sector ahead of roll-out of TCFD recommendations.
- South32 ranks highest and is only company featured to have a target to reach net zero operational emissions by 2050.

Overview

The shift to a low-carbon world presents the question of what role mining companies, as raw material suppliers, will play in a transition and the nature of their strategic options. There is a growing trend of companies being asked to stress test their portfolios against scenarios underpinned by stricter climate action in line with the 'Aiming for A' shareholder resolutions that passed in 2016 with strong support at Rio Tinto, Anglo American and Glencore.

The G20 Financial Stability Board's Task Force on Climate-related Financial Disclosures has recently published its final recommendations, which could become the basis for nationally recommended or even

mandated disclosures on climate risk and opportunity assessment going forward. There is also a growing awareness of the need for all sectors to put in place climate risk management strategies and disclose to investors and stakeholders in greater detail than ever before.

Scenario testing remains at an early stage but given the high impact nature of this sector investors need to scrutinize any scenarios put forward that simply validate current strategic positioning rather than are structured to meet ambitious climate targets. This is particularly important in sectors that have large capital commitments and long lead time projects and assets.

Figure 38: Climate governance and strategy summary

Company	Carbon regulation supportiveness	Emissions reduction targets	Emissions verification	Climate-related remuneration	Use of internal carbon price	CDP Score (2016) ⁽ⁱ⁾	Overall weighted rank	Climate governance & strategy rank	Climate governance & strategy grade
South32	1	5	2	1	5	B	2.8	1	A
BHP	6	5	2	5	2	B	4.5	2	B
Teck	1	4	11	8	3	B	4.8	3	B
Antofagasta	3	10	5	1	10	B	5.5	4	C
Vedanta Resources	5	2	10	5	8	C	5.6	5	C
Glencore	9	3	8	5	1	B	5.8	6	C
Boliden	6	5	7	8	5	A-	5.9	7	C
Rio Tinto	10	1	6	8	5	B	6.2	8	C
Anglo American	11	8	4	1	4	B	6.6	9	D
Freeport-McMoRan	8	10	1	1	10	C	6.8	10	D
Vale	4	9	9	8	8	A-	6.9	11	D
First Quantum Minerals	12	10	12	8	10	B-	10.4	12	E
Weighting	30%	25%	15%	15%	10%	5%			

(i) CDP score for 2016 disclosure cycle. 2017 disclosure cycle has not yet been scored.

Note: In calculating the weighted rank in this table, we use the weighted ranks for each area (where relevant).

We display non-weighted ranks in this summary for simplicity only

Source: CDP

41. InfluenceMap is a UK-based not-for-profit whose remit is to map, analyze and score the extent to which corporations are influencing climate policy and legislation. They score companies in two ways: i) Organizational score: represents the stance a company takes in influencing climate policy and legislation as well as its transparency of positions on key climate issues, and ii) Relationship score: represents the strength of a company's relationships with trade bodies or other entities and its ability to influence climate policy and legislation. The two scores for each company are combined to produce a total score which ranges from 0 (complete opposition to carbon regulation) to 100 (fully supportive of carbon regulation) with 50 representing a relatively neutral stance. See <http://www.influencemap.org> for additional details.

In this section, we assess how companies are planning for a low-carbon future through aligning their strategy with the associated risks and opportunities presented by the transition. We rank companies on their climate governance and strategy using the following key metrics:

- ▼ **Metric 1) Carbon regulation supportiveness:** We use InfluenceMap analysis to assess companies on their stance on climate change and how they seek to influence climate policy and legislation, either directly or through trade bodies⁴¹.
- ▼ **Metric 2) Emissions reduction targets:** We assess the coverage and strength of each company's operational carbon emissions reduction targets.
- ▼ **Metric 3) Emissions verification:** We form a scorecard that assesses the companies' emissions accounting procedures. This includes: level of third party verification and assurance, scope of verification and levels of uncertainty.
- ▼ **Metric 4) Climate-related remuneration:** This assesses the extent to which executive remuneration at companies is linked to climate-related metrics and indicators.
- ▼ **Metric 5) Use of an internal carbon price:** This metric is used to identify the extent to which internal carbon prices, as a proxy for climate regulatory action, are incorporated into future capital expenditure plans and other key business decisions.
- ▼ **Metric 6) CDP Score:** The 2016 CDP Score (previously also known as CDP Performance Band) provides an aggregate measure of quality of climate-related disclosure and management systems addressing climate risks.

Highlights

- ▼ South32 is the only company in our sample to have a target to fully decarbonize its own operations by 2050, i.e. zero net company emissions. It aims to achieve this through wholesale decarbonization of its energy supply, land use management and the purchasing carbon offsets.
- ▼ Nine of the 12 companies featured currently have operational emissions reduction targets – an improvement from two years ago. Four reduce emissions from a base year, three keep absolute emissions flat and two are reductions based on 'business as usual' trajectories.
- ▼ Mining trade associations such as the World Coal Association and Minerals Council of Australia, acting on behalf of companies such as BHP, Rio Tinto, Glencore and Anglo American, remain active in lobbying for greater coal use.

- ▼ BHP and Rio Tinto are identified as the two most active companies in carbon regulation lobbying (InfluenceMap's 'engagement intensity'), with a focus on Australian policies.
- ▼ The incoming carbon emissions tax in South Africa highlights different approaches taken by companies – South32 has taken a supportive stance on the policy whereas Anglo American has not.
- ▼ Seven of the 12 companies use an internal carbon price in company capital planning, product demand scenario testing and regulatory cost accounting. Price levels disclosed by companies vary from around US\$10/t CO₂ up to US\$140/t CO₂ (the price level cited in the IEA 450ppm Scenario).
- ▼ Antofagasta does not anticipate using internal carbon prices despite an indirect price on electricity generation emissions coming into force in Chile in 2017. Teck has supported plans for carbon pricing in Canada despite suggesting in its 2017 CDP response that certain carbon pricing assumptions could cost its operations up to CAD100m annually by 2022.
- ▼ BHP released its first climate resilience scenario test for investors in 2015, quantifying the financial impacts of different climate-constrained scenarios on its business.
- ▼ Miners' central (expected) case scenarios tend to translate to delayed climate action and support current company portfolio positions. This raises the risk of not accounting for any accelerated pace in carbon regulation, technology or demand changes, or manifestation of the physical impacts from climate change.
- ▼ The focus on scenario-based resilience testing for mining companies has gathered momentum in last two years on the back of 'Aiming for A' shareholder resolutions and the release of the TCFD recommendations (see page 32 for further discussion).
- ▼ Glencore's most recent climate reporting to investors re-asserts its bullish position on thermal seaborne coal market forecasts; at odds with IEA scenarios that are in line with country NDCs (see box on page 35) and recent data releases on the drastic slowdown of coal plant construction⁴² and falling global coal consumption⁴³.
- ▼ Evidence of executive pay link to operational emissions performance at seven of the 12 companies; however, it typically accounts for 5% or less of total reward packages.
- ▼ First Quantum is the only company to not to externally verify its emissions.

42. Boom and Bust 2017, TRACKING THE GLOBAL COAL PLANT PIPELINE

43. BP Statistical Review, 2017

Miners are still 'Aiming for A'

Shareholder resolutions filed at the 2016 AGMs of three of the miners featured in this report received management support and high levels of voting approval (98% Glencore, 96% Anglo American and 99% Rio Tinto). The resolutions had five key asks for companies to report to shareholders concerning strategic climate risk assessment and action. BHP produced its own portfolio climate resilience assessment in 2015 and therefore avoided a shareholder resolution filing.

The 'Aiming for A' Strategic Resilience for 2035 and Beyond resolution asks were:

- ▼ operational emissions management;
- ▼ asset portfolio resilience to the IEA's scenarios;
- ▼ low-carbon R&D and investment strategies;
- ▼ relevant strategic KPIs and for executive incentives;
- ▼ public policy positions to climate change.

We have assessed all the companies featured in this report on several of these topics during this section; however, we focus on four companies below that were subject to shareholder engagement on the issues. We summarise below what three of these companies have communicated back to shareholders as part of their annual reporting in 2016 and 2017:

Figure 39: Company progress on 2016 shareholder resolutions

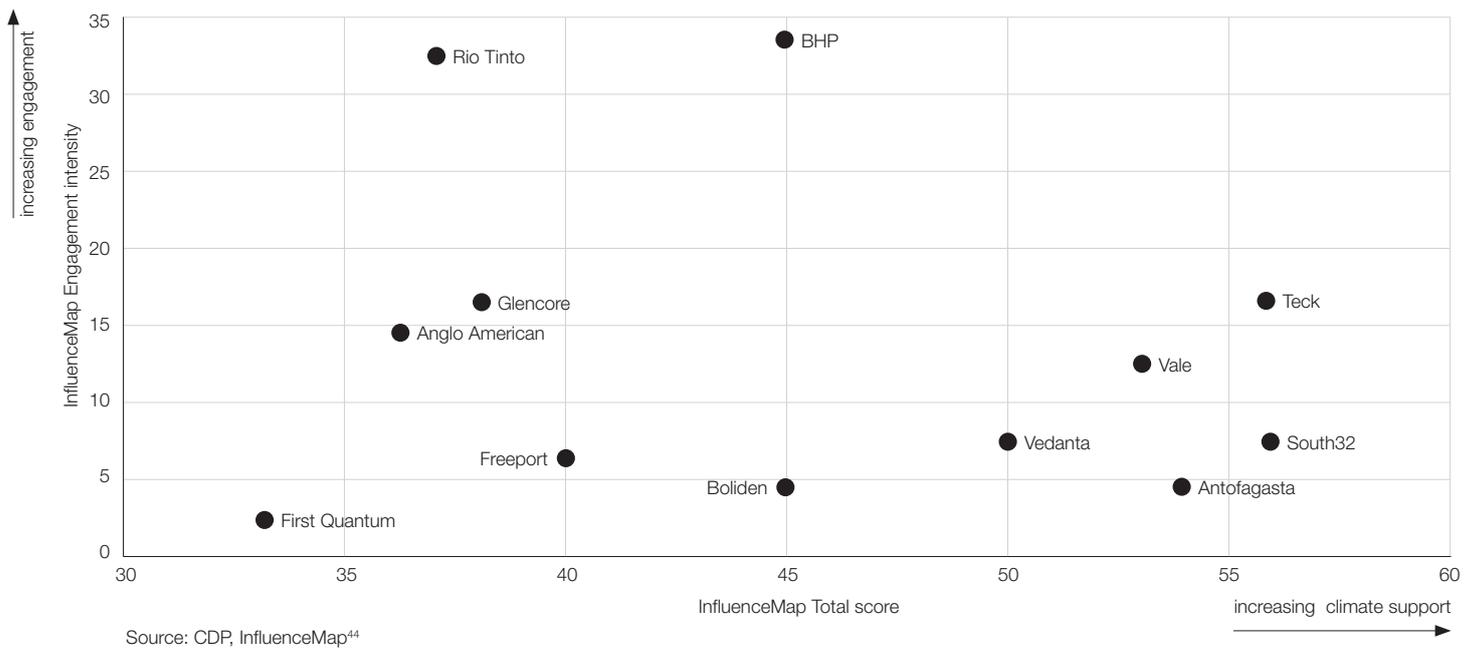
Company	Climate publications	Operational CO ₂ targets	Portfolio resilience assessment	Low-carbon R&D	Climate KPIs in remuneration	Public policy position
BHP	2015, 2016	Flat absolute emissions until 2017.	Four scenarios, outcomes for commodity groups and estimated impact on company EBITDA.	Refer to metric 4 of Transition Opportunities.	Yes, within Health, Safety, Environment and Community.	Refer to metric 1 of this section.
Rio Tinto	2017	Emissions intensity reduction target out to 2020.	Three scenarios – Limited action, Regional Differences and Co-operative outcomes. Description of scenarios only in 2017 climate report.	Refer to metric 4 of Transition Opportunities.	No.	Refer to metric 1 of this section.
Anglo American	2017	Existing 22% absolute emissions target based relative to BAU emissions by 2020.	Description of expected quantitative scenarios work to be published in 2018.	Refer to metric 4 of Transition Opportunities.	CEO's bonus is linked to achieving emissions target early.	Refer to metric 1 of this section.
Glencore	2016, 2017	New group-wide 5% emissions intensity target by 2020.	Three scenarios – Delayed, Committed and Ambitious action. Indicative directional impacts on commodities disclosed.	Refer to metric 4 of Transition Opportunities.	Carbon related compensation KPIs set at asset level.	Refer to metric 1 of this section.

All four companies have operational emissions reductions targets and three have incorporated emissions-related KPIs into executive remuneration. Rio Tinto and Anglo American rank well in our assessment of investment in innovative technology and InfluenceMap's ranking earlier in this section highlights the public policy actions of the companies.

Only BHP produces a financial impact assessment of two of its scenarios – 'Global Accord' and 'Shock' – which indicate an approximately 5-10 and 25-30 percentage point decrease in expected base case EBITDA by 2030 (BHP base case EBITDA in 2030 is more than double its 2016 level). Anglo American provides qualitative insights on demand levels of copper and platinum in future carbon-constrained futures. Glencore provides directional indications of potential commodity demand levels movement (+ / -) according to certain scenarios. The company's assessment of its seaborne thermal coal business in its climate resilience reporting is consistent with its bullish assertion on the commodity's future, contrary to the IEA 450ppm scenario. Rio Tinto produced a largely descriptive narrative of scenarios in 2017 that they intend to model quantitatively in future for the benefit of investors.

Based on current climate reports, investors are not able to judge how companies are placed against a two degree target and will have to wait for future reports for a more comprehensive and standardised approach to risk assessment of asset portfolios and the financial implications. In 2016 the three companies subject to resolutions all scored 'B' in their respective 2016 CDP scores and, are therefore, still 'Aiming for A'.

Figure 40: Carbon regulation supportiveness



Source: CDP, InfluenceMap⁴⁴

Figure 41: Emissions reduction targets

Company	Intensity or absolute emissions reduction target	% emissions scope covered	Target year	Target reduction CAGR	Reduction on Business-as-Usual trajectory	Rank
Rio Tinto	Intensity	95%	2020	-2.3%	N	1
Vedanta	Intensity	100%	2020	-2.2%	N	2
Glencore	Intensity	100%	2020	-1.3%	N	3
Teck Resources	Absolute	100%	2030	-0.4%	N	4
BHP	Absolute	100%	2017	0.0%	N	5
Boliden	Intensity	100%	2018	0.0%	N	5
South 32	Absolute	100%	2021	0.0%	N	5
Anglo American	Absolute	100%	2020	-4.8%	Y	8
Vale	Absolute	100%	2020	-0.6%	Y	9
Antofagasta	None	0	N/A	0	N/A	10
First Quantum Minerals	None	0	N/A	0	N/A	10
Freeport-McMoRan	None	0	N/A	0	N/A	10

Source: CDP

Figure 42: Emissions verification

Company	Rank	Total score	Scope 1 verification	Scope 1 assurance type	Proportion of scope 1 verified	Uncertainty scope 1 verified	Scope 2 verification	Scope 2 assurance type	Proportion of scope 2 verified	Uncertainty scope 2 verified
Freeport-McMoRan	1	17.6	Complete	Reasonable	100%	0-2%	Complete	Reasonable	100%	0-2%
BHP	2	17.1	Complete	Reasonable	100%	2-5%	Complete	Reasonable	100%	2-5%
South32	2	17.1	Complete	Reasonable	100%	2-5%	Complete	Reasonable	100%	2-5%
Anglo American	4	15.5	Complete	Limited	100%	2-5%	Complete	Reasonable	100%	0-2%
Antofagasta	5	15.2	Complete	Reasonable	85%	2-5%	Complete	Reasonable	94%	2-5%
Rio Tinto	6	13.7	Complete	Limited	100%	0-2%	Complete	Limited	100%	0-2%
Boliden	7	13.5	Complete	Limited	100%	2-5%	Complete	Limited	100%	0-2%
Glencore	8	13.3	Complete	Limited	100%	2-5%	Complete	Limited	100%	2-5%
Vale	9	13.2	Complete	Limited	100%	5-10%	Complete	Limited	100%	2-5%
Vedanta Resources	10	13.0	Complete	Limited	100%	5-10%	Complete	Limited	100%	2-5%
Teck	11	12.5	Complete	Limited	100%	10-20%	Complete	Limited	100%	0-2%
First Quantum Minerals	12	0.0	None			5-10%	None			5-10%

Source: CDP

44. The 'engagement intensity' is a metric of the extent to which the company is engaging on climate change policy matters, whether positively or negatively. A low score indicates low levels of engagement with a higher score showing greater engagement with climate policies.

