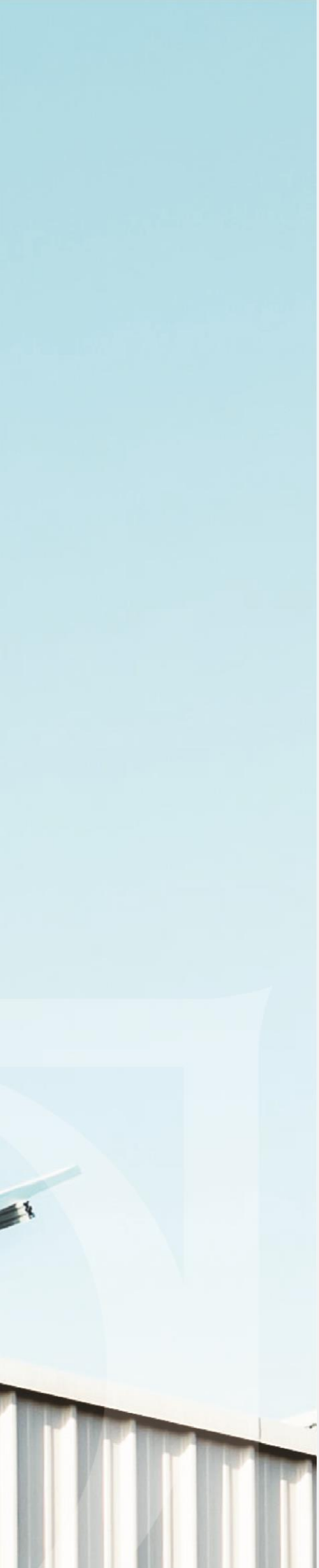
RFC Ambrian

Mining & Metals Decarbonisation Pathway

A framework to critically evaluate decarbonisation pathways of major miners, and a review of BHP, Rio Tinto, Vale, and Anglo American.

November 2021



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Foreword

This report had its genesis in a recent conversation with a CEO from a major global insurance company, who outlined a remarkable viewpoint. The insurance company in question has significant exposure to major mining companies and were re-evaluating their support for the entire mining industry - to the point of withdrawal of insurance underwriting. Soundings with other material stakeholders echoed a similar viewpoint to varying degrees.

This viewpoint arises from the perception of mining as an inherently unsustainable industry, and one which presents significant transition risks. Stakeholders are not sure if their mining and metals clients are doing enough to decarbonise, or if clients are simply providing lip service to placate stakeholders whilst continuing business as usual (the dreaded perception of 'greenwashing'). Whilst those in the mining industry are looking to increase the production of raw materials critical to decarbonising the global energy supply, institutions which enable the industry are struggling to evaluate the credibility of the industry's ability to do so whilst decreasing emissions in a sustainable manner. Such an outcome presents a significant challenge for society.

It is in this context that RFC Ambrian developed a framework specific to the mining industry to guide the evaluation of mining and metals decarbonisation efforts and the credibility of stated decarbonisation targets.

Executive Summary

Financial institutions, insurance firms, shareholders and other stakeholders are grappling with their exposure to the mining and metals sector in light of climate risks, societal pressure and regulatory headwinds. In response, effectively all major mining companies have a stated target, or ambition to achieve net zero emissions by 2050 (or earlier) and have outlined strategies to achieve these ambitions. Net zero claims for the mining industry are bold – and will require billions of dollars to achieve. Establishing credible decarbonisation strategies and pathways are essential to the industry's success in a carbon constrained future and gaining continued support from stakeholders.

Why credible decarbonisation strategies matter

1. Stakeholder scrutiny and action is increasing

Stakeholders are increasingly wary of climate change risks and perceptions of greenwashing, and in turn are applying pressure to their clientele. The long domino of stakeholders imparting pressure down the chain is quickly landing on the mining and metals industry's doorstep and continues to impact ESG reporting, AGM resolutions and climate goals reported by industry.

2. Increased cost of capital and access to finance

Pressure for financial institutions and asset managers to act in relation to climate targets is creating a strong incentive to align with companies with green credentials. Lending to 'brown industries' often demands a higher rate of return, and in some cases access to finance can be withdrawn completely. Inclusion or exclusion from sustainable investing products, which now comprise one third of total assets under management globally, has an implicit impact on a firm's cost of capital

3. Insurability

Increased frequency and severity of extreme weather events leave insurers heavily exposed to outsized losses related to physical risk. Transition risks resulting from changes in asset values in a low-carbon economy impact assets of high emission intensity and fossil fuel assets. It's not surprising insurers are re-evaluating their portfolio exposure to the mining and metals sector as climate friendly and ethical underwriting accelerates.

4. Loss of market share

Consumers of raw materials are pressuring miners to provide low carbon products. Supplier screening for high emission commodities is inevitable for certain consumer facing industries and technology is being developed to aid transparency. Commodity producers unable to adapt may lose premiums associated with 'net zero' or 'low carbon' commodities and could lose market share in the long run.

5. Risk of increased operating costs

Whilst hurdles remain in implementing a global carbon price mechanism, its implementation would result in a material reordering of relative cost curves positions and absolute levels – therefore impacting company's relative competitiveness.

6. Litigation, greenwashing and regulation

The potential for litigation regarding climate change is an increasing tail risk for the mining industry. Litigation regarding corporate greenwashing is on the rise and company boards may be ultimately held accountable for disclosures. Marketing low carbon/net zero commodities, unsubstantiated green revenue estimates and claims of 100% renewable powered assets may also become ammunition for disgruntled stakeholders or climate activists in the future.

7. Failure to meet aims of The Paris Agreement

The risk of over promising and under delivering is significant for the mining industry. But the risk of not achieving the collective goals and aims under The Paris Agreement impact the whole of society. This will severely undermine the sustainability of our modern society.