Figure 43: Climate-related remuneration

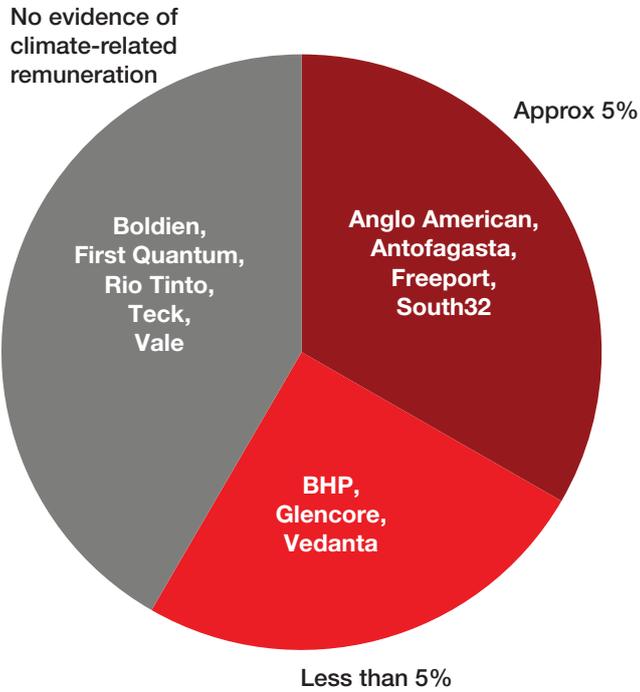
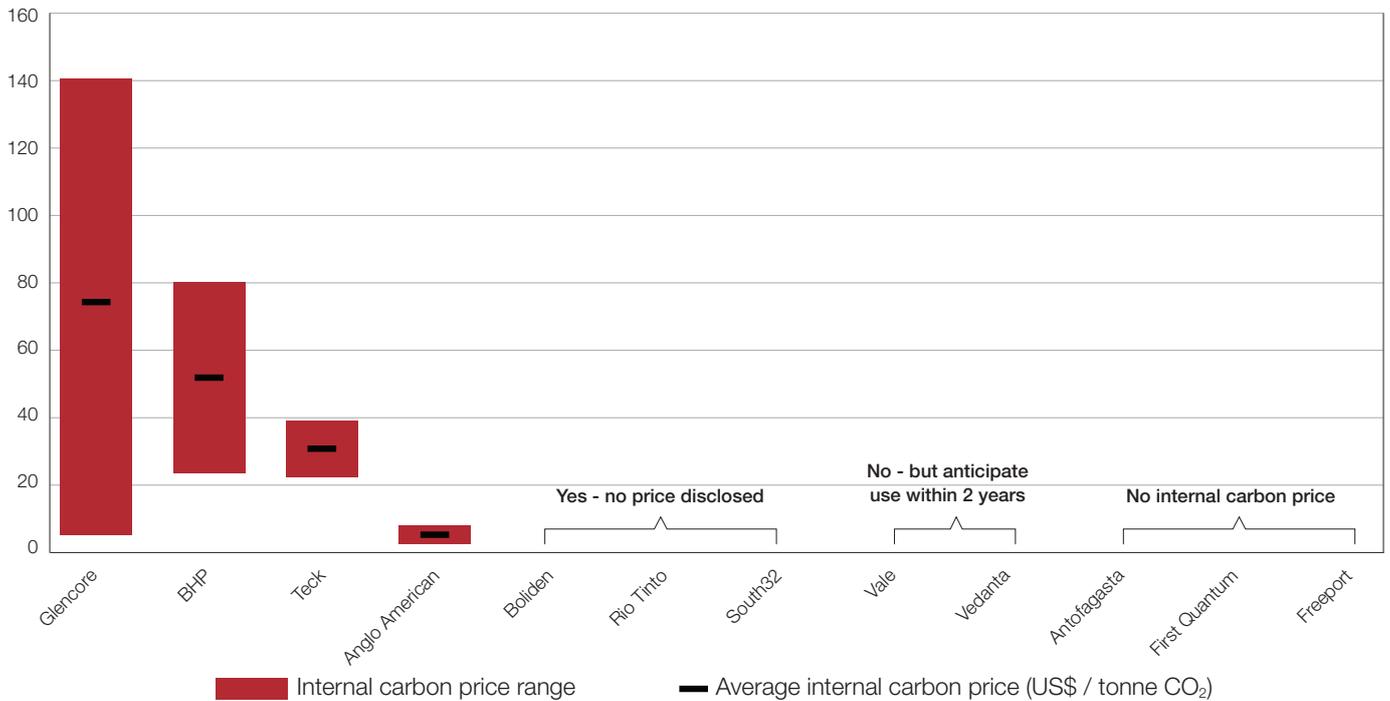


Figure 44: Use of an internal carbon price



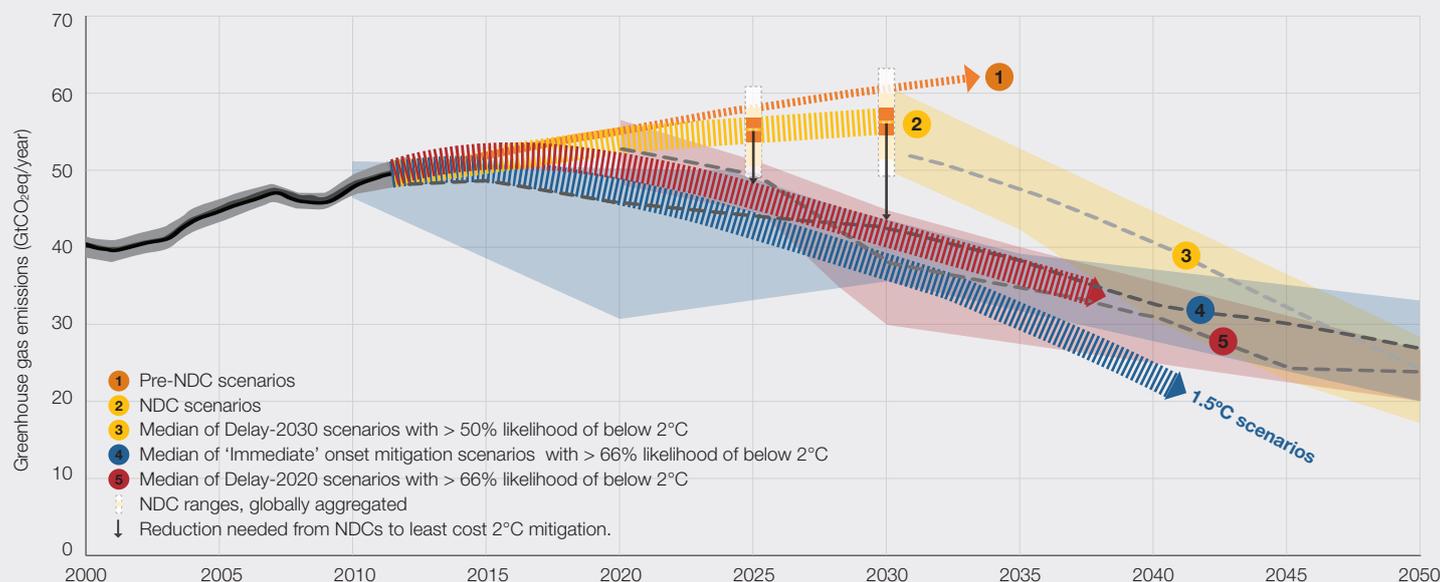
Source: CDP, company reports

Implications of NDCs for the mining sector

Leading up to and following the Paris climate change agreement, countries key to the commodities sector such as India and China have submitted Nationally Determined Contributions (NDCs) to the United National Framework Convention on Climate Change (UNFCCC).

NDCs are voluntary agreements by countries setting out what post-2020 climate actions they intend to take to contribute to global emission targets based on national priorities, capabilities and responsibilities⁴⁵. While these agreements are not legally binding, they point to ambitions at the country level to meeting climate change targets to 2030 and are subject to review every five years – NDCs submitted to date currently fall short of meeting the 2°C target set by the Paris Agreement. This implies a requirement for more ambitious CO₂ emission reductions in NDCs going forward based on science based carbon constraints.

Figure 45: Projected emissions profiles NDCs vs. 2 degrees



Source: UNFCCC synthesis of INDCs, IPCC AR5 scenario database

Importantly, most scenarios that look at meeting the 2°C post 2030, include a rapid decline in CO₂ emissions from the energy and industry-related sectors⁴⁶. A number of these scenarios incorporate a wider deployment of Carbon Capture and Storage (CCS) than is likely given the current pace of development and deployment of the technology – this may give a false sense of how much fossil fuel power generation and industrial emissions from fossil fuel sources can realistically be incorporated in scenarios looking to deliver a 2°C target.

Therefore, while current NDCs from countries such as China and India may not have a clear read across to demand for thermal coal in power generation and metallurgical coal in steel, the direction of travel and risks to long term capital projects committed particularly to thermal coal remain high. In the EU, where absolute emission cuts and stringent decarbonization pathways are being pursued, Europe’s 12 biggest utilities have written off more than €100bn of assets since 2010⁴⁷ highlighting the cost of transitioning to a low-carbon pathway.

Chinese commitment to peaking of emissions by 2030 and its recent rhetoric of providing leadership in climate change could be significant. This with the combination of health concerns as a result of severe air pollution, the slowdown in electricity demand growth as the economy matures (12% in 2011 to 4% in 2014) and the potential for overcapacity should the pace of investment in coal power generation continue, could act as real catalysts for a slow-down in Chinese appetite for thermal coal.

In India, plans to build mega high efficiency coal power plants requiring higher quality imported coal, are being shelved driven by the significant drive for solar power as prices for the latter have fallen considerably and are now in line with coal power prices. The water intensive nature of thermal coal power plants is another constraint for India which suffers from water stress and has competing demands for the resource from agriculture.

Below we table current NDC targets and policies in China and India. However, as outlined above a focus on submitted NDCs may prove a red herring for long term capital decisions and portfolio positioning.

Figure 46: Country NDC targets

Country	Target	Sectors impacted	Updates since Paris
India	2030 emissions intensity of GDP, down 35% from 2005.	Electricity, transport.	Cancelling of planned coal fired power plants.
China	Peak emissions by 2030, emissions intensity of GDP reduce 65% from 2005 levels by 2030.	Steel, heavy industry, electricity generation.	Consolidation in electricity sector, closing of coal mines.

Source: CDP

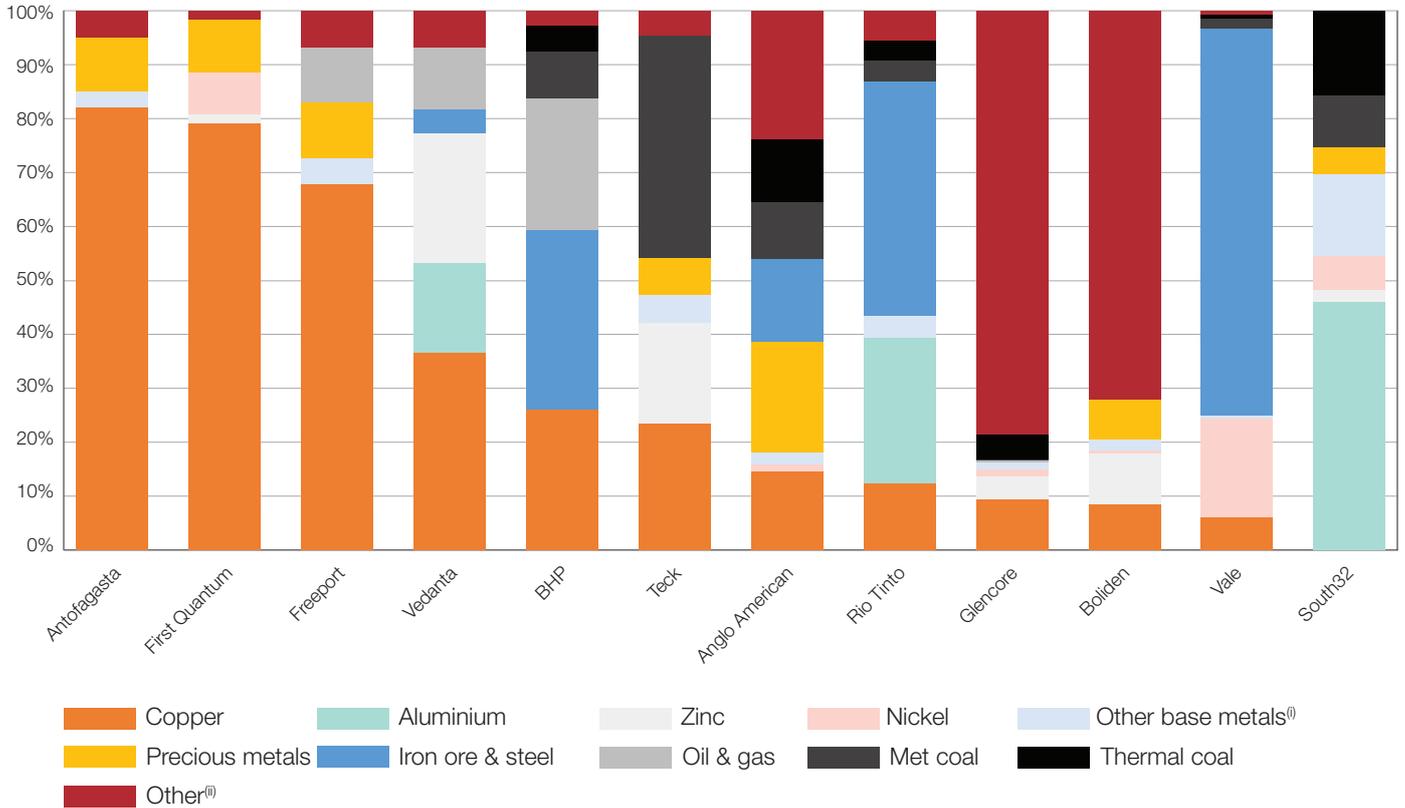
45. UNDP, 2015

46. Rogeij et al. Paris Agreement climate proposals need a boost to keep warming well below 2 degrees, 2016

47. FT: Jeffries, 28/06/2017

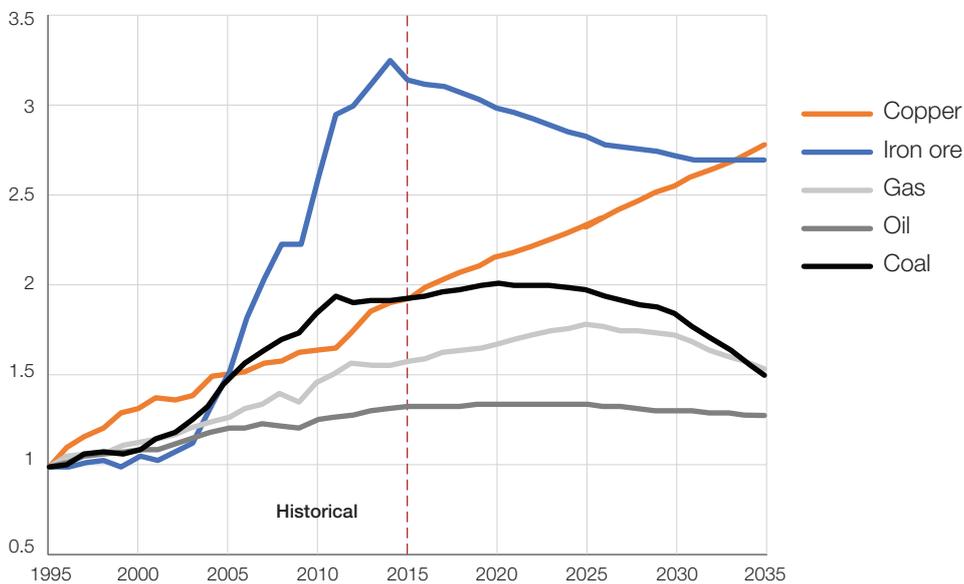
Supplementary figures

Figure 47: Revenue split by commodity (2015-2016)



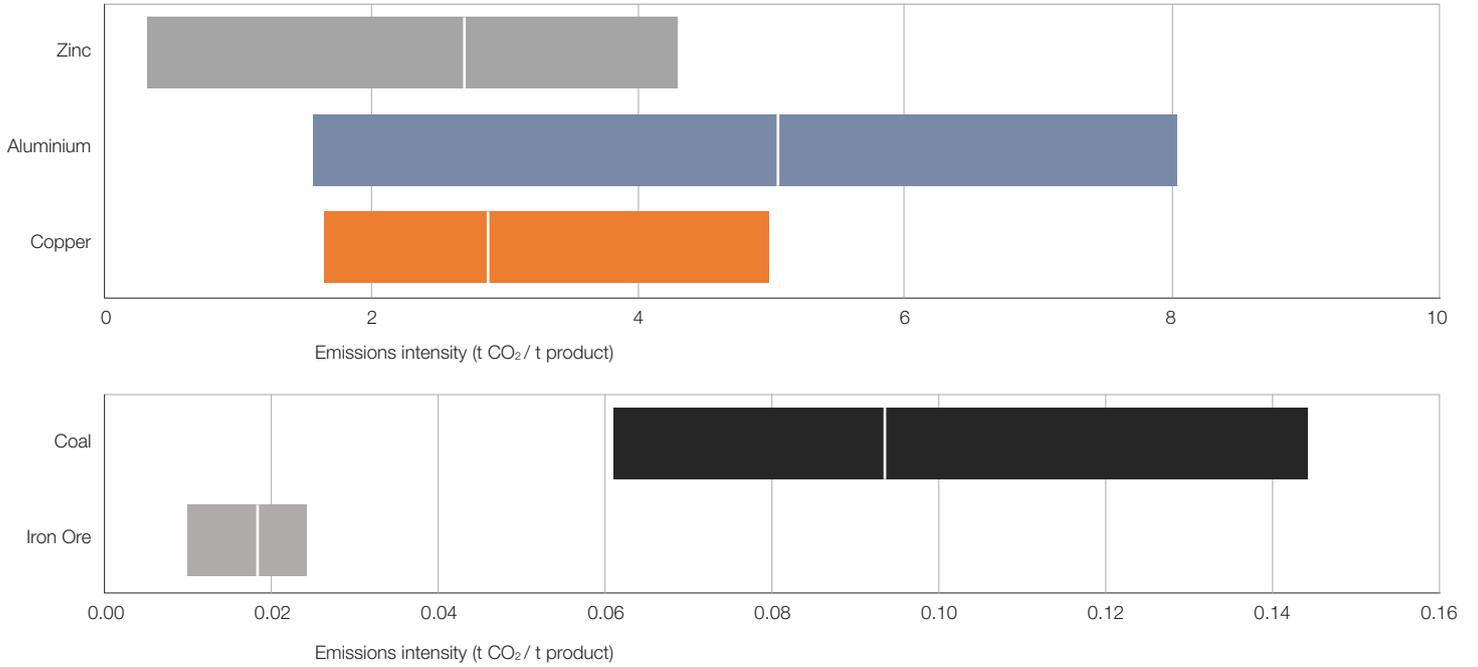
(i) 'Other base metals' includes lead, molybdenum, manganese, titanium, cobalt and vanadium.
 (ii) 'Other' includes agriculture and marketing for Glencore, smelting for Boliden and diamonds for Anglo American and Rio Tinto.
 Source: CDP, company reports

Figure 48: Demand growth for resources (indexed 1995):



Source: McKinsey – Beyond the Supercycle, February 2017. Projections based on accelerated technology scenario for oil, gas and coal. Moderate adoption scenario for iron ore and copper.

Figure 49: Scope 1+2 emissions intensity by commodity (average and range)



Source: CDP, company reports

Figure 50: Total company emissions split by geography

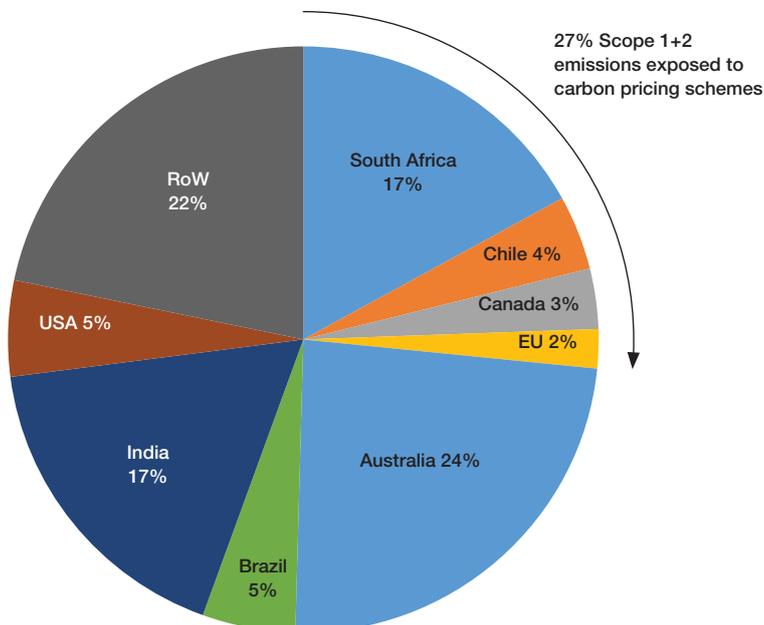
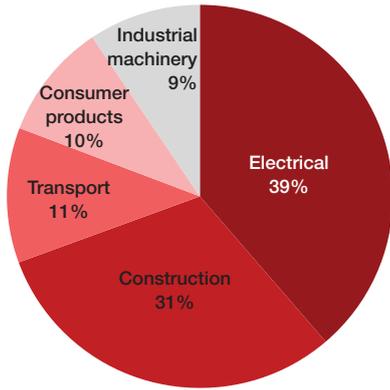


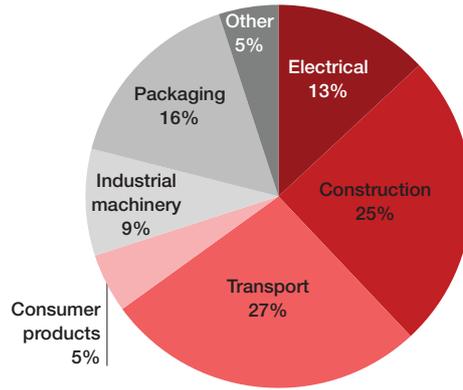
Figure 51: Global commodity consumption by sector

Copper⁽ⁱ⁾



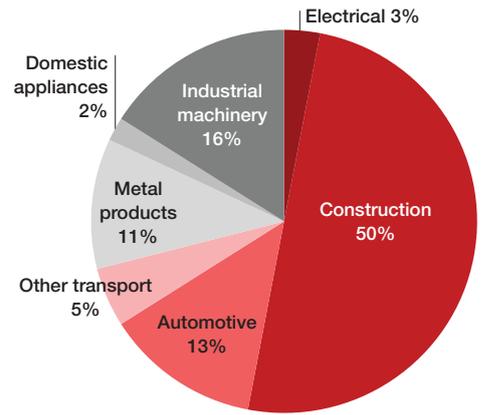
(i) 2015, GFMS Copper survey

Aluminium⁽ⁱⁱ⁾



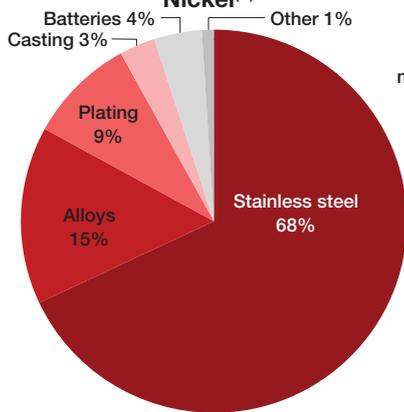
(ii) 2016, CRU

Steel⁽ⁱⁱⁱ⁾



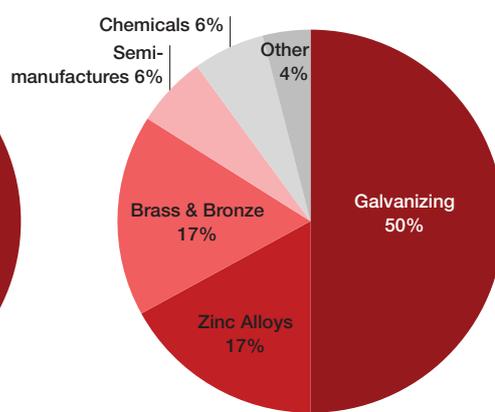
(iii) 2015, World Steel Association

Nickel^(iv)



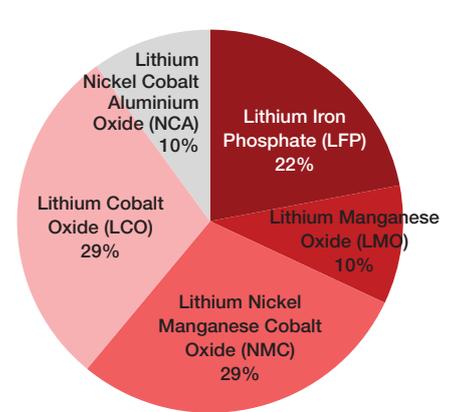
(iv) 2015, International Nickel study group

Zinc^(v)



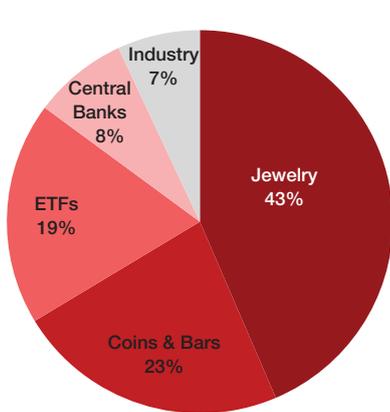
(v) 2014, International Zinc Association

Lithium Ion batteries^(vi)



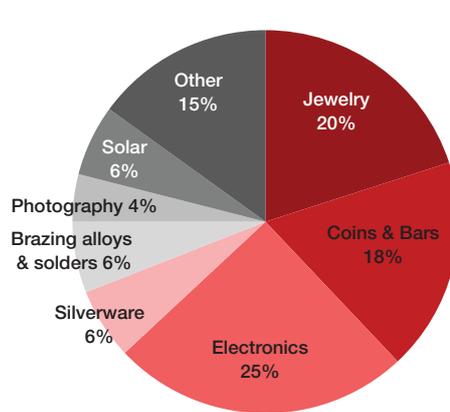
(vi) 2015, ResearchInChina

Gold^(vii)



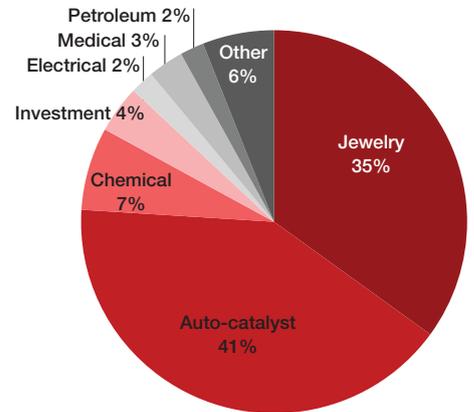
(vii) 2016, Credit Suisse

Silver^(viii)



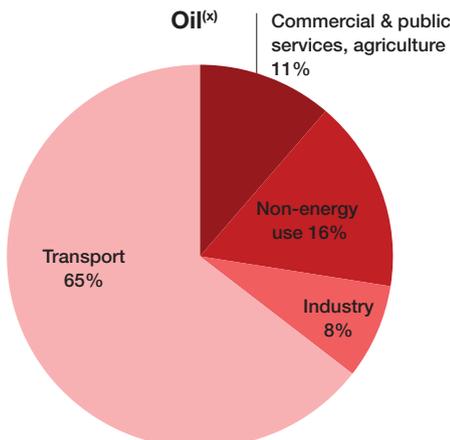
(viii) 2014, GFMS

Platinum^(ix)



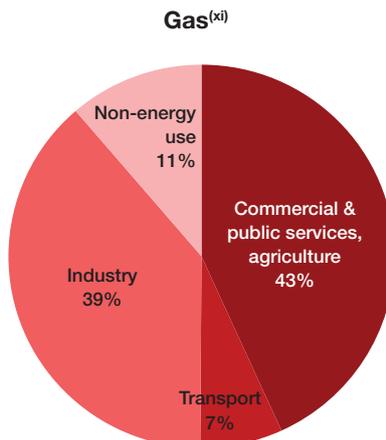
(ix) 2016, World Platinum Investment Council

Oil^(x)



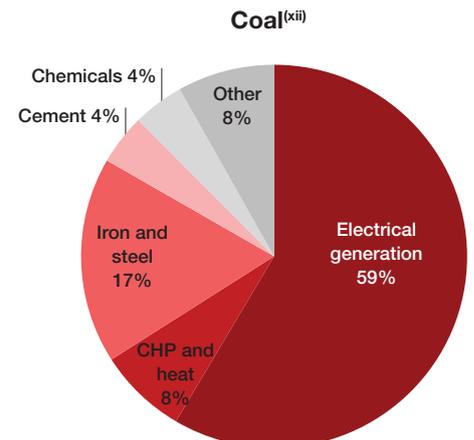
(x) 2014, IEA Key World energy statistics 2016

Gas^(xi)



(xi) 2014, IEA Key World energy statistics 2016

Coal^(xii)



(xii) 2014, IEA WEO 2016

Appendix I: Company engagement traffic light system

Company performance overview

League Table Rank	Companies	Country	Transition risks			Physical risks			Transition opportunities					Climate governance and strategy					Total								
			Emissions intensity	Energy intensity	Scope 3 emissions exposure	Production costs	EBITDA split	Physical risks rank	Asset exposure to water stress	Water withdrawal intensity	% water recycled and fresh water use	Water governance and policy	Transition opportunities rank	CAPEX split	CAPEX intensity	Capital flexibility	R&D / Innovation	Renewable energy	Climate governance and strategy rank	Carbon regulation supportness	Emissions reduction targets	Emissions verification	Climate-related remuneration	Use of internal carbon price	GDP score	Green	Amber
1	Vale	Brazil	3	1	6	1	4	3	5	6	8	6	9	1	4	11	4	9	9	4	8	8	8	1	8	9	3
2	Boliden	Sweden	4	4	1	2	4	2	12	2	4	4	9	3	7	7	6	5	7	8	5	5	1	9	7	4	
3	BHP	Australia/UK	1	2	11	4	1	6	3	7	9	1	5	7	2	2	6	5	2	5	2	8	3	9	8	3	
4	Rio Tinto	Australia/UK	2	4	7	9	9	10	10	1	5	5	2	3	2	8	10	1	6	8	5	5	6	9	6	5	
5	Glencore	Switzerland	10	3	8	7	5	7	2	4	3	4	7	8	6	6	9	3	8	5	1	6	6	5	11	4	
6	South32	Australia	7	10	9	6	6	3	4	11	12	12	1	6	1	1	1	5	2	1	5	5	6	6	10	4	
7	Antofagasta	UK	11	9	1	12	7	1	8	3	2	10	2	9	4	4	3	10	5	1	10	3	6	8	4	8	
8	Teck	Canada	6	6	10	8	3	4	9	12	11	11	8	5	3	3	1	4	11	8	3	3	6	4	10	6	
9	Anglo American	UK	9	8	12	7	7	4	1	9	10	5	6	4	10	9	11	8	4	1	4	4	3	4	13	3	
10	Freeport-McMoRan	USA	5	7	4	10	11	5	9	8	6	8	10	11	5	10	8	10	1	1	10	11	3	9	8		
11	First Quantum Minerals	Canada	7	11	1	5	8	12	7	5	1	7	10	12	n/a	12	12	10	12	8	10	6	3	7	10		
12	Vedanta Resources	UK	12	12	5	11	10	9	11	10	7	3	12	10	11	5	5	2	10	5	8	11	2	7	11		

Source: CDP

This heat map is designed to help investors pinpoint priority areas for engagement.