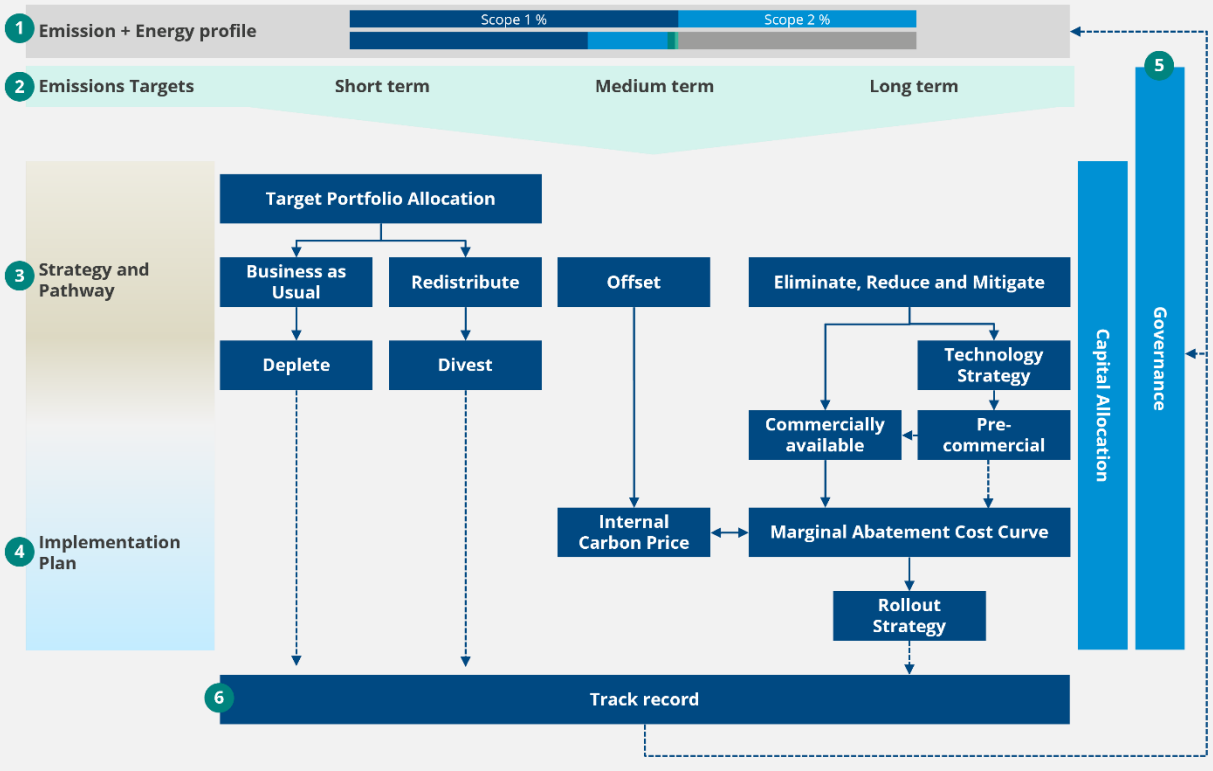
RFC Ambrian's decarbonisation framework

Following approaches from stakeholders grappling with their involvement, and miners trying to communicate a meaningful decarbonisation pathway, RFC Ambrian developed a framework specific to the mining industry to guide the evaluation of mining and metals decarbonisation efforts and the credibility of stated decarbonisation targets.

RFC Ambrian's mining and metals decarbonisation framework includes 7 steps:

1. Compiling the current emission profile, energy usage and current portfolio allocation.
2. Identifying the company emissions targets.
3. Mapping and categorising the company decarbonisation strategy and pathway.
4. Overlaying the company implementation plan, capital allocation and resourcing.
5. Assessing governance frameworks and transparency with respect to decarbonisation.
6. Identifying, assessing, and comparing the company track record and initiatives completed to date.
7. Evaluating the overall company decarbonisation strategy and pathway with consideration to each of the previous steps.

Visualising RFC Ambrian's mining and metals decarbonisation framework

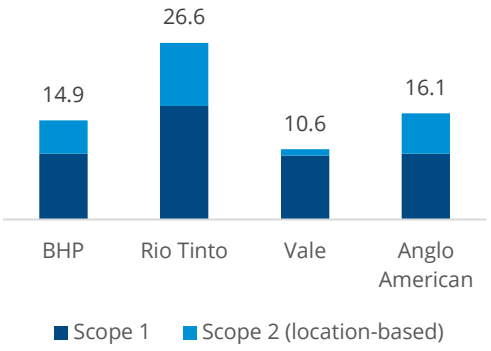


Source: RFC Ambrian

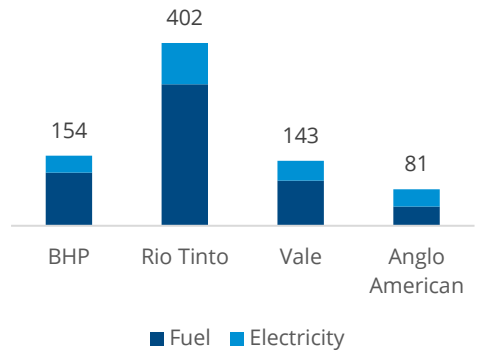
Evaluating major mining companies – by the numbers

RFC Ambrian applied the framework to some of the largest diversified miners – BHP, Rio Tinto, Vale and Anglo American - to critically evaluate their proposed strategies and pathways including how they intend to meet milestones and achieve goals. The report steps through each of the 7 steps in the framework – some summary key facts and figures are shown here.

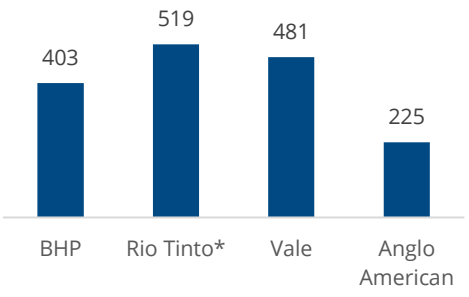
Scope 1 + 2 emissions (Mt CO2e Op. basis)



Energy use (PJe)



Scope 3 emissions (Mt CO2e Op. basis)

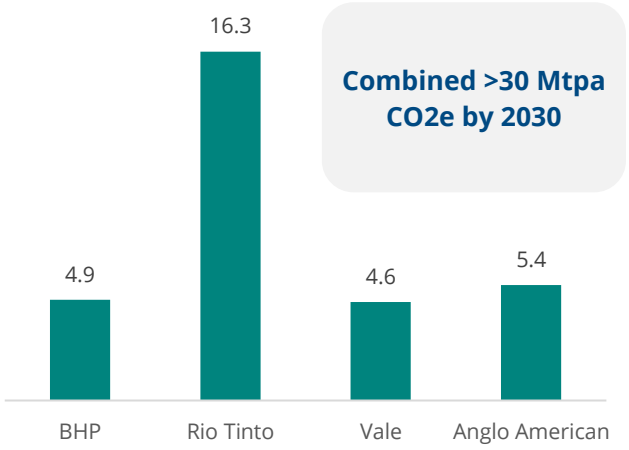


*Equity basis

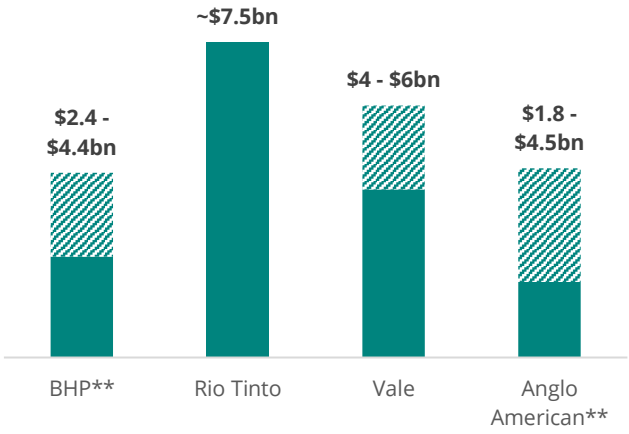
**RFC Ambrian analysis

Source: Company announcements, RFC Ambrian analysis

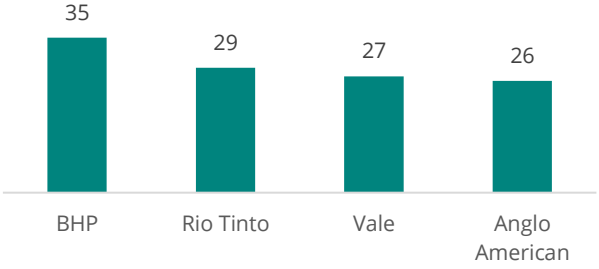
Emissions reduction to meet announced medium-term target (Mtpa CO2e vs. baseline year)



Announced decarbonisation funding (US$bn)



Number of recently announced initiatives, R&D projects, renewable projects and partnerships



Comparing medium-term (2030) emission reduction targets and strategic pathways

BHP	Rio Tinto	Vale	Anglo American
By 2030 (vs FY2020 Baseline year)	By 2030 (vs 2018 Baseline year)	By 2030 (vs 2017 Baseline year)	By 2030 (vs 2016 Baseline year)
At least **30% absolute reduction**	**50% absolute reduction**	**33% absolute reduction**	Net **30% absolute reduction** **30% improvement in energy efficiency** **8 carbon neutral** operations
• Decarbonising electricity supply (FY21-FY25) • Facilitate electrification and diesel displacement (FY26-FY30)	• Switching to renewables • Optimise processing plants and trial new technologies	• Zero scope 2 emissions (self-sufficient renewables) • Energy efficiency and new processes in pelletizing and metallurgy • Electrification to replace diesel consumption	• Improving energy efficiency • Invest in innovation, FutureSmart MiningTM technologies, H2 fuel cell rollout • Switch to renewables

Who does what well, and what can they learn from each other?