Green = good performance

Amber = monitor performance, possible concern

Red = area of concern, engage with company

We have not assigned a uniform number of green, amber and red across the metrics according to rank. Instead, we have reviewed the results of each metric in detail and assigned the above colours according to the underlying values for each metric.

Appendix II: Company summaries

Vedanta Resources

Country: UK

Market cap (LTM Q2 2017): US\$ 2.2 bn

2016 emissions: 53.3 mt CO₂ (Scope 1+2)

League Table rank	Transition risks	Physical risks	Transition opportunities	Climate governance & strategy
12 / 12	E	E	D	C

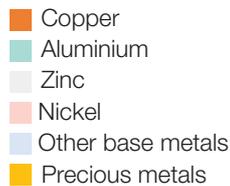
Company strengths

- Recently adopted a company-wide emissions reduction target to reduce emissions intensity by 16.3% by 2020 compared to 2012 base year through energy efficiency processes and greater use of renewables.
- Scope 3 emissions exposure is lower compared to sample companies that produce coal and iron ore.
- Portfolio is reasonably diversified across commodities. Copper, aluminium and zinc account for 66% of earnings and 74% of CAPEX. (However, 18% of CAPEX was spent on oil and gas projects.) The company has the lowest current sustaining CAPEX intensity (US\$78/ t Cu eq.).
- Vedanta appears to have emissions-related KPIs in its executive remuneration packages.

Company weaknesses

- It has both the highest emissions and energy intensity levels, both of which increased from 2010-2016. It has heavy coal use in mining, smelting and power operations, illustrated by energy consumption split shown below. Share of renewables is only 4%.
- Vedanta has one of the lowest water recycling rates and performs poorly relative to peers in water governance, despite producing a public water policy. Vedanta's mining operations in India are already exposed to high water stress risk.
- Unit production costs have remained relatively flat over 2013-2016 in comparison to aggressive cost cutting by other companies.
- Company's gearing is the highest (59%) among the sample, indicating less financial flexibility than peers and Vedanta has recently acquired Cairn India's oil & gas operations.

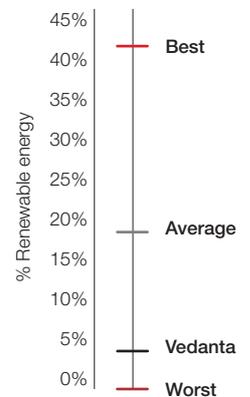
EBITDA 2015-2016



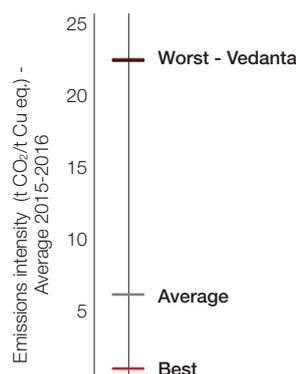
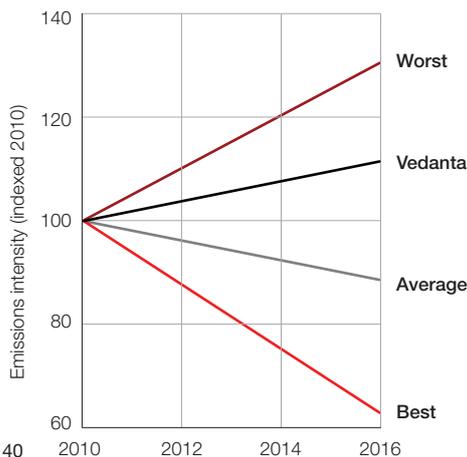
CAPEX 2015-2016



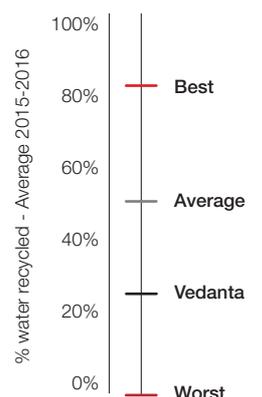
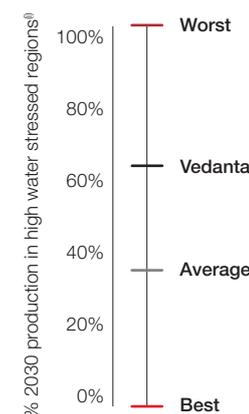
Energy consumption - 2016



Emissions intensity



Water resilience



(i) Baseline water stress in 2030 in high / extremely high / arid conditions and assuming current production levels.

First Quantum Minerals

Country: Canada

Market cap (LTM Q2 2017): US\$ 6.3 bn

2016 emissions: 1.4 mt CO₂ (Scope 1+2)

League Table rank	Transition risks	Physical risks	Transition opportunities	Climate governance & strategy
11 / 12	B	E	C	E

Company strengths

- Strategic positioning in copper a key strength for the company as earnings and capital spend is focused on a metal which will benefit from a low-carbon transition. However, portfolio lacks diversification.
- The company's exposure to large downstream Scope 3 emissions is very low as it does not produce coal or iron ore. It ranks joint 1st for the metric.
- First Quantum has the fourth lowest emissions intensity of production level.

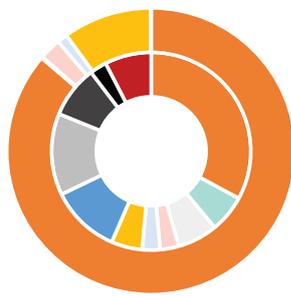
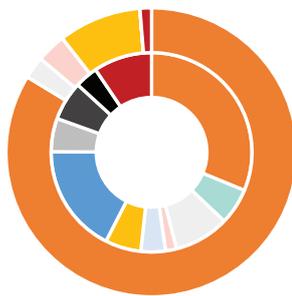
Company weaknesses

- Relatively high gearing (30%) and highest Net debt / EBITDA ratio among the companies of 4.5x. (However, this is expected to reduce to 3.25x by 2019 in line with the Cobre Panama commissioning schedule).
- Its emissions and energy intensity levels both increased over 2010-2016 and the company has no meaningful emissions reduction target.
- The company ranks second last for water resilience. It has one of the highest water withdrawal intensities, does not disclose a water recycling rate and uses a high proportion of fresh surface water.
- Ranks last for climate governance and strategy. InfluenceMap ranks the company last for carbon regulation supportiveness; the company does not link remuneration to climate targets.
- First Quantum ranks last for innovation, with no evidence of R&D or applications of new technologies to the business. The company does not disclose data on its renewable energy use and does not use an internal carbon price. It is also the only company not to externally verify its emissions.

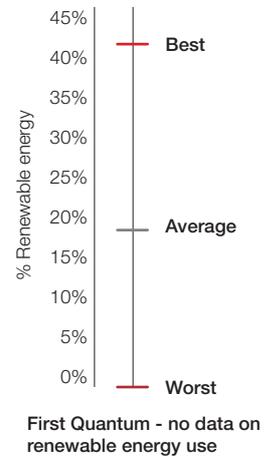
EBITDA 2015-2016

CAPEX 2015-2016

Energy consumption - 2016



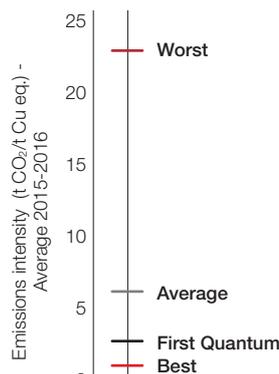
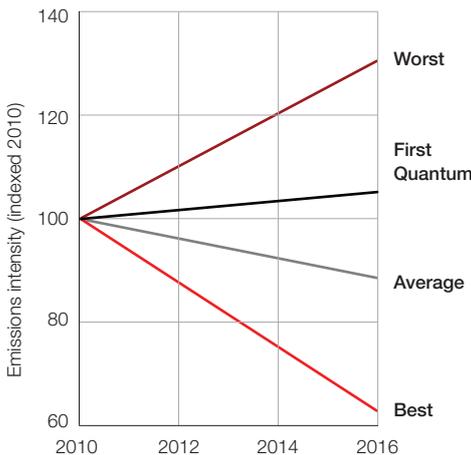
Outer circle:
First Quantum
Inner circle:
average for
12 companies



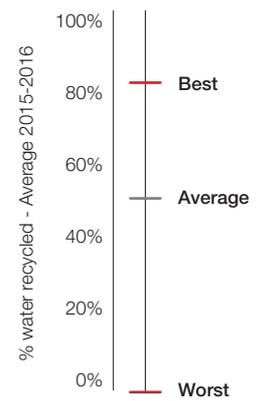
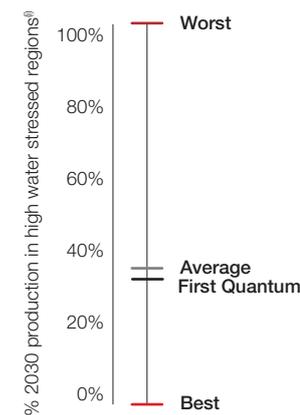
- Copper
- Aluminium
- Zinc
- Nickel
- Other base metals
- Precious metals
- Iron ore & steel
- Oil & gas
- Met coal
- Thermal coal
- Other

- Coal & coke
- Fuel oil
- Diesel / gasoline
- Natural gas
- Other
- Biofuel / waste
- Electricity

Emissions intensity



Water resilience



(i) Baseline water stress in 2030 in high / extremely high / arid conditions and assuming current production levels.

First Quantum - no data on water recycling

Freeport-McMoRan

Country: USA

Market cap (LTM Q2 2017): US\$ 16.1 bn

2016 emissions: 10.3 mt CO₂ (Scope 1+2)

League Table rank	Transition risks	Physical risks	Transition opportunities	Climate governance & strategy
10/ 12	C	D	D	D

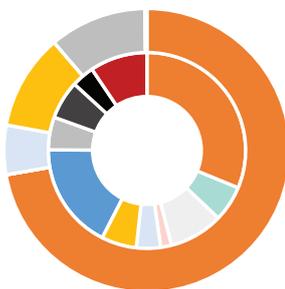
Company strengths

- Has earnings exposure to metals with positive demand outlook in a low-carbon transition, namely copper. Company strategy is re-focused towards copper business after completion of oil and gas asset sales in December 2016.
- Fourth largest reduction in emissions intensity; however, the company does not have an emissions reduction target and ranks 8th for current emissions intensity level.
- Scope 3 emissions exposure is lower compared to sample companies that produce coal and iron ore.
- The company has the third highest percentage of water recycled (80%) and sources 22% of its energy needs from renewables.

Company weaknesses

- Over 40% of CAPEX was spent on oil and gas projects across 2015-2016. However, the sale of its Deepwater GOM and onshore California oil and gas assets (86% of its oil and gas portfolio on a production basis) marks a significant shift in strategy.
- Unit production costs not reduced as fast as peers over 2013-2016 (CAGR of -4.6% compared to sample average of -10%)
- Water withdrawal intensity is high and has increased over time. By 2030, 78% of production is projected to be exposed to extremely high baseline water stress or arid conditions.
- Company gearing is the second highest (56%), indicating less financial flexibility than peers.
- Lags behind others in R&D and applications of new technologies.

EBITDA 2015-2016



- Copper
- Aluminium
- Zinc
- Nickel
- Other base metals
- Precious metals

CAPEX 2015-2016



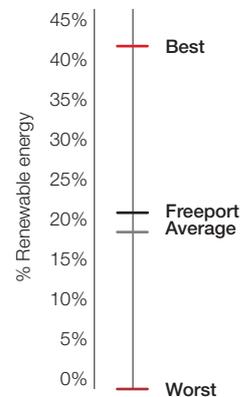
- Iron ore & steel
- Oil & gas
- Met coal
- Thermal coal
- Other

Energy consumption - 2016

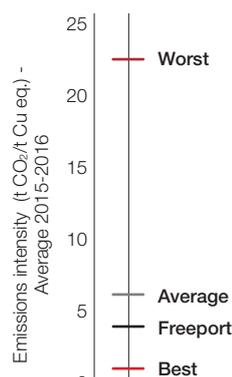
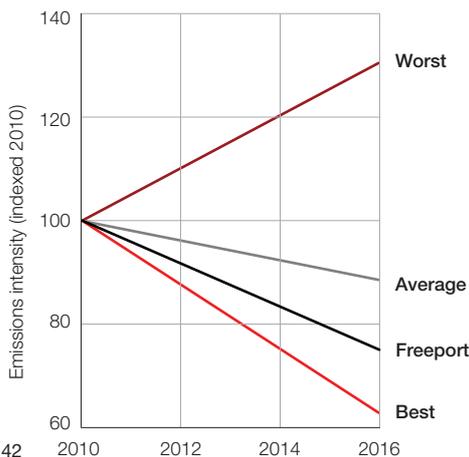


- Coal & coke
- Fuel oil
- Diesel / gasoline
- Natural gas
- Other
- Biofuel / waste
- Electricity

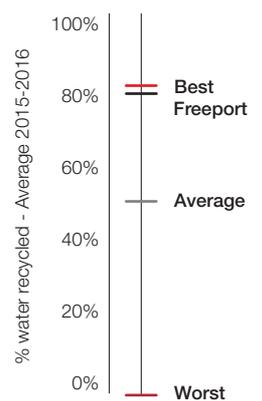
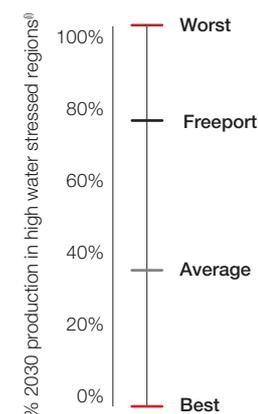
Outer circle: Freeport
Inner circle: average for 12 companies



Emissions intensity



Water resilience



(i) Baseline water stress in 2030 in high / extremely high / arid conditions and assuming current production levels.