BHP	› Significant support for R&D and industry partnerships › Scope 3 initiative leader to date › Low emission technology strategy
Rio Tinto	› Strategy and pathway driven by a bottom-up approach to support ambitious 50% scope 1 + 2 emissions reduction › Comprehensive and detailed abatement opportunity set › Largest decarbonisation funding commitment of US$7.5bn
Vale	› Renewable energy leader, ambitious renewable energy self-sufficiency plans in Brazil › Explicit shadow carbon price used to evaluate abatement opportunities and integration with capital allocation decisions › Large decarbonisation funding commitment - US$4-6bn by 2030
Anglo American	› Energy reduction targets via ECO2MAN program to implement energy saving at the operational level (with an impressive track record) › FutureSmart Mining™ technology strategy › Ambitious targets - net-zero by 2040, 8 carbon neutral operations by 2030

Evaluation findings

The evaluation demonstrated the mining and metals industry intent to decarbonise, with ambitious net zero targets accompanied by plausible pathways to decarbonise. Each company has already implemented multiple meaningful initiatives and continue to develop new initiatives to meet their stated targets. There is always room to improve and address some inadvertent decarbonisation trends which have the potential to derail the credibility of the industry to execute on their decarbonisation targets and ambitions in the long term.

Inadvertent decarbonisation trends	
Energy efficiency	Elimination, reduction and mitigation of emissions is not always the priority, when in fact it should form the core pillar of any decarbonisation strategy
Technology strategy	Lack of dedicated focus (or proof thereof) to identify, pilot, and implement technologies with the potential to provide outsized carbon emission abatements in the long term
Abatement opportunities	Developing and updating valid marginal abatement cost curves which effectively compete for capital allocation is critical
Renewable PPA procurement	Renewable power purchase agreement ("PPA") procurement should support new renewable generation capacity, and not be procured from existing generation
Scope 2 measurement methodologies	Location-based vs. market-based scope 2 emissions and what it means for "100% renewable energy" claims
Energy storage	Ignoring the inevitable need to back up variable renewable energy for offsite grid generation
Electrification	Going 'all-in' on electrification and the potential to lose sight of larger sustainability goals (and forgetting about energy efficiency)
Asset depletion	Winding down high emission assets is not a valid strategy in isolation and should be combined with an elimination, reduction, and mitigation strategy
Carbon offsets	Plugging emission gaps to meet targets diverts attention away from actions miners could be undertaking to improve their operational emissions
Implementation plan	An inadequate implementation plan prevents the effective translation of board and senior ambitions to the site level

RFC Ambrian mining company evaluation summary table

	BHP	Rio Tinto	Vale	Anglo American
Strategy and pathway				
Redistribution	🟠	🟠	🟠	🟠
Eliminate, reduce, and mitigate (Efficiency focus)	🔴	🟢	🟠	🟢
Carbon offsets	🔴	🟠	🟠	🟢
Technology strategy	🟢	🟠	🟠	🟢
Implementation plan				
Abatement opportunities (MACC)	🟠	🟢	🟢	🔴
Shadow carbon price	🟠	🟢	🟢	🟠
Capital allocation and resourcing	🟢	🟢	🟢	🟢
Governance	🟢	🟢	🟢	🟢
Track record				
Initiatives implemented	🟠	🟠	🟠	🟢
Renewable energy	🟠	🟠	🟢	🟠
Technology and other Initiatives	🟢	🟠	🟠	🟢
Target credibility evaluation				
Medium-term credibility (2030 target)	🔴	🟢	🟢	🟠
Net-Zero target credibility (long-term target)	🟠	🟠	🔴	🟠
Scope 3 ambition/target credibility	🟢	🟠	🟠	🔴
Governance and transparency	🟢	🟠	🟠	🟠

Conclusions

The mining and metals industry is difficult to assess due to the breadth of commodity products, mining methods, and uniqueness of each of asset which constitute a company portfolio. Its status as 'hard-to-abate', means the complexity of solutions required to decarbonise demands a carefully curated decarbonisation strategy and pathway. The challenge for the mining sector is massive as they are expected to radically decarbonise whilst simultaneously increase profitability, grow production, and replace reserves in the face of declining ore grades.

RFC Ambrian's framework places a focus on the physical processes at play when a decarbonisation decision is made, and therefore enables an evaluation of the long-term sustainability of such decisions and strategies beyond 'reporting'. Several areas for improvement and common pitfalls have been identified – some of which are short term issues caused by a lack of alignment between market forces, incentives for the private sector and the societal goal of decarbonisation, and thus may take years to become evident. This summary concludes with a subset of RFC Ambrian's 'hard-to-abate' questions, which stakeholders can use to challenge and further assess company decarbonisation strategies and ultimately, long-term sustainability.

A subset of some 'hard-to-abate' questions

- Are emission targets predicated on location based or market based scope 2 emissions? How do location based scope 2 emissions compare to market based scope 2 emissions?
- Do you have any corresponding energy intensity and absolute energy reduction targets?
- What is the estimated implicit carbon price required to achieve your 2030 targets? 2050 targets?
- How have you assessed technology risk and maturity in your abatement opportunity set?
- What R&D, pilot projects or demonstrations have you initiated to address your largest emission source? How are you going about doing this – partnerships, investee companies or self developed?
- What portion of the company's renewable PPAs have contributed to underpinning new generation? What portion is sourced from existing renewable generation?
- At what marginal abatement price will the company consider carbon offsets?

Introduction

Financial institutions, insurance firms, shareholders and other stakeholders are grappling with their exposure to the mining and metals sector in light of climate risks, societal pressure and regulatory headwinds. This translates to increased scrutiny of the industry's decarbonisation efforts, even though the mining and metals industry has an essential role in supplying critical minerals and metals to enable the energy transition away from fossil fuels. The mining industry quite literally provides the building blocks for society, however it also has a relatively outsized impact on the environment due to its extractive and energy intensive nature.

In response, effectively all major mining companies have a stated target, or ambition to achieve net zero emissions by 2050 (or earlier) and have outlined strategies to achieve these ambitions. Whilst the intention is sound, the path to net zero is riddled with unknowns and requires in-depth industry knowledge to evaluate. ESG ratings provide a broad indication with environment as a constituent component, but significant ratings dispersion is evident amongst providers. Market participants are also displaying heightened sensitivity to greenwashing, a practice to which the mining industry is highly susceptible given the juxtaposition of 'extractive industries' with terms like 'green' and 'sustainable'. Activist efforts targeting greenwashing are rising in sophistication and a number of general frameworks are emerging for identifying greenwashing tactics[1].

Establishing credible decarbonisation strategies and pathways is essential to the industry's success in a carbon constrained future and gaining continued support from stakeholders. To date there has been a cautious approach by the industry to achieve emission abatement, as they rationally opt for divestments, procure renewable power, carbon offsets or pursue other low hanging, short term emission abatements which utilise existing technologies. This approach has thus far resulted in minimal change at the site or operational level – leading to a significant disconnect between the ambitions of the board and senior management, what is announced to the market, and what is occurring on-site.

The industry is reaching a tipping point whereby existing technologies can no longer meet the emissions reduction trajectory required by 2030 or 2050 net zero commitments. This leads us to an intriguing dilemma, whereby miners are keen to see new emission abatement technology developed but are often not willing to accept new technology risk, instead adopting a 'wait and see' approach. This approach may work with technologies with a broad market, for example, renewable electricity production and associated storage, however it will not work for mining and metals specific technologies which are unable to be developed, piloted, and ultimately reach commercial maturity without industry support.

In this context of the mining industry struggling to effectively communicate defensible decarbonisation strategies and pathways, RFC Ambrian is proposing a framework for evaluating the climate change policies, plans and ambitions of the world's largest diversified mining companies.

This report begins with an outline of the risks of overpromising and underdelivering (i.e. the risk for getting it wrong), including greenwashing and reputational risks. We then proceed to lay out a framework for analysing the validity and feasibility of proposed decarbonisation strategies and importantly, how the strategy is intended to trickle down to the site level and drive operational change. We then apply the framework to the largest diversified miners to critically evaluate their proposed strategies and pathways including how they intend to meet milestones and achieve goals, how the strategy aligns with their portfolio allocation and emissions profile as well as alignment with initiatives implemented to date. Finally, we summarise our findings, discuss the implications for the industry and pose some 'hard-to-abate' questions which stakeholders can use to probe mining companies' decarbonisation efforts.

Companies covered: BHP, Rio Tinto, Vale and Anglo American.

1. The Risks of Getting it Wrong

This section summarises the ultimate purpose of this report – to discuss the importance of pursuing real change. There are many risks to the mining and metals industry of overpromising and failing to deliver on long dated decarbonisation targets and the credibility of decarbonisation strategies and pathways in the short- to medium-term need evaluation.

Stakeholder scrutiny is increasing

Stakeholders are increasingly wary of climate change risks and perceptions of greenwashing. A key turning point occurred in January 2020, when the largest asset manager in the world, BlackRock, Inc., announced sustainability as the new standard for investment strategy and called for greater transparency and sustainability standards. One year later accusations emerge that Blackrock themselves are greenwashing, including the ex-BlackRock sustainable investing chief investment officer denouncing the entire industry, claiming "Wall Street is greenwashing finance"[(2)]. The long domino of stakeholders imparting pressure down the chain is quickly landing on the mining and metals industry's doorstep. Some examples relating to the companies covered in this report include:

- BHP (August 2021) – shareholder's encouraged by proxy advisor to vote against BHP's climate strategy on the basis the current targets do not appear to be certified by external organisations (principally the Science Based Target Initiative ("SBT")) and not aligned with The Paris Agreement[(3)]. Additionally, in what appears to be a backflip by activist groups on fossil fuel divestments - activists have also called upon BHP to manage down its fossil fuel production in line with its stated support for net-zero emissions and the Paris Climate Agreement (rather than divest the assets via the proposed Woodside merger)[(4)].
- Rio Tinto (May 2021) – activist brought forth two resolutions to Rio Tinto Limited: 1) that Rio Tinto's targets should be independently verified as aligned with the climate goals of the Paris Agreement (99.0% of votes cast voted in favour of the resolution (votes cast - 58.2%)); and 2) Rio Tinto enhance its annual review of industry associations to ensure that the review identifies areas of inconsistency with the Paris Agreement (99.0% of votes cast voted in favour of the resolution (votes cast - 58.2%))[(5)].
- Anglo American (May 2016) – shareholders owning 5% of Anglo American's voting stock tabled a resolution calling for increased transparency from Anglo American with respect to climate change (96.3% of votes cast voted in favour of the resolution (votes cast – 68.5%))[(6)].

The mining industry needs to stay ahead of the curve by implementing decarbonisation initiatives that have a real impact and thus demonstrate resilience and credibility. The landscape is readily changing and initiatives that were applauded without analysis a short time ago are now being scrutinised heavily. Carbon offsets are one such initiative and a topic widely discussed in this report. Emissions accounting management is gradually moving into the limelight. Furthermore, regulators are starting to turn their attention to greenwashing (discussed further below under "Litigation, greenwashing and regulation") and its potential to undermine confidence in the decarbonisation transition.

Increased cost of capital and access to finance

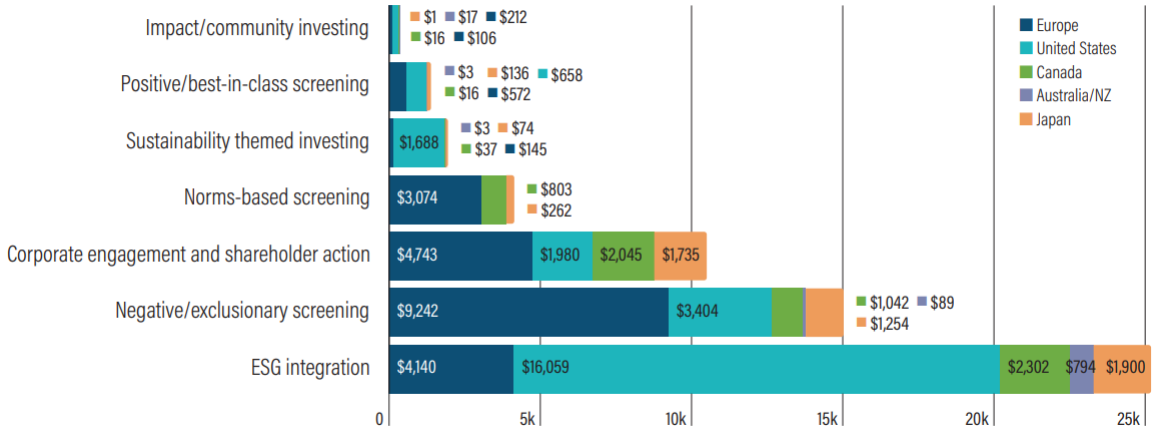
Financial institutions are under increasing pressure from their own stakeholders (including regulatory) on climate risk management and global sustainability. In response, financial institutions are increasing the breadth and depth of ESG assessments and are broadly channelling funds into companies with green credentials. Many financial institutions are assisting with guiding their existing clients towards greener pathways; however it is not

always straight forward. In fact some forward facing commodity producers may struggle to obtain financing if their underlying assets are powered by coal or fuel oil to avoid any perception of association. Green bonds, green loans, and other sustainability-linked lending is increasing drastically, but eligibility criteria are strict and do not always support the transition of so called 'brown' industries, despite these industries contributing the lion's share of emissions. There is strong momentum for transition bonds and loans for brown industries, however financiers are approaching with caution to avoid stakeholder criticism of greenwashing. As a result the assessment process for transition loans is currently more rigorous than vanilla green lending products, decreasing the available funding for transition activities.

Financial institutions are increasingly demanding higher rates of return for lending to fossil fuel companies and brown industries. Such measures are often explicit adjustments, for example Natixis' Green Weighting Factor, which can result in a lower analytical risk weighting of up to 50% for green deals, while facilities with a negative climate impact can be increased by up to 24%[7]. Financial institutions have essentially turned their backs on thermal coal assets entirely, forcing such assets to private sources of funding.

The rising trend in responsible or ethical investing has also resulted in an explosion of sustainable, ESG, ethical and green marketed Exchange Traded Funds ("ETF's"). Sustainable investing (a term is inclusive of all investment approaches that consider ESG factors) now constitute 35.9% of total assets under management as of 2020[8]. There are varying degrees of sustainable investing, the bulk of which relates to ESG integration (systematic inclusion by investment managers based on ESG factors) and negative screens for companies in specific sectors (e.g. oil and gas, thermal coal) as shown in Figure 1.