Anglo American

Country: UK

Market cap (LTM Q2 2017): US\$ 16.0 bn

2016 emissions: 17.8 mt CO₂ (Scope 1+2)

League Table rank	Transition risks	Physical risks	Transition opportunities	Climate governance & strategy
9 / 12	E	B	D	D

Company strengths

- ▾ Ranks fourth on water resilience. It has a relatively high water recycling rate (65%) and the strongest water governance and policy.
- ▾ Its FutureSmart Mining™ program looks at applying innovative technologies across the business. Applications include advanced drilling and cuttings systems, automation of trucks and advanced evaporation measurement.
- ▾ Announced sale of thermal coal assets to Eskom will reduce exposure to the commodity.
- ▾ De Beers recently announced plans to be the world's first carbon neutral miner within five to 10 years. The diamond subsidiary is actively investigating the use of waste rock from mining to absorb carbon in the atmosphere through a process called mineral carbonation.
- ▾ Anglo American's CEO has emissions reduction linked KPI in his remuneration package.

Company weaknesses

- ▾ It has the highest estimated Scope 3 emissions intensity of production at 68 t CO₂/ t Cu eq.
- ▾ Anglo American has announced plans to sell thermal coal assets; however, total coal made up a quarter of earnings and CAPEX spend across 2015-2016.
- ▾ Reductions in both emissions and energy intensity have been weaker than the sample average and its emissions target is less ambitious than other companies.
- ▾ InfluenceMap cited the company's objection to the incoming South African carbon tax as a reason for its low ranking in carbon regulation supportiveness.

EBITDA 2015-2016

CAPEX 2015-2016

Energy consumption - 2016

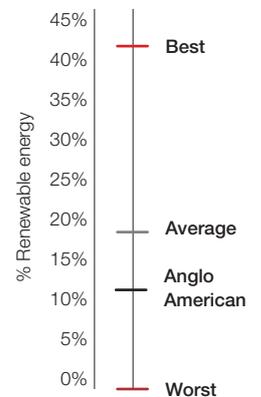


Outer circle:
Anglo American
Inner circle:
average for
12 companies

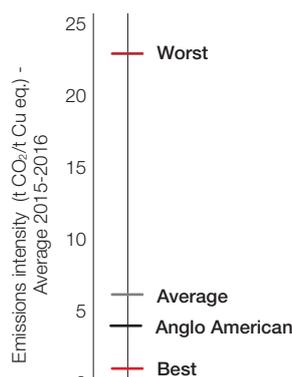
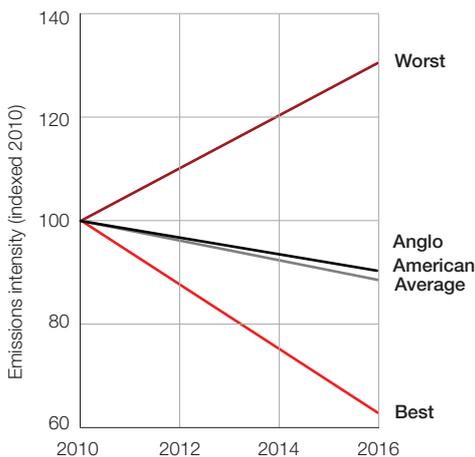


- Copper
- Aluminium
- Zinc
- Nickel
- Other base metals
- Precious metals
- Iron ore & steel
- Oil & gas
- Met coal
- Thermal coal
- Other

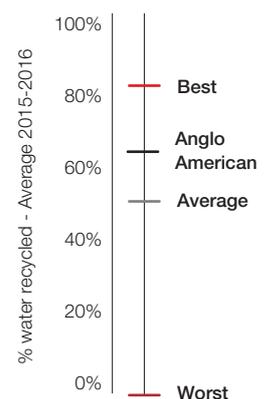
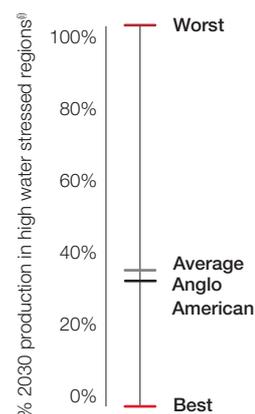
- Coal & coke
- Fuel oil
- Diesel / gasoline
- Natural gas
- Other
- Biofuel / waste
- Electricity



Emissions intensity



Water resilience



(i) Baseline water stress in 2030 in high / extremely high / arid conditions and assuming current production levels.

Teck

Country: Canada

Market cap (LTM Q2 2017): US\$ 10.8 bn

2016 emissions: 2.9 mt CO₂ (Scope 1+2)

League Table rank	Transition risks	Physical risks	Transition opportunities	Climate governance & strategy
8 / 12	D	B	E	B

Company strengths

- 28% of energy is from renewable sources, third highest within company sample. It has a renewable energy target to expand its renewable portfolio to 100MW of capacity by 2030.
- Ranks third on climate governance and strategy. InfluenceMap ranks the company joint first for carbon regulation supportiveness and it applies the third highest average internal carbon price.
- Reduced emissions and energy intensity over 2010-2016 faster than sample average.
- Teck has limited exposure to current water stress and future baseline water stress risk.

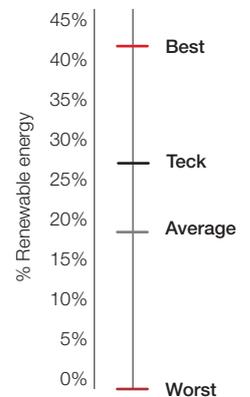
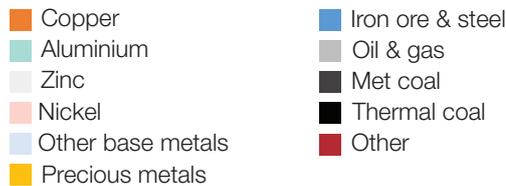
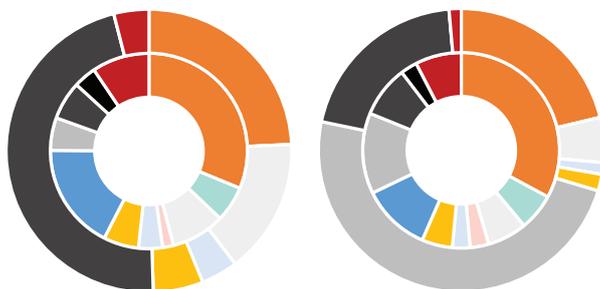
Company weaknesses

- Ranks last on transition opportunities. Approximately half of earnings are from coking coal and around 70% of its capital expenditure is allocated to fossil fuel development (50% to its Canadian oil sands projects, Fort Hills, which is due for start up in late 2017).
- The company had rigid capital expenditure commitments and cut total CAPEX intensity the least between 2013-2016. However, sustaining CAPEX intensity is the third lowest.
- The company has relatively high estimated Scope 3 emissions intensity, over 28 times higher than its Scope 1+2 emissions.
- Copper equivalent unit costs are the highest within the company sample and it has not reduced costs as fast as peers over 2013-2016.

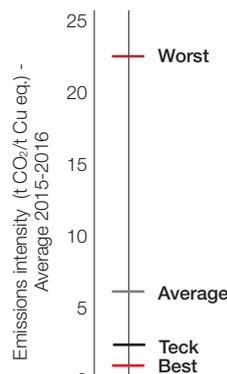
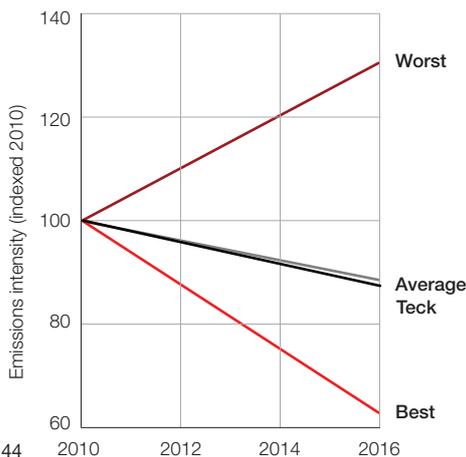
EBITDA 2015-2016

CAPEX 2015-2016

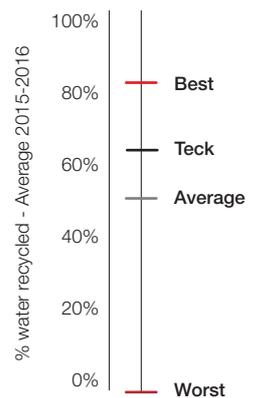
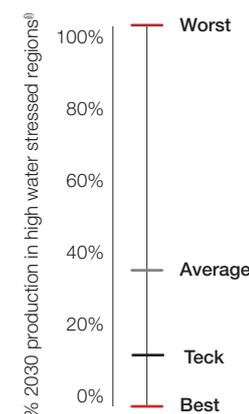
Energy consumption - 2016



Emissions intensity



Water resilience



(i) Baseline water stress in 2030 in high / extremely high / arid conditions and assuming current production levels.

Antofagasta

Country: UK

Market cap (LTM Q2 2017): US\$ 7.1 bn

2016 emissions: 2.8 mt CO₂ (Scope 1+2)

League Table rank	Transition risks	Physical risks	Transition opportunities	Climate governance & strategy
7 / 12	C	C	B	C

Company strengths

- ▼ Earnings exposure by commodity and capital spending is focused on copper which has a positive demand outlook in a low-carbon transition. However, portfolio lacks diversification.
- ▼ The company's exposure to large downstream Scope 3 emissions is very low as it does not produce coal or iron ore. It ranks joint 1st for the metric.
- ▼ Uses a high percentage of seawater and recycles over 80% of water withdrawn.
- ▼ Low balance sheet leverage (gearing second lowest at 11%) indicating greater financial flexibility than peers.

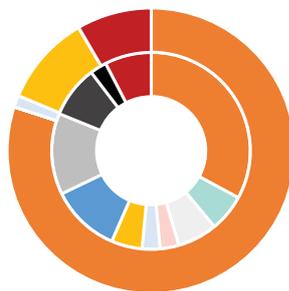
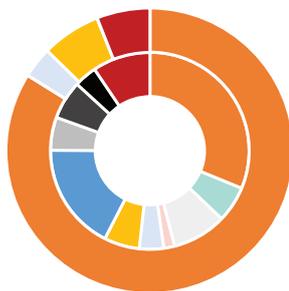
Company weaknesses

- ▼ Both emissions and energy intensity levels increased over 2010-2016 and the company has no emissions reduction target.
- ▼ The company has not reduced copper equivalent unit costs as fast as peers over 2013-2016.
- ▼ By 2030 half of the company's production is exposed to extremely high baseline water stress risk and the remaining output will be located in arid regions.
- ▼ No disclosure of research and development expenses and the company lags behind peers in application of new technologies at the mine site. However, it is looking to increase use of renewable energy sources in operations.
- ▼ No use of internal carbon price despite recently introduced Chilean tax on power generation emissions.

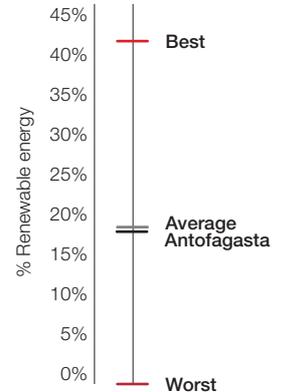
EBITDA 2015-2016

CAPEX 2015-2016

Energy consumption - 2016



Outer circle: Antofagasta
Inner circle: average for 12 companies

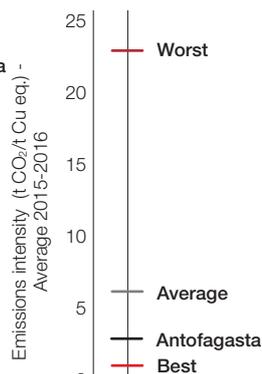
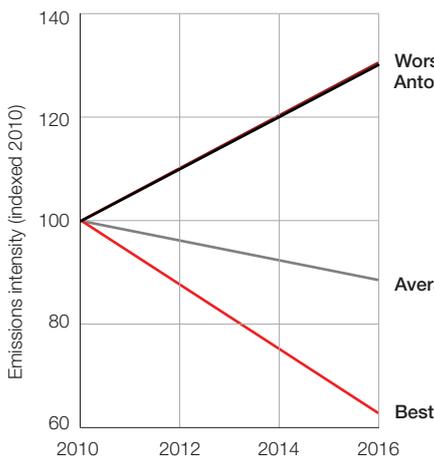


- Copper
- Aluminium
- Zinc
- Nickel
- Other base metals
- Precious metals

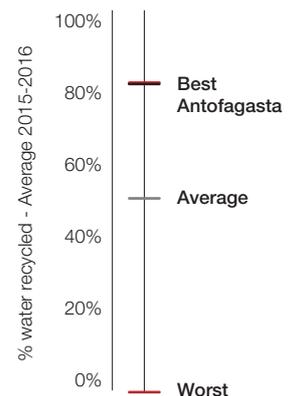
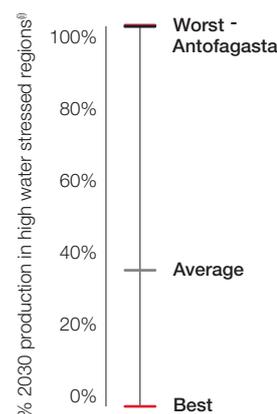
- Iron ore & steel
- Oil & gas
- Met coal
- Thermal coal
- Other

- Coal & coke
- Fuel oil
- Diesel / gasoline
- Natural gas
- Other
- Biofuel / waste
- Electricity

Emissions intensity



Water resilience



(i) Baseline water stress in 2030 in high / extremely high / arid conditions and assuming current production levels.

South32

Country: Australia

Market cap (LTM Q2 2017): US\$ 9.3 bn

2016 emissions: 23.5 mt CO₂ (Scope 1+2)

League Table rank	Transition risks	Physical risks	Transition opportunities	Climate governance & strategy
6 / 12	D	B	D	A

Company strengths

- Ranking a clear first for climate governance and strategy. InfluenceMap ranks the company joint first for carbon regulation supportiveness and its emission reduction targets are linked to executive pay.
- Targeting net zero operational emissions by 2050 – plans to achieve this through wholesale energy switching, intelligent land management and purchasing carbon offsets.
- Ranking first for capital flexibility – currently cash positive.
- Technology Roadmap – recent partnership with GE to enable digital transformation of company.
- The company has the second lowest water withdrawal intensity per unit of production in its operations.

Company weaknesses

- More than 50% of current company CAPEX is spent on coal assets (14% on thermal coal).
- The company has the second highest energy and emissions intensity levels. It also has a relatively high estimated Scope 3 emissions intensity due to its coal production.
- Ranking second last for reduction of Total CAPEX intensity since 2013.

EBITDA 2015-2016



- Copper
- Aluminium
- Zinc
- Nickel
- Other base metals
- Precious metals

CAPEX 2015-2016



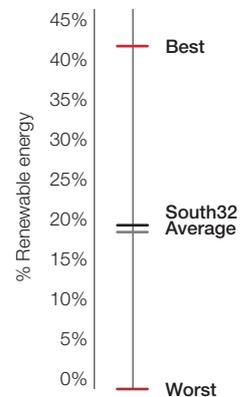
- Iron ore & steel
- Oil & gas
- Met coal
- Thermal coal
- Other

Outer circle: South32
Inner circle: average for 12 companies

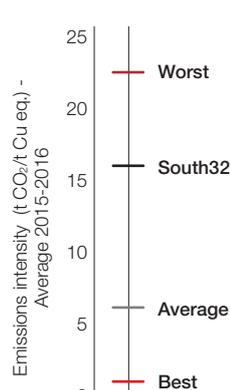
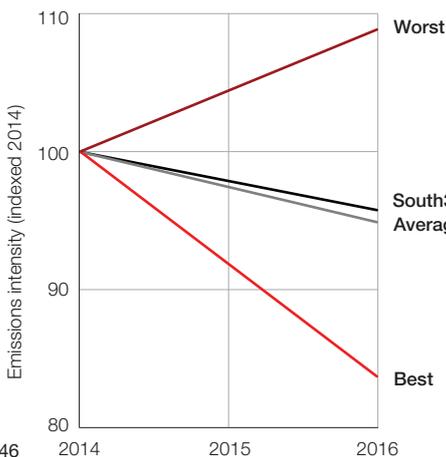
Energy consumption - 2016



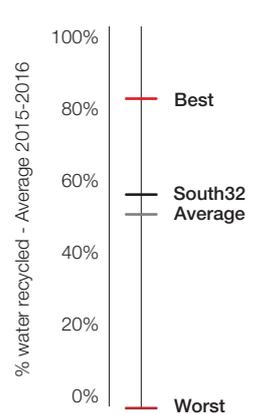
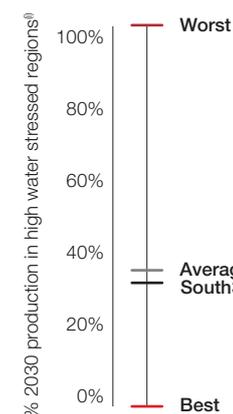
- Coal & coke
- Fuel oil
- Diesel / gasoline
- Natural gas
- Other
- Biofuel / waste
- Electricity



Emissions intensity



Water resilience



(i) Baseline water stress in 2030 in high / extremely high / arid conditions and assuming current production levels.

Glencore

Country: Switzerland

Market cap (LTM Q2 2017): US\$ 40.6 bn

2016 emissions: 35.6 mt CO₂ (Scope 1+2)

League Table rank	Transition risks	Physical risks	Transition opportunities	Climate governance & strategy
5 / 12	C	B	B	C

Company strengths

- ▼ Diversified portfolio which includes its marketing business. Earnings exposure and capital spending on metals with positive demand outlook in a low-carbon transition e.g. copper, nickel and cobalt; however, thermal coal accounts for approx. 17% of EBITDA and 12% of CAPEX.
- ▼ Unit production costs reduced faster than sample average over 2013-2016 and current copper equivalent unit costs are the third lowest. It also has the second largest reduction in energy intensity since 2010.
- ▼ Reduced Total CAPEX intensity third fastest (2013-2016). However, has the highest current sustaining CAPEX intensity (636 \$/ t Cu eq.)
- ▼ Uses an internal carbon price of up to US\$140 / t CO₂.
- ▼ The company has recently introduced an emission reduction target and asset level links between pay and climate KPIs.

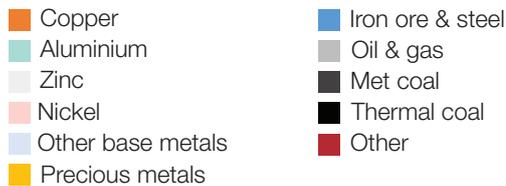
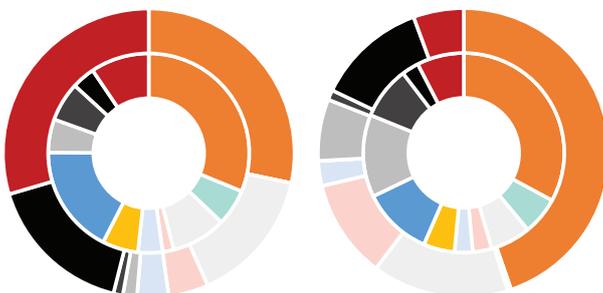
Company weaknesses

- ▼ Strategy biased to thermal coal, highlighted by its failed bid of \$2.675bn for Rio's Coal & Allied assets (total CAPEX spend in 2016 was \$3.5bn).
- ▼ Has relatively high emissions and energy intensity levels. However, has a more ambitious emissions reduction target than sample average.
- ▼ Has relatively high estimated Scope 3 emissions intensity due to its fossil fuel business segments.
- ▼ No disclosure of research and development expenses and the company lags behind peers in application of new technologies at the mine site.

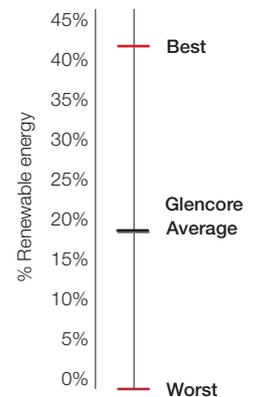
EBITDA 2015-2016

CAPEX 2015-2016

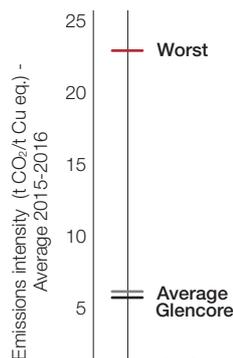
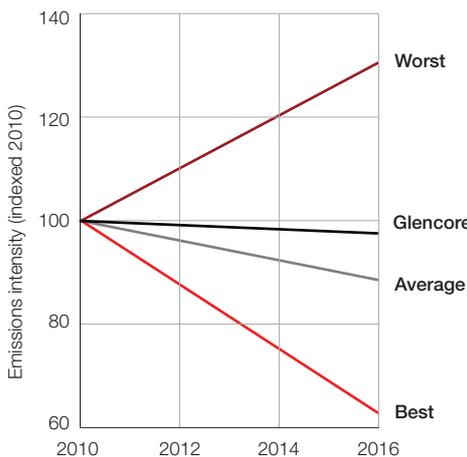
Energy consumption - 2016



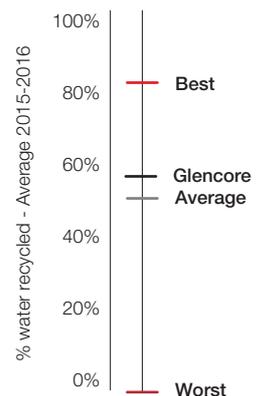
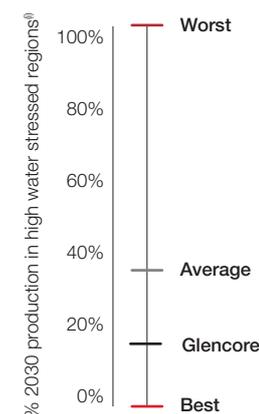
Outer circle: Glencore
Inner circle: average for 12 companies



Emissions intensity



Water resilience



(i) Baseline water stress in 2030 in high / extremely high / arid conditions and assuming current production levels.

Rio Tinto

Country: Australia / UK

Market cap (LTM Q2 2017): US\$ 63.4 bn

2016 emissions: 32.4 mt CO₂ (Scope 1+2)

League Table rank	Transition risks	Physical risks	Transition opportunities	Climate governance & strategy
4 / 12	B	C	A	C

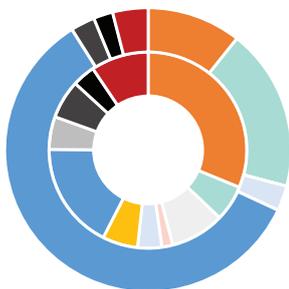
Company strengths

- Ranking first for transition opportunities. Its Mine of the Future™ program is pushing technological applications in mining.
- Strategy has shifted away from thermal coal, highlighted by its decision to sell Coal & Allied assets. We estimate that its earnings exposure to coal will reduce from 4.9% to 2.5% on completion of the sale.
- Has strong capital flexibility with the third lowest geared balance sheet (17%). Reduced CAPEX intensity the most and reduced unit production costs second fastest since 2013.
- Has the second highest share of renewable energy consumption (33%) and has the third largest reduction in energy intensity since 2010.
- Largest reduction in emissions intensity since 2010 and has the most ambitious emissions reduction target.

Company weaknesses

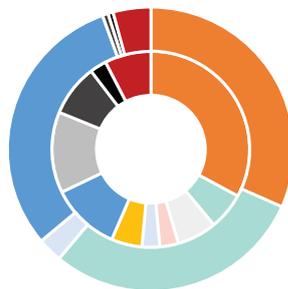
- Lack of diversification - portfolio heavily weighted to iron ore. However, the company does allocate significant CAPEX to copper and aluminum business segments.
- Ranking 10th for water governance and policy and has a relatively low percentage of water recycled compared to the sample average. The majority of its assets will be exposed to extremely high and arid conditions by 2030.
- InfluenceMap ranks the company 10th for carbon regulation supportiveness.
- No evidence of a link between executive remuneration KPIs and climate goals.
- Significant absolute Scope 3 emissions from iron ore business of approximately 600m tonnes.

EBITDA 2015-2016



- Copper
- Aluminium
- Zinc
- Nickel
- Other base metals
- Precious metals

CAPEX 2015-2016



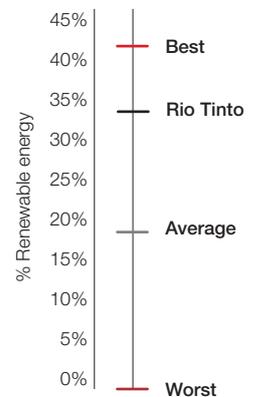
- Iron ore & steel
- Oil & gas
- Met coal
- Thermal coal
- Other

Outer circle: Rio Tinto
Inner circle: average for 12 companies

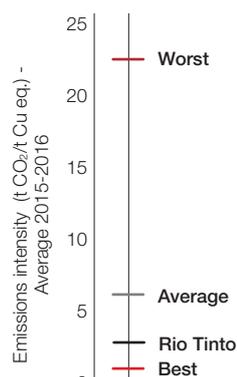
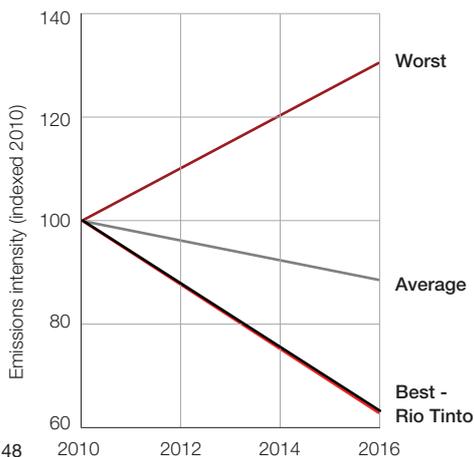
Energy consumption - 2016



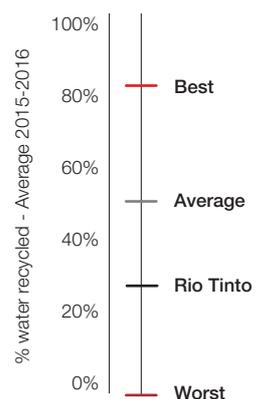
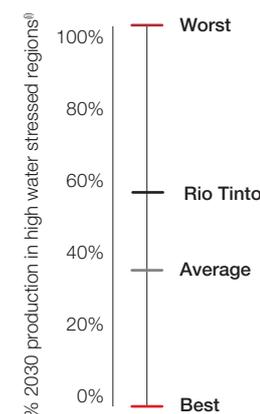
- Coal & coke
- Fuel oil
- Diesel / gasoline
- Natural gas
- Other
- Biofuel / waste
- Electricity



Emissions intensity



Water resilience



(i) Baseline water stress in 2030 in high / extremely high / arid conditions and assuming current production levels.

League Table rank	Transition risks	Physical risks	Transition opportunities	Climate governance & strategy
3 / 12	B	A	C	B

Company strengths

- ▀ Ranks second for physical risks. Has the lowest water withdrawal intensity, the lowest use of fresh surface water and a robust water governance strategy. It is currently building desalination infrastructure at its Escondida copper mine in Chile.
- ▀ Has low cost efficient operations: copper equivalent unit costs are the second lowest and it reduced unit costs third fastest since 2013. It also has the second lowest sustaining CAPEX intensity (191 \$/ t Cu eq.) and reduced total CAPEX intensity second fastest since 2013.
- ▀ Second largest reduction in emissions intensity since 2010 and third lowest emissions intensity level; however, its current emissions target only aims to keep emissions flat.
- ▀ Ranks second for climate governance and strategy. Uses an internal carbon price and has exec remuneration.

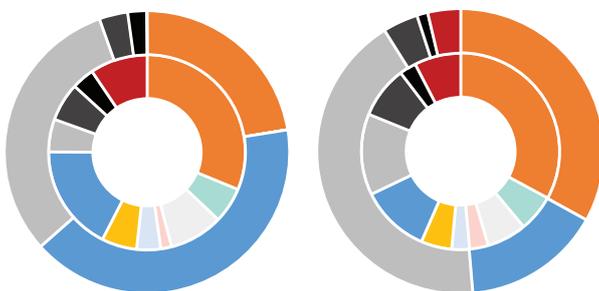
Company weaknesses

- ▀ Has the second highest estimated Scope 3 emissions intensity at 68 t CO₂/ t Cu eq and over 650m tonnes in absolute terms.
- ▀ The company has less exposure to commodities conducive to a low-carbon transition than its peers. Spin-off of South32 reduced diversification, its oil and gas business accounted for a third of earnings and 42% of CAPEX over 2015-2016.
- ▀ Share of renewables in total energy consumption is only 0.16% and focus on R&D and technology lags behind the industry leaders.

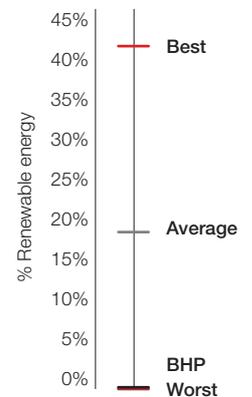
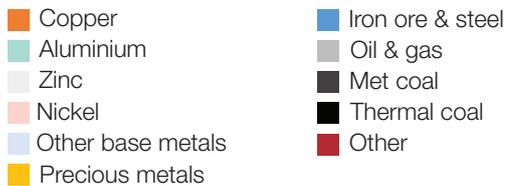
EBITDA 2015-2016

CAPEX 2015-2016

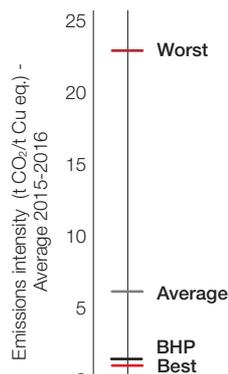
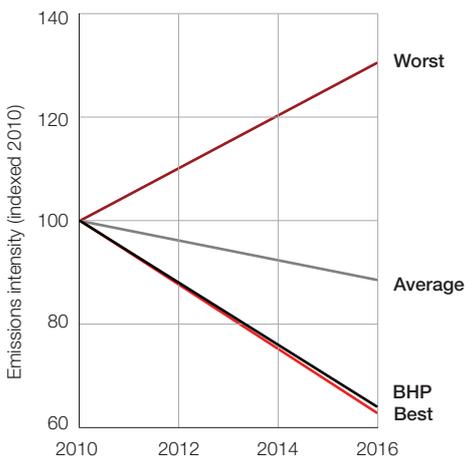
Energy consumption - 2016



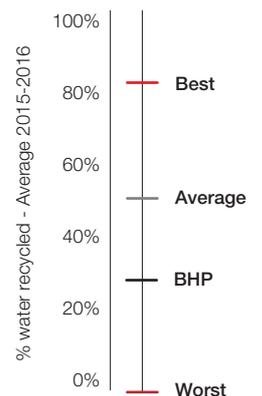
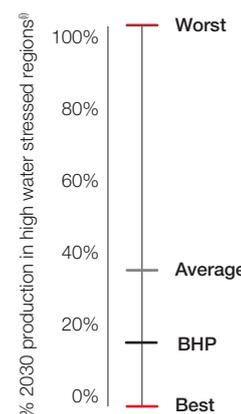
Outer circle: BHP
Inner circle: average for 12 companies



Emissions intensity



Water resilience



(i) Baseline water stress in 2030 in high / extremely high / arid conditions and assuming current production levels.