Figure 1. Sustainable investing assets by strategy and region (US$bn)



Source: Global Sustainable Investment Alliance

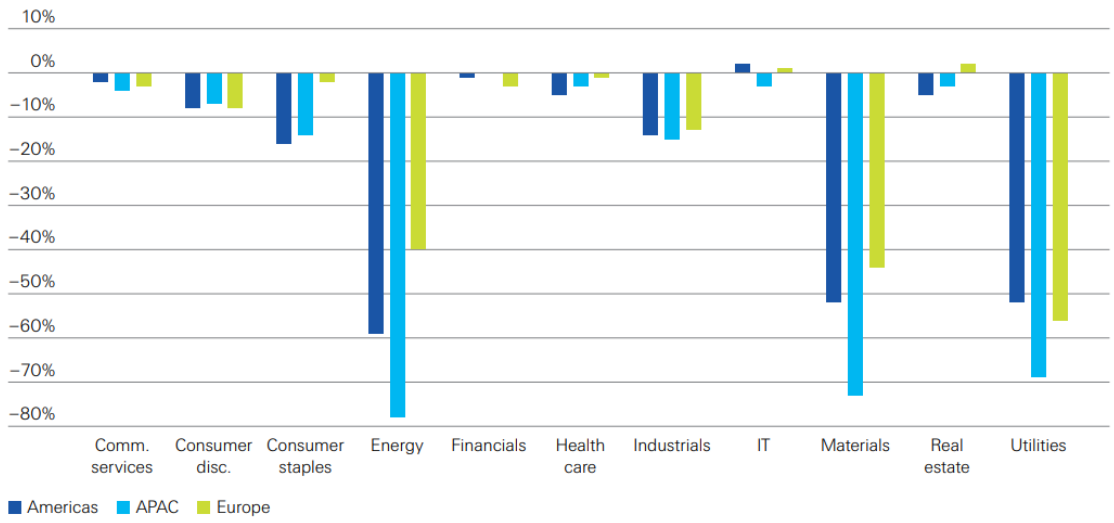
Investors increasingly demand their money is invested in companies making a difference and not just maintaining the status quo. A move towards positive screening is underway, albeit from a low base - just 4% of ESG ETF's undergo positive screening[9]. It's likely the screening process will become more robust over time as investors and fund managers increase their sophistication with respect to emissions. Regulators are also clamping down on the definition of ESG marketing products (see section Litigation, Greenwashing and Regulation below). Inclusion or exclusion from such ETFs and investment products provide an implicit change in the cost of capital in the long run.

Insurance

The insurance industry is facing an uphill battle against escalating climate change risks and corresponding regulation. Increased frequency and severity of extreme weather events leave insurers heavily exposed to outsized losses related to physical risk. It's not surprising insurers are moving to climate friendly and ethical underwriting as they carry outright explicit exposure to climate events. Consequently, they have a vested interest in both assessing the clients they insure and, as a major participant in financial markets, also assess where to allocate investment funds.

Insurers are also facing a growing amount of transition and liability risks. Transition risks are owed to changes in asset values and the increased cost of doing business in a low-carbon economy – due to their energy intensity nature, the energy and materials sector are most exposed as indicated in.

Figure 2. Transition risk – Impact of US$100/t global carbon tax on revenue-weighted earnings



Source: Swiss Re (2021)

The thermal coal industry is suffering from a dwindling insurance market as more and more major insurers take a stance against providing any insurance or reinsurance for thermal coal mines and power plants, those both in operation and in planning. A recent example is Swiss Re, one of the world's largest reinsurers, which announced it will no longer provide coverage to high carbon emitting industries, and will also divest its US$110bn balance sheet of such investments over the coming decades[10]. The future may hold a similar binary decision for high emission assets, or more broadly those with a poor environmental and sustainability record.

Loss of market share

Just as mining companies are coming under pressure for their downstream scope 3 emissions, end users, particularly those which are consumer facing, are pressuring their suppliers to provide products with less emissions intensity, such as Apple using carbon neutral aluminium. In some instances, this may be limited to the financial loss of a premium for supplying a 'net zero' commodity, but in certain circumstances companies can be effectively blacklisted from supplying commodities to a particular end user. An extreme example is the recent scandals involving child labour in the DRC and the responsible sourcing of cobalt in particular – to the point where BMW announced it would source cobalt for its next generation of EVs from Moroccan and Australian mines from 2020[11]. Consequently, it is not a stretch to consider end users negatively screening suppliers and commodity products for high emission intensity commodities. In fact, miners have already started the process of screening for emissions of their upstream suppliers, such as BHP requiring its direct supplies to reach net zero by 2050 (but not its customers).

Platforms based on blockchain technology are emerging and purport to provide customers end-to-end commodity supply transparency required to practically complete such screening activities. Currently, multiple competing technologies exist in the space, each with their own sponsors creating material conflicts with respect to the validity of such platforms. However, there is no denying the widespread adoption of such a technology (potentially via a single validated platform) could substantially shake up commodity pricing in the long term, and in the context of this paper, provide a transparent means for stakeholders to directly assess the emissions intensity (and other ESG metrics) of each commodity a mining and metals company produces.

Many large consumer facing businesses are already screening suppliers and only using recycled materials as the ideology of a pure circular economy gains traction. Whilst the concept of a circular economy without any mining seems fanciful, in a similar vein to net zero ambitions, the Netherlands has announced an ambition for a fully circular economy by 2050[12]. Such ambitions support the growing view that the mining industry is inherently unsustainable and for some, supporting a pure circular economy is considered the only path forward.

Increased operating costs

In addition to the impacts to the cost of capital and insurance, carbon prices would have a material impact to the operating costs of the mining and metals industry. Whilst multiple hurdles remain in implementing a global carbon price, the move to a global carbon pricing mechanism would result in material reordering of cost curves positions and absolute levels and lead to material variations in the relative competitiveness of mining and mineral assets, particularly for emissions intensive commodities such as aluminium, copper and nickel. Whilst downstream processing can be relocated, the orebody will always be constrained by its jurisdiction and, without additional capital, the prevailing local energy generation mix.

Litigation, greenwashing and regulation

A material tail risk facing the mining and metals industry is the potential for litigation around climate change. Litigation could take the form of holding companies accountable for emissions or for greenwashing.

A few years ago, it was unthinkable that a major oil and gas company could be successfully held accountable for climate change, however the recent historic precedent set by a Dutch court requiring Royal Dutch Shell to reduce its greenhouse gas emissions by 45% by 2030, including scope 3 emissions[13], has widespread implications. Stakeholders are increasingly concerned about such tail risks, and while it is currently limited to thermal coal and oil and gas companies in the short term,

the momentum of such climate change activism could flow over to other commodities and industries as well.

A greater probability litigation event is certain stakeholders litigating over 'greenwashing', meaning companies and their board may be ultimately held accountable for greenwashing disclosures. Regulators worldwide are increasing their scrutiny in response, specific examples include:

- The US Securities and Exchange Commission questioning ESG ratings fitness for purpose over a broad range of companies and seeking feedback from asset managers with regards to the spread of greenwashing[14].
- The European Commission undertaking a consultation process with respect to substantiating green claims, including tackling greenwashing issues[15].
- The Australian Securities and Investment Commissions have conducted a review of the threat of greenwashing in the funds management space[16].