Boliden

Country: Sweden

Market cap (LTM Q2 2017): US\$ 6.4 bn

2016 emissions: 1.0 mt CO₂ (Scope 1+2)

League Table rank	Transition risks	Physical risks	Transition opportunities	Climate governance & strategy
2 / 12	A	B	B	C

Company strengths

- Has the lowest current emissions intensity level and the second lowest energy intensity level. However, it has a flat emissions target. The company's exposure to large downstream Scope 3 emissions is very low as it does not produce coal or iron ore. It ranks joint 1st for the metric.
- Has earnings exposure and CAPEX spend in desired commodities and its large smelting business adds diversification.
- Through its smelting arm, it is an industry leader in electronic scrap recycling. In 2016, 11% of total feed was from secondary recycled materials.
- Is active in applications of new technologies and was an early adopter of mine automation systems. It has the highest share of renewable energy and the second highest R&D / sales ratio.
- Ranks third in water resilience. The company is exposed to low levels of water stress yet has reduced its water withdrawal intensity, uses a high proportion of brackish/seawater, and has water recycling rate of 75%.

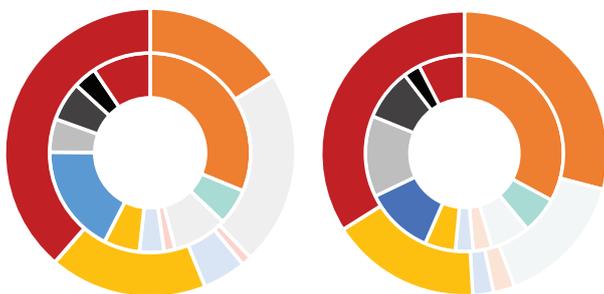
Company weaknesses

- Copper equivalent unit costs are the 10th highest within company sample and it has not reduced costs as fast as peers over 2013-2016.
- Ranks last for water governance and policy scorecard and does not respond to CDP's water questionnaire request.
- Second highest sustaining CAPEX intensity and reduced total CAPEX intensity less than sample average since 2013.
- No evidence of climate related remuneration for executives.

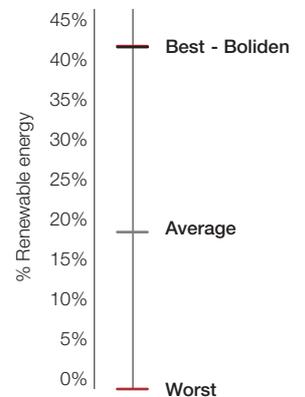
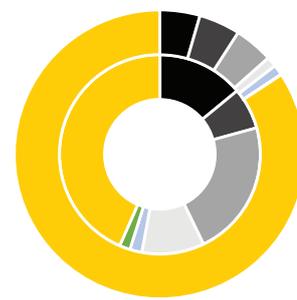
EBITDA 2015-2016

CAPEX 2015-2016

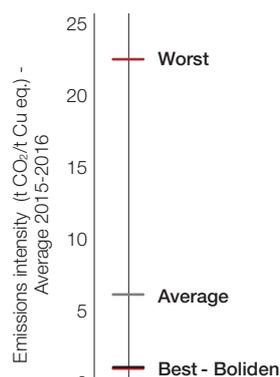
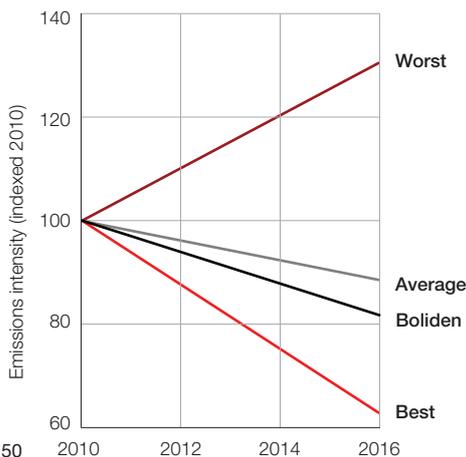
Energy consumption - 2016



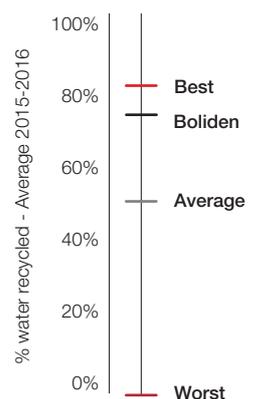
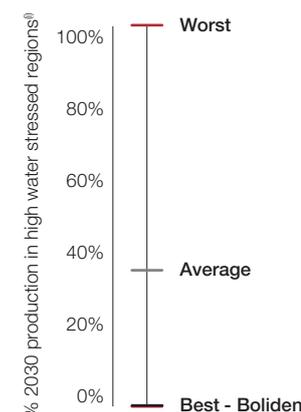
Outer circle: Boliden
Inner circle: average for 12 companies



Emissions intensity



Water resilience



(i) Baseline water stress in 2030 in high / extremely high / arid conditions and assuming current production levels.

Vale

Country: Brazil

Market cap (LTM Q2 2017): US\$ 31.8 bn

2016 emissions: 14.7 mt CO₂ (Scope 1+2)

League Table rank	Transition risks	Physical risks	Transition opportunities	Climate governance & strategy
1 / 12	A	A	C	D

Company strengths

- ▀ Ranks first for both transition risks and physical risks. It has significantly reduced both emissions intensity (ranks 3rd) and energy intensity (ranks 1st) since 2010.
- ▀ Copper equivalent unit costs are the lowest within company sample and it has reduced costs the most since 2013.
- ▀ Has the lowest asset exposure to future water stress and the highest water recycling rate (82%)
- ▀ Has a strong focus on innovation through the Vale Institute of Technology and has the highest R&D expense / sales ratio. Many new technologies are being implemented at its S11D iron ore project.

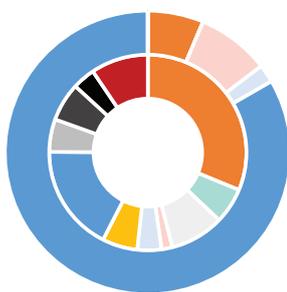
Company weaknesses

- ▀ Portfolio is heavily weighted to iron ore and 16% of its CAPEX was spent on met and thermal coal over 2015-2016.
- ▀ Its sustaining CAPEX intensity is relatively high compared to company sample and it has less financial flexibility than peers due to relatively high gearing (38%).
- ▀ Has limited emissions verification and its emissions target is based off a "business-as-usual" baseline and lacks ambition.
- ▀ No evidence of climate related remuneration for executives and no use of internal carbon price; however, does anticipate doing so within next two years.

EBITDA 2015-2016

CAPEX 2015-2016

Energy consumption - 2016

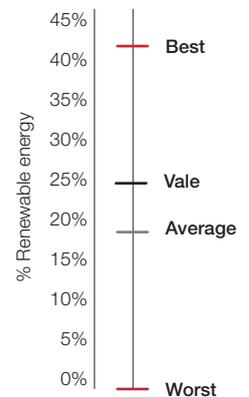


Outer circle: Vale
Inner circle: average for 12 companies

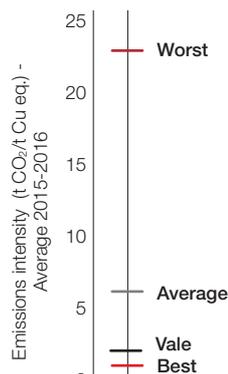
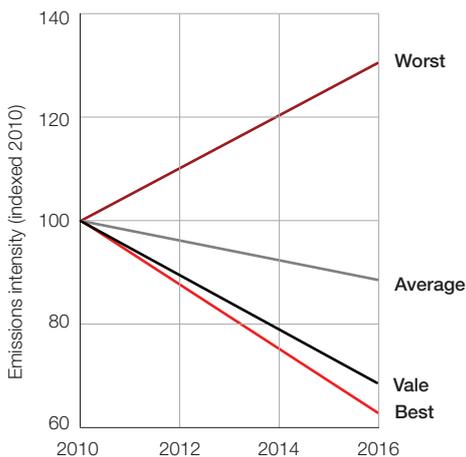
- Copper
- Aluminium
- Zinc
- Nickel
- Other base metals
- Precious metals

- Iron ore & steel
- Oil & gas
- Met coal
- Thermal coal
- Other

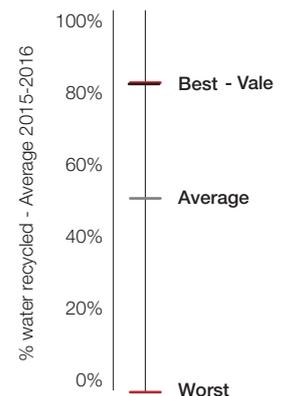
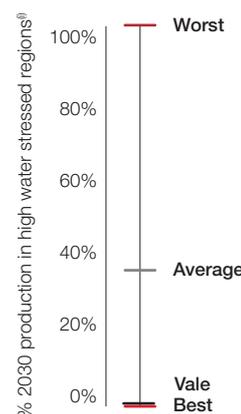
- Coal & coke
- Fuel oil
- Diesel / gasoline
- Natural gas
- Other
- Biofuel / waste
- Electricity



Emissions intensity



Water resilience



(i) Baseline water stress in 2030 in high / extremely high / arid conditions and assuming current production levels.

Appendix III: Methodology and limitations

Cu-equivalent production figures:

- ▼ We collate annual commodity production figures from company sources from 2010 to 2016.
- ▼ A single commodity price deck is collected using average annual commodity prices from 2010 to 2016 using Bloomberg.
- ▼ Relative copper equivalent prices are calculated by dividing the average annual 2010 to 2016 price for each commodity by the average annual 2010 to 2016 price for copper.
- ▼ Company copper equivalent production in each year is calculated by multiplying commodity production by its respective copper equivalent price. This is summed at a company level to produce a total company wide copper equivalent production figure.
- ▼ This figure is used to normalize carbon emissions, energy consumption, costs, CAPEX and water withdrawal to produce individual company 'per unit of copper equivalent production' calculations.
- ▼ Where significant mergers or acquisitions have taken place⁴⁸, we seek to adjust figures to be more reflective of underlying company performance.

Transition risks

The overall transition risk ranking is determined as follows:

We combine the weighted ranks of the five metrics using the following weightings: metric 1) 20%, metric 2) 20%, metric 3) 15%, metric 4) 20% and metric 5) 25%.

Metric 1) Emissions performance

Current emissions intensity

- ▼ We collate emissions figures for each company from 2010 to 2016 at a company level using data from the CDP questionnaire and company sources.
- ▼ We divide company emissions by company copper equivalent production for the corresponding year to produce an emissions intensity figure.
- ▼ We take the average of 2015 and 2016 as the company current emissions intensity.
- ▼ Companies with a lower emissions intensity of production are ranked higher.

Change in emissions intensity

- ▼ Using the company emissions intensities described above, a line of best fit is calculated between 2010 and 2016.
- ▼ The change in emissions intensity is a CAGR of the line of best fit values for 2010 and 2016.
- ▼ Companies that have reduced their emissions intensity of production quicker are ranked higher.

The weighted rank for the metric is calculated by applying a 70% weight to the CAGR and 30% weight to the current emissions intensity⁴⁹.

Metric 2) Energy intensity

Current energy intensity

- ▼ We collate energy consumption figures for each company from 2010 to 2016 at a company level using data from the CDP questionnaire and company sources.
- ▼ We divide company emissions by company copper equivalent production for the corresponding year to produce an energy intensity figure.
- ▼ We take the average of 2015 and 2016 as the company current emissions intensity.
- ▼ Companies with a lower energy intensity of production are ranked higher.

Change in energy intensity

- ▼ Using the company energy intensities described above, a line of best fit is calculated between 2010 and 2016.
- ▼ The change in emissions intensity is a CAGR of the line of best fit values for 2010 and 2016.
- ▼ Companies that have reduced their energy intensity of production quicker are ranked higher.

The weighted rank for the metric is calculated by applying a 70% weight to the CAGR and 30% weight to current level of energy intensity⁴⁹.

Metric 3) Exposure to carbon price

- ▼ We estimate 2015 and 2016 company Scope 3 emissions (Use of Sold Products and Processing of Sold Goods) using company annual production figures of iron ore, oil, natural gas, thermal coal and

48. We have adjusted for Glencore's acquisition of Xstrata in 2011 by adding Xstrata's emissions, production and energy use to Glencore figures pre-2012. BHP's trend line only accounts for South32's production, emissions, production and energy use in 2016. We also adjusted the years taken for First Quantum Minerals' trend line and excluded 2010 as the data point was identified as an outlier.

49. We acknowledge the challenges of comparing a set of diverse mining companies with varying commodity and location mixes and therefore assign a 30% weighting to the emissions intensity level versus a 70% weighting to the trend. Nevertheless, ranking the level accounts for the consideration that companies with lower emissions intensities may find it more difficult to decrease these relative to companies which are reducing their emissions from a higher base.

metallurgical coal and multiplying them by commodity-specific average emissions factors (iron ore 1.46t CO₂/t, thermal coal 2.1t CO₂/t, metallurgical coal 2.88t CO₂/t, oil 0.35t CO₂/barrel and 0.055t CO₂/MMBTU) sourced from the EIA and IPCC.

- ▼ We divide company Scope 3 emissions by company copper equivalent production for the corresponding year to produce a downstream emissions intensity of copper equivalent production.
- ▼ We take the average mean of 2015 and 2016 as the current company downstream emissions intensity of production.
- ▼ Companies with a lower downstream emissions intensity of production are ranked higher.
- ▼ Company that do not produce iron ore, oil, natural gas, thermal coal or metallurgical coal are not assessed as the Scope 3 emissions of remaining commodities produced by the companies (such as copper, zinc and aluminum) are not significant.

Metric 4) Production costs

- ▼ We collate unit costs of production across commodities for 2013 – 2016 from company reports.
- ▼ Unit costs are the direct cash costs (costs incurred in mining, processing, freight, realization and selling costs) incurred in producing one unit of saleable production. Companies typically report unit costs for base metals (copper, zinc etc) at C1 i.e. inclusive of by-product credits and for bulk products (coal and iron ore) at FOB (costs on board at port).
- ▼ For each commodity unit costs are multiplied by the production. Total costs are then divided by total copper equivalent production to provide the copper equivalent unit cost in US\$/ lb Cu eq. Where appropriate a constant exchange rate is applied over time periods to avoid impact of currency fluctuations.
- ▼ Companies with a lower copper equivalent unit cost for 2016 are ranked higher.
- ▼ A line of best fit is calculated between 2013 and 2016.
- ▼ The change in copper equivalent unit cost is a CAGR of the line of best fit values for 2013 and 2016.
- ▼ Companies that have reduced their unit costs quicker are ranked higher.
- ▼ The weighted rank for the metric is calculated by applying a 70% weight to the CAGR and 30% weight to the copper equivalent unit cost.

Metric 5) EBITDA split

- ▼ We collate financial data by commodity for 2015 and 2016 from company reports.
- ▼ Adjusted EBITDA split by commodity for 2015-2016 is used for company comparison. Adjusted EBITDA is used to exclude the impacts of exceptional items such as asset impairments.
- ▼ Where EBITDA is only broken down by specific mining sites, revenue split or copper equivalent production split from the mine is used to assign the proportion of EBITDA to each commodity.
- ▼ We use a merit order system to rank companies based on their exposure to each commodity.
- ▼ The merit order system favors commodities likely to be demanded in greater volumes in a low-carbon environment (e.g. nickel and copper), and disfavors those likely to be threatened by substitution (e.g. thermal coal)⁵⁰.
- ▼ The merit order system was devised by considering various commodity demand scenarios in combination with EBITDA sensitivity analysis. The system also accounts for diversification of a company's portfolio.

Limitations

- ▼ Using copper-equivalent as a normalizing factor has its limitations including year-on-year commodity price fluctuations, differing commodity ore grades and multiple pricing points for products.
- ▼ Scope 3 emissions have been calculated using a emissions factor for the commodities featured in this report. We recognize that emissions from use or processing of sold products can vary, e.g. according to calorific and carbon content in the case of coal.
- ▼ We have weighted company trends of emissions and energy intensity higher in recognition of the difficulty for companies with lower emissions to continue to reduce them further.
- ▼ Whilst we account for significant M&A activity amongst the companies, some smaller acquisitions or disposals may not be adjusted for in the analysis.
- ▼ Unit costs of production are not always reported consistently across companies (e.g. inclusions of by-product credits, royalties etc). In addition a copper equivalent unit cost masks the complexities associated with each commodity (e.g. relationship between costs and margins) and is less appropriate for South32 which does not produce copper. All-in sustaining costs (AISC) which also include capital

50. See Figure 48 in the 'Supplementary figures' section for example commodity demand scenario.

used in mine development and production would provide a more comprehensive look at operational cost efficiency.

Physical risks: Water resilience

The overall water resilience rank and grades are determined as follows:

- ▼ We combine the weighted ranks of the four-metrics using the following weightings: metric 1) 30%, metric 2) 25%, metric 3) 25%, metric 4) 20%. This determines the overall weighted rank for water resilience.
- ▼ The water resilience grade is awarded according to the overall weighted rank.

Metric 1) Asset water stress exposure

- ▼ We collate geographical coordinates and production data from the GlobalData database. Water stress risk exposure is assessed for mining operations only. Oil and gas sites, smelting facilities and aluminum operations are excluded from the analysis.
- ▼ Production data is average from 2014-2016 to maximize data points and commodities are converted into copper equivalent to give a single production figure for each mine. Production figures taken from GlobalData are used as a proxy for mine size only.
- ▼ To account for the ownership stake each company has in an individual asset, total production figures are multiplied by the ownership stake percentage given by GlobalData.
- ▼ We use WRI's Aqueduct tool to assign a current overall water stress risk and future baseline water stress risk classification to the mines according to geographic location. This is categorized into low, low to medium, medium to high, high, extremely high and arid conditions.
- ▼ Water stress exposure is calculated by applying a 40% weight to current water stress and 60% weight to future water stress to give an overall water stress exposure index score.

Current water stress

- ▼ Each site is weighted based on production relative to a company's total production (using GlobalData figures). This gives a greater precedence to sites with higher capacities.
- ▼ At a mine level, we identify the level of water stress risk exposure using the WRI overall water risk indicator score weighted to the mining industry and based on the following metrics: (i) Physical risks quantity (60.2%) based on baseline water stress, inter-annual and seasonal variability, flood occurrence,

drought severity, upstream storage, and groundwater stress. (ii) Physical risks quality (4.9%) based on return flow ratio and upstream protected land. (iii) Regulatory and reputational risk (35%) based on media coverage, access to water and threat to amphibians.

- ▼ The score, ranging from 0 (low risk) to 5 (high risk) corresponds to one of five risk categories and assigns a classification for each site.
- ▼ We calculate the total percentage of production each mine contributes to total production in each WRI risk category. Then we scale the number according to the following weighting: low=0%, low to medium=5%, medium to high=15%, high=35%, extremely high=45% and divide by the total production. This approach assigns greater weight to mines facing higher water stress risk.
- ▼ Finally, we normalize this number to produce a water stress exposure index ranging from 0 (all mines exposed to low water stress risk) to 1 (all mines exposed to extremely high water stress risk). The higher the index value the more exposed a company is to water stress and therefore we use the index to rank the companies relative water stress asset exposure levels.

Future water stress (2030)

- ▼ At a mine level, we identify the level of baseline water stress risk exposure weighting the three scenarios: 25:50:25 (optimistic: business as usual: pessimistic) as defined by WRI.
- ▼ We scale the percentage of production each mine contributes to total production in each WRI risk category according to the following weighting: low and low to medium=0%, medium to high=5%, high=15%, extremely high=35%, arid conditions =45%.

Metric 2) Water withdrawal intensity

Current water withdrawal intensity

- ▼ We collate water withdrawal figures for each company from 2012 to 2016 at a company level using data from the CDP water questionnaire, company sources and Bloomberg.
- ▼ We divide company water withdrawal by company copper equivalent production for the corresponding year to produce a withdrawal intensity figure.
- ▼ We take the average of 2015 and 2016 as the company current withdrawal intensity.
- ▼ Companies with a lower withdrawal intensity are ranked higher.

Change in water withdrawal intensity

- Using the company water withdrawal intensities described above, a line of best fit is calculated between 2012 and 2016.
- The change in water withdrawal intensity is a CAGR of the line of best fit values for 2012 and 2016.
- Companies that have reduced their water withdrawal intensity quicker are ranked higher.

The weighted rank for the metric is calculated by applying a 50% weight to current withdrawal intensity and 50% weight to the CAGR.

Metric 3) Fresh surface water use and water recycled rate

Fresh surface water use

- Water withdrawal by source is collated for each company at a company level using data from the CDP water questionnaire, company sources and Bloomberg.
- We take the average of 2015 and 2016 to give the relative percentages of fresh surface water (including rainwater), Brackish surface water/seawater, groundwater and other water sources including municipal and wastewater.
- Companies are ranking based on their relative percentage of fresh surface water. Companies with low levels of fresh surface water withdrawals are ranked higher.

Water recycling rate

- Water recycling rates, expressed as a percentage are collated at a company level from company sources and Bloomberg.
- We take the average of 2015 and 2016 as the company water recycling rate.
- Companies with a higher water recycling rate are ranked higher.

The weighted rank for this metric is calculated by applying a 30% weight to fresh surface water use and a 70% water to weight recycling rate.

Metric 4) Water governance

We use the following approach to score companies according to their water governance.

- Metrics are taken from the 2017 CDP water questionnaire. Where a company has not disclosed to CDP we look for equivalent data points from company sources.

- Companies are scored based on 10 metrics. Each metric is scored out of 5, relative to the number of variables within the metric. Companies with higher scores are ranked higher.
- We use the following metrics and weighting: Disclosure to the CDP water program (8.33%), Identification of a risk assessment, scale, frequency, and timeframe (8.33% respectively) and the geographic scale of the risk assessment (15%). Number of water related data points that have been externally verified (15%), water policy factors (8.33%), targets and goals (15%) and ICMM reporting adherence or membership (5%).
- Companies are ranked by their weighted average points total, with a higher score indicating better water governance.

Limitations

- Asset level production data sourced from GlobalData was not verified and therefore there could be inaccuracies within the dataset.
- Analysis does not capture further water use metrics such as consumption or discharge. Depending on a company's location, such metrics may be deemed more relevant than withdrawal.
- Insufficient granularity of data limits our ability to assess how fresh surface water and water recycling rates have changed overtime. Furthermore, the relative merits/issues of groundwater use have not been assessed.
- The WRI aqueduct tool used in isolation may have limitations. It is important to note that water stress exposure must be viewed in the wider context of water use and management practices.

Transition opportunities

The overall transition opportunities rank and grade is determined as follows:

- We combine the weighted ranks of the five-metrics using the following weightings: metric 1) 35%, metric 2) 20%, metric 3) 20%, metric 4) 10%, metric 5) 15%. This determines the overall weighted rank for transition opportunities.
- The transition opportunities grade is awarded according to the overall weighted rank.

We apply the following methodologies to calculate the weighted rank for each metric:

Metric 1) CAPEX split

- ▼ We collate details of capital expenditure by commodity for 2015 and 2016 from annual reports.
- ▼ CAPEX split by commodity for 2015-2016 is used for company comparison.
- ▼ Where CAPEX is only broken down by specific mining sites, revenue split or copper equivalent production split from the mine is used to assign the proportion of CAPEX to each commodity.
- ▼ We use a merit order system to rank companies based on their exposure to each commodity.
- ▼ The merit order system favors commodities likely to be demanded in greater volumes in a low-carbon environment (e.g. nickel and copper), and disfavors those likely to be threatened by substitution (e.g. thermal coal).

Metric 2) CAPEX intensity

- ▼ We collate data for total and sustaining capital expenditure from 2013 to 2016 from annual reports and investor presentations. (Where appropriate a constant exchange rate is applied over time periods to avoid impact of currency fluctuations.)
- ▼ Copper equivalent production is used to provide a CAPEX intensity figure (US\$/ tonne Cu eq.)
- ▼ For Total CAPEX intensity a line of best fit is calculated between 2013 and 2016.
- ▼ The change in Total CAPEX intensity is a CAGR of the line of best fit values for 2013 and 2016.
- ▼ The mean value for 2015 and 2016 is used to compare sustaining CAPEX intensity for each company.
- ▼ The weighted rank for the metric is calculated by applying a 70% weight to the CAGR and 30% weight to sustaining CAPEX intensity.

Metric 3) Capital flexibility

- ▼ We collate financial data for 2016. For BHP and South32 values are taken from Half Year results, 31st December 2016, to allow fair comparison.
- ▼ Financial gearing (leverage) is calculated for each company as: $(\text{Net debt}) / (\text{Net debt} + \text{Shareholders' equity})$
- ▼ The weighted rank for the metric is calculated by applying a 50% weight to financial gearing and 50% weight to Net debt / EBITDA.

Metric 4) R&D and innovation

- ▼ We collate financial data, R&D expenses, and data on company activity in areas of innovation and technology. Data is sourced from company reports, investor presentations and data reported to CDP.
- ▼ We developed a scorecard based approach – companies were ranked and assessed qualitatively on current and planned activity in new technologies, future strategy, company structure (e.g. creation of specific business areas focused on innovation / research) and disclosure.
- ▼ We rank companies on their average R&D expense to sales ratio over the period 2014-2016.
- ▼ The weighted rank for the metric is calculated by applying a 70% weight to the scorecard rank and 30% weight to R&D expenses to sales ratio.

Metric 5) Renewable energy

- ▼ We collate data on total energy consumption and split by fuel type from company reports and data reported to CDP (CC11.3)
- ▼ Companies are ranked based on the total percentage of energy consumption from renewable sources in 2016.

Limitations

- ▼ Historical CAPEX split does not account for future company spending commitments and we recognize that company strategy evolves with time.
- ▼ Analysis does not capture the complexities of company investment cycles. Analysis of full-cycle value creation would allow in depth cross-company analysis.
- ▼ Projected future capital spend and proportion of CAPEX which is discretionary has not been analyzed.
- ▼ There is a lack of cross-company quantitative data when assessing performance in areas such as innovation, R&D and applications of technology at the mine site. Some companies have started to highlight specific projects or investments but in general communication could be better.

Climate governance and strategy

The overall climate governance and strategy rank and grades are determined as follows:

- ▼ We combine the weighted ranks of the seven metrics using the following weightings: metric 1) 30%, metric 2) 25%, metric 3) 15%, metric 4) 15%, metric 5) 10%, and metric 6) 5%. This determines the overall weighted rank for climate governance and strategy.

- ▼ The climate governance and strategy grade is awarded according to the overall weighted rank.

Metric 1) Carbon regulation supportiveness

Our CDP carbon regulation supportiveness metric uses InfluenceMap's total score which combines the company organization score and relationship score according to their proprietary algorithm. A full description of InfluenceMap's detailed methodology can be found on its website (<https://influencemap.org/page/Our-Methodology>). Its methodology comprises three stages: (a) aggregation of suitable data sources (SEC disclosures, legislative consultations, CDP responses etc.); (b) assessment (via raw scores) of those data sources using suitable queries; and (c) input of the raw scores and other factors into its algorithm to arrive at comparable metrics of regulatory supportiveness for corporations. It analyzes these data sources with a series of 12 queries relating to various aspects of climate change policy and legislation. It then scores each data source/query intersection (or cell) on a 5-point scale, with clearly consistent evidence and guidelines.

- ▼ Organizational score is computed over 96 scoring cells by InfluenceMap's proprietary algorithm that accounts for weightings and irrelevant data sources/queries. The organizational score is expressed as a percentage, with 100% representing very supportive influence on climate policy.
- ▼ Relationship score is a reflection of a corporation's climate influencing activities through its influencers (i.e. trade association etc.). The relationship score is also expressed as a percentage, with 100% representing very supportive influence over climate policy.
- ▼ The weighted rank for the metric is calculated by applying a 100% weight to InfluenceMap's total score.

Metric 2) Emissions reduction targets

We use the following approach to score companies on their emissions reduction target disclosure and strength. Our ranking is based on an assessment of the following factors:

- ▼ Whether a company has a current emissions reduction target (absolute or intensity emissions reduction).
- ▼ Targets that are based on reductions relative to a Business-As-Usual trajectory are viewed less favorably.
- ▼ The CAGR % reduction in emissions implied by the target from the base year until the target end date, with greater reductions favored.
- ▼ We rank each of the factors individually and aggregate the ranks to produce an overall ranking.

Metric 3) Emissions verification

- ▼ We use the following approach to score companies according to their Scope 1+2 emissions data transparency.
- ▼ The start point in the analysis is the proportion of emissions verified by a third party. We score this out of 10. If 100% are verified, this achieves 10 points. Then, points are awarded according to the proportion verified, i.e. a company with 86% of emissions verification is awarded 8.6 points.
- ▼ We then adjust the score (max 10) according to the uncertainty of the scope verified. If the uncertainty is 5%, we deduct 0.5 points, if the uncertainty is 2%, we deduct 0.2 points, and so on.
- ▼ We multiply the remaining score according to the level of assurance as follows: high assurance = 100%; reasonable = 90%; moderate = 80%; limited = 70%; don't know yet = 50%; none = 0%.
- ▼ We then multiply the remaining score (still max 10) according to the status of the verification: complete = 100%; underway = 75%; none = 0%.
- ▼ We rank companies according to their final score, with higher scores favored.

Metric 4) Climate-related remuneration

- ▼ We developed a scorecard based on responses to CDP climate change questionnaire CC1.2 and CC1.2a on incentives for the management of climate change issues, including the attainment of targets. We scored companies based on these responses and sought further information from the company's own public reporting. The focus of the remuneration scorecard was on climate related indicators such as company performance against emission reduction or energy intensity targets.

Metric 5) Use of an internal carbon price

- ▼ We collect data on the use of internal carbon prices from companies' responses to question CC2.2c-d from the 2017 CDP climate change questionnaire.
- ▼ We rank companies according to whether they use an internal carbon price, whether they disclose the price level(s) used and how high it is - with higher prices favored.

Metric 6) CDP Score

- ▼ The scoring methodology is a means to assess the responder's progress towards environmental stewardship as communicated through the company's 2016 CDP response. The methodology ultimately yields a score based on the evaluation. The scoring methodology assesses the level of detail and comprehensiveness in a response, as well as the company's awareness of environmental issues, its management methods, and progress towards environmental stewardship. CDP is committed to transparency and as such provides the full scoring methodology for every program online, alongside webinars and explanations.

Limitations

- ▼ Climate considerations in executive remuneration tend to relate to operational climate indicators rather than strategic or transitional plans. Where climate performance indicators were not separately identified, assumptions on the proportion it accounted for were made.
- ▼ Companies' disclosure on use of internal carbon prices varied significantly, not allowing a full analysis of how they are applied.

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