Readers will remember the extreme case of the Volkswagen DieselGate scandal, but recent complaints have extended to misleading advertising around low carbon energy from BP[17]. The mining and metals industry is far from immune to such litigation – the move to marketing green commodities, green revenue estimates and claims of 100% renewable powered assets may be ammunition for disgruntled stakeholders or climate activists in the future.

Failure to meet aims of The Paris Agreement

The risk of over promising and under delivering is significant for the mining industry, but the risk of not achieving the collective goals and aims under The Paris Agreement impact the whole of society.

Ultimately as a global industry and as a global civilisation this will mean that we don't come close to achieving The Paris Agreement, and don't come close to limiting the temperature increase to 2.0°C. This will severely undermine the sustainability of our modern society.

2. RFC Ambrian's Decarbonisation Framework

Insurers, financial institutions, and other stakeholders are re-evaluating their support for the mining industry in light of global decarbonisation goals. As section 1 discussed, supporting the industry carries significant transition risk. The entire industry - not just coal - is considered by some as inherently unsustainable. Insurers and financial institutions in particular are trying to assist miners with their transition, but often find it difficult to reconcile the miners' stated goals with their actions. They are often petrified at the prospect of greenwashing allegations if the clients they support are found to have acted disingenuously.

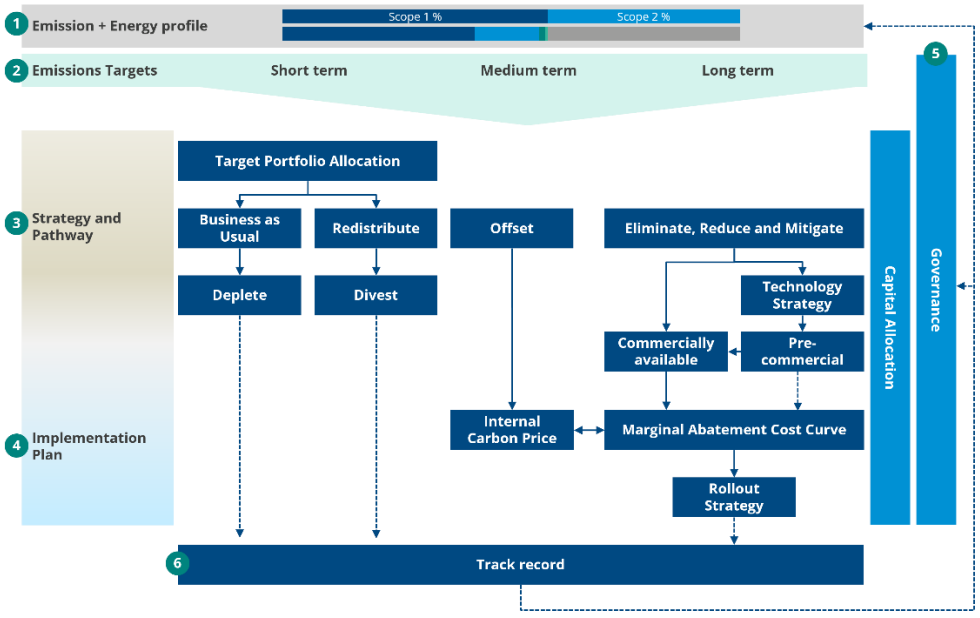
Following approaches from these firms and mining clients who are seeking advice regarding how to proceed, RFC Ambrian has developed a framework to guide the evaluation of miner's decarbonisation efforts and the credibility of their stated targets. This section outlines RFC Ambrian's mining and metals decarbonisation framework, including the underlying rationale.

2.1 Framework Overview

RFC Ambrian's mining decarbonisation framework is summarised by the following steps:

1. Compiling the current emission profile, energy usage and current portfolio allocation.
2. Identifying the company emissions targets.
3. Mapping and categorising the company decarbonisation strategy and pathway.
4. Overlaying the company implementation plan, capital allocation and resourcing.
5. Assessing governance frameworks and transparency with respect to decarbonisation.
6. Identifying, assessing, and comparing the company track record and initiatives completed to date.
7. Evaluating the overall company decarbonisation strategy and pathway with consideration to each of the previous steps.

Figure 3. Visualising RFC Ambrian's mining and metals decarbonisation framework



Source: RFC Ambrian

2.2 Current Emissions, Energy Profile and Portfolio Allocation

This step identifies the company emissions according to scope 1, 2 and 3 emissions and categorised by commodity. Companies can report using two different emissions consolidation methodologies, which should be noted and where possible adjusted to allow comparison among peers:

- Operational control approach - whereby a company reports 100% of emissions from assets they control and does not account for GHG emissions from assets they do not control. Can be further delineated into financial control approach.
- Equity share approach – company accounts for the equity share of its emissions.

The two approaches provide the same result when the company owns 100% of an asset. For this report the consolidation method the company chooses to present in its reporting will be noted but presented as the operational control approach for the sake of comparison.

Where data is available, analysis should be undertaken to measure emissions at the asset or business unit level to compare emissions intensity verses peers via a GHG emissions intensity curve. For this report the scope has been limited to companies' emissions as reported via their most recent sustainability report as opposed to diving into emissions measurements, boundaries, and categorisation.

Equally important to understanding the emissions profile is to investigate total energy usage (electricity, diesel, gas and other) to ensure reported emissions are not simply being managed at the expense of greater energy use. Such analysis considers the energy intensity of operations and cross references against the emissions profile to ensure absolute energy usage is not increasing at an unsustainable rate. Furthermore, consideration should be given to boundaries of the operation, including any integration of downstream processing to ensure an apples-to-apples comparison.

2.3 Emission Targets

Whilst correctly stating mining companies' emissions targets seems trivial, this step delves into the fine print of stated targets and ambitions for each emission scope. Some of the key items to consider with respect to emissions targets include:

- consolidation approach of equity vs. operational control (as discussed in 1.1);
- absolute and intensity basis;
- selection of baseline years and the extent which these operate under a business-as-usual scenario;
- delineation of scope 2 emissions into location-based and market-based measures;
- whether decarbonisation objectives are stated as a target, ambition, or goal; and
- whether targets are science based and aligned with the Paris Agreement.

2.4 Decarbonisation Strategy and Pathway

Decarbonisation strategies vary drastically with respect to their framing and presentation. This is a function of each miner's existing emissions profile and portfolio decisions informing their optimal strategy and decarbonisation pathway. Regardless, each strategy can be broadly grouped according to several categories for consistent evaluation.

2.4.1 Target portfolio allocation

Strategy and pathway are shaped by company target portfolio allocation, which informs which assets it intends to retain, deplete, divest, expand, or acquire. As such, miner's decarbonisation strategies are often intertwined with their target portfolio allocation.

2.4.2 Business as usual – natural decline

As all mining assets have a finite life and require capital to replace reserves, miners can employ an explicit 'do nothing' strategy with respect to an asset

by not allocating capital to replace reserves, whilst continuing to produce and thus deplete high GHG emission intensity assets (whether scope 1, 2 or 3). This ultimately leads to a decline in emissions as the asset is starved of capital, ramps down production and is ultimately closed and rehabilitated.

RFC Ambrian's framework recognises that companies which choose to retain and thus take responsibility for and provide transparency around high emission assets may result in better societal outcomes than outright divestment (see Redistribute below). However, business as usual is not an effective strategy in isolation, and it must be combined with an elimination, reduction, and mitigation strategy to effectively reduce the lifetime emissions of the asset in question.

2.4.3 Redistribute

Redistribution is shifting emissions to elsewhere in the real economy, effectively removing associated emissions from the mining company's 'emissions balance sheet' but delivering no, or minimal, net benefit to emissions of a given country or society at large (i.e. 'societal emissions'). These actions may be deliberate, such as divestment, or inadvertent as discussed below.

Divestment

Outright divestment of a high GHG emission intensity asset.

RFC Ambrian's framework places little value on divesting high GHG emission intensity or fossil fuel assets and believes the process can be detrimental in many instances. Often acquirers of such assets have less capital adequacy and therefore less ability to implement capital projects to reduce emissions (not to mention coverage and performance of rehabilitation obligations). Divested assets may also be acquired by private operators who can function under the radar - increasing production and therefore potentially resulting in a net negative benefit to societal emissions.

An increasing amount of institutions negatively screen for fossil fuel assets and there is an implicit benefit to doing; increasing the cost of capital and broadly preventing capital allocation to such assets. However, where demand for the commodity remains (e.g., fossil fuels and/or energy) and the divested asset continues to operate, an equivalent, or even better carbon reduction could be achieved by focusing on reducing or eliminating emissions.

Inadvertent redistribution

These actions are more difficult to identify and categorise, but broadly encompass a redistribution of emissions to another sector of the economy. A specific example includes procuring certain renewable PPAs, where the purchase of renewable power is from an established renewable power generation asset and is unlikely to underpin any new renewable capacity (See note on 20). In such a scenario the underlying power supplied (the specific electrons if you will) powering the mining asset are often still generated from fossil fuels. Therefore, societal emissions are unchanged, with emissions shifted to other end users in the electricity network. This sleight of hand is difficult to discern and requires knowledge of the source of electricity, and whether in fact the PPA does in fact support new renewable generation capacity.

RFC Ambrian's framework is critical of company efforts which result in a redistribution of emissions, whether inadvertent or intentional. Inadvertent and intentional redistributions will ultimately lead to sub-optimal societal outcomes.

As mentioned, these actions are difficult to categorise and would likely fall somewhere along a spectrum, rather than a clearly inadvertent or intentional binary outcome. Regardless, an inadvertent redistribution will be inherently unsustainable in the long term from either an emissions or cost perspective. There are only so many existing renewable assets which can provide cheap, uninterrupted renewable power once baseload fossil fuel power is phased out - at some stage additional storage and renewable energy generation is required.

A note on scope 2 emissions:

Location-based vs. market-based allocation methods

Location-based scope 2 emissions	Market-based scope 2 emissions
Average emissions intensity of the electricity grid in which consumption occurs, or emissions from self-generation.	Emissions from contractual instruments such as renewable power purchase agreements and any associated renewable energy certificates or credits.

Recent changes to GHG emissions accounting have enabled corporations to report zero emissions from renewable PPA contracts by reporting market-based scope 2 emissions (or renewable energy certificates, green tariffs depending on jurisdiction), whilst still drawing electricity from the grid. In instances where a renewable PPA does not support new renewable generation these actions fail to have any discernible positive impact on societal emissions[18], as illustrated in Figure 4.

Figure 4. Illustrating location-based vs. market-based scope 2 emissions reporting

	Company A	Company B	Remark
Scope 2 emissions	1,000 ktpa CO2e	1,000 ktpa CO2e	*Company A and Company B are identical firms using the same amount of energy and connected to the same electricity grid*
Carbon abatement initiative	Procure renewable PPA from existing renewable generator for 100% of its electricity generation	Energy efficiency program to reduce energy consumption by 10% company-wide	*Company A uses market-based reporting* *Company B uses location-based reporting*
Post initiative reported Scope 2 emissions	Nil (100% reduction)	900 ktpa (10% reduction)	*Company A reports superior environmental performance*
Post initiative *actual* societal emissions	**Unchanged**	**100 ktpa reduction**	***But only Company B's actions result in a reduction of societal emissions***

Source: Brander et al. 2017, adapted by RFC Ambrian

Whilst the underlying economic rationale makes sense; procuring renewable power supports renewable energy generation and thus the renewable energy market; market-based allocations using existing renewable energy generation are not additional. This results in a misallocation of resources and reduces the incentive for individual companies to reduce or eliminate their operational carbon emissions (as opposed to their reportable emissions).

This is especially dangerous for the mining industry as declining ore grades will inevitably result in an increase in energy use over time so the incentive to manage emissions via market-based instruments is very high and perversely may even incentivise mining companies to use more energy, a topic covered in Section 7.

2.4.4 Carbon offsets

This step includes analysing the procurement of carbon offsets or funding of carbon offset projects. Again, this strategy sees the company make no fundamental change to operations, and instead rely on supporting other industries with a negative carbon footprint to 'offset' company emissions.

RFC Ambrian's evaluation framework presumes offsets are not a valid strategy for reducing the emissions of the mining and metals industry in the long term unless the underlying offset project(s) or credit(s) are directly related to the commodity value chain. If the offset does indeed pertain to some direct aspect of the commodity value chain, then our framework would suggest they be assessed for quality[19]:

Additionality - GHG emission reductions are additional if they would not have occurred in the absence of a market for offset credits; and

Permanence – GHG emission reductions must be permanent over time and unlikely, or impossible, to be reversed. A reversal occurs if at any point in the future, the rate of GHG emissions accelerates and becomes higher than it would have been if the project had never happened.

The availability of quality carbon offsets is limited and thus should be saved for emissions which are hardest to abate and towards the end of the decarbonisation journey, not as the first steps.

2.4.5 Eliminate, reduce and mitigate

Any action which results in an elimination, reduction or mitigation of emissions from a societal perspective. The actions available to a mining company are driven by its existing asset portfolio and emissions profile resulting in significant divergence between strategies.

This category is further refined into those actions available today using current technology and actions requiring advancement in technology to achieve, particularly in the category of 'hard-to-abate' emissions.

Commercially available technology

This may include installation of renewable energy (either self-operated or a renewable PPA which underpins new renewable generation), general efficiency improvements (e.g. install power saving light globes), reduction (e.g. switching from diesel to gas-fired generation), behavioural initiatives (e.g. not idling haul trucks for higher utilisation), optimisation initiatives (e.g. minimising truck haulage lengths and wait times) and elimination (e.g. switching from diesel vehicles to electric haulage) to name a few.

Pre-commercial and hard-to-abate emissions

This broad category is driven by the portfolio allocation and emission profile; some initiatives include decarbonising mining fleet/material movement, heat, steel production and carbon capture and storage.

In RFC Ambrian's view, the eliminate, reduce, and mitigate strategy is the only valid and sustainable pathway to long-term emissions reduction and compliance with obligations under The Paris Agreement. Furthermore, it is a valid strategy regardless of the company portfolio allocation decisions. Importantly, one should also investigate actual energy usage, not just emissions. Such analysis should consider the energy intensity over time from all sources to investigate efficiency of the underlying operation. Energy intensity is likely to be a key future sustainability driver in the mining and metals industry as the impacts of decreasing ore grades and the corresponding increase in energy intensity is appreciated by the market.

2.5 Implementation Plan

What use is a strategy without a specific and actionable plan to execute it?

Whilst the company strategy sketches out a broad pathway towards its emissions target, the implementation plan describes the 'how'. Principally, how does the company intend to eliminate, reduce and mitigate emissions? It may sound like a trivial question, but this step is critical

for mining companies to reduce their emissions in a sustainable fashion.

2.5.1 Abatement opportunity set and internal carbon prices

Foremost, a company needs to understand its specific emissions reduction opportunity set at the site level. Site level opportunities are then aggregated into a company-wide abatement opportunity set to assist with identifying larger reduction levers (which should in turn assist with refining the broader strategy and pathway).

Thus, the description of how a company identifies, pipelines, prioritises, and encourages emissions reduction opportunities is a vital indicator of the feasibility of any proposed strategy.

The primary tool to compare emissions reduction opportunities involves construction of a Marginal Abatement Cost Curve ("MACC"). The MACC plots the potential GHG emissions reduction (in CO2e) of each opportunity against the cost of implementing such a project, effectively ranking them. The cost is generally presented as an equivalent break-even carbon price, so those opportunities with a positive cost impact (negative implied carbon price) will plot to the left side of the curve and those with a negative cost impact will plot to the right (positive implied carbon price).

The MACC also supports the evaluation of the cost of abatement and the implied carbon price (internal or explicit) required to incentivise or achieve a particular volume of abatement. Consequently, a company-wide MACC informs what projects and associated costs are required to achieve the stated emission reduction objective for a particular year.

Whilst simple in its message it is fundamentally crucial to correctly understand and assess each opportunity on a risk/return basis, as with any capital allocation decision, if not properly considered it will be a case of garbage-in, garbage-out. The initial distinction relies upon identifying whether the abatement opportunity is commercially available or not. The MACC is a 'live' opportunity set and as such should be iterated, refined, and reviewed periodically to add new opportunities, progress advancing technologies and remove the opportunities which have been implemented or were not feasible after assessment.

2.5.2 Rollout strategy

Rollout strategy pertains to how effectively mining companies can deploy commercially available abatement opportunities at the site level. As such processes are unique to each firm and often not communicated externally, this can be assessed through the company track record.

2.5.3 Technology implementation strategy

Technologies which are not ready for commercial deployments require further assessment, development, and testing. For abatement opportunities which are considered essential to achieving emissions targets - but not yet commercially available - a clear technology strategy should be demonstrated and appropriately resourced. A wait-and-see approach will see the mining industry in the same place it is in today as many of the technologies do not have applications in other industries. Complexity arises across multiple fronts when assessing technology opportunities, and requires a cross-disciplinary team to properly assess across multiple facets:

- What stage of development is the technology at?
- How many years until a commercially viable product is available?
- What are the competing options or substitutes?
- What is the risk of failure of the technology to deliver? Operational risk? Reputational risk?
- Can the opportunity be rolled out across multiple sites, or is it bespoke?

The above requires a fundamental understanding of mining, geology, mineralogy, metallurgy, finance, energy, emissions, technology risk and technology commercialisation.

The technology implementation strategy is broad enough to warrant a dedicated report. For the purpose of this report, companies will be assessed on their approach to:

- R&D program(s);
- pilot and trial testing;
- transitioning pilot projects to full implementation;
- technology partnerships;
- pipelining new opportunities; and
- direct investment in emerging technology.

2.5.4 Capital allocation and resourcing

The next facet is ensuring the strategy is adequately resourced to enact the plan and ultimately achieve the stated targets. This is an area where the devil lies in the details as decarbonisation funding and projects are generally considered under a broader capital allocation framework. Capital allocation will also need to determine how to best allocate between projects which are commercial and can be implemented today and those which require further investment via pilots, trials, and R&D.

2.6 Governance and Transparency

Governance and goes directly to the credibility of a decarbonisation strategy, whilst another broad topic the most key components include:

- Ensuring an appropriative emissions reduction target, defined pathway and implementation plan is put in place;
- Correctly incentivising implementation of the strategy to achieve quantifiable emissions reduction goals; and
- Implementing systems to ensure the ambitions of the board and senior management level are translated to personnel at the site level – i.e. empowering personnel at the site level to share ideas, take calculated risks, and ensuring an aligned site culture.

A key aspect which is often missing is the link between the ambitions of the board/ senior management and personnel at the site level. Technology opportunities which are on the cusp of commercial deployment often require a first customer to take on some technology risk – such proposals struggle to gain approval at the site level and consideration must be given for the task owner and funding source (site capex, or corporate funding initiative?).

Transparency allows for companies to accurately communicate their plans to the market, without omission. Without transparency we won't know what progress has or will be made in relation to meeting the objectives of The Paris Agreement.

2.7 Track Record – Initiatives Completed to Date

Are companies putting their money where their mouth is?

Scrutinising the company track record is key to assessing the credibility and thus likelihood of achieving current decarbonisation ambitions.

Previous initiatives completed need to be identified and categorised before assessing alignment with stated targets, strategies, and pathway. For the purpose of this report, publicly announced initiatives over the past 3 years have been considered, including those disclosed via annul reports, public announcements and Climate Disclosure Project Worldwide ("CDP") annual climate change responses.

2.8 Evaluation

Finally, an evaluation of the credibility of the overall decarbonisation strategy and pathway is made based on the above factors.

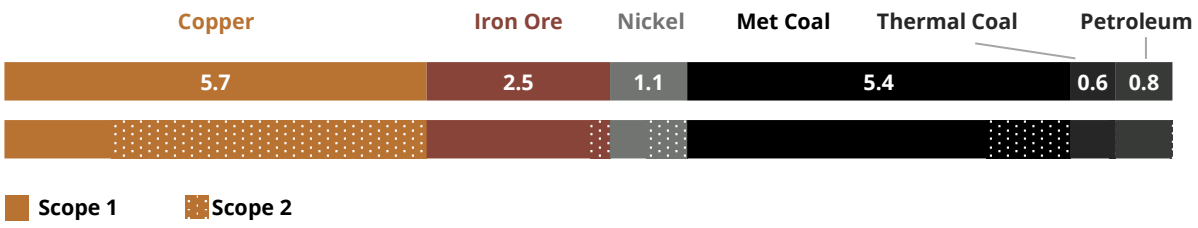
The following sections illustrate the application of RFC Ambrian's framework to four major diversified mining companies, BHP, Rio Tinto, Vale and Anglo American.

3. BHP

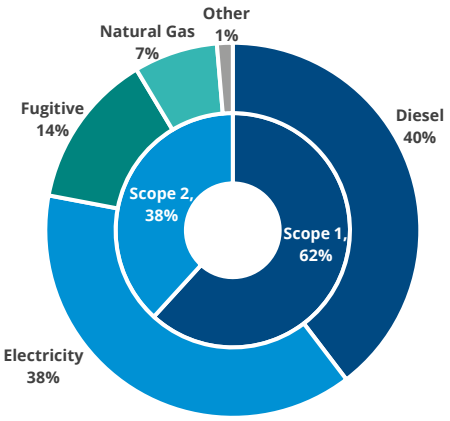
3.1 Existing Emissions and Energy Use Profile

BHP's current operational emissions see its copper operations having an outsized contribution to its total emissions (36%), a function of the relatively high energy intensity of its South American operations (desalination, crushing & grinding, SX-EW) and corresponding high emissions profile of its existing procured energy. The next largest contributor is its metallurgical coal operations, predominately driven by fugitive methane emissions. Despite contributing the majority of BHP's revenue, iron ore is responsible for a relatively small proportion of emissions due to the direct shipping nature of Western Australia iron ore requiring a minimal amount of downstream processing before being sold to customers. For reporting purposes, BHP states its emissions on an operational control basis, but also release equity and financial control data.

Figure 5. BHP FY21 scope 1 and scope 2 emissions by commodity (top, Mt CO2e) and source (bottom, %)



Scope 1	9.9 Mt CO2e	
Scope 2	6.2 Mt CO2e (Market-based)	5.0 Mt CO2e (Location-based)
Total	**16.2 Mt CO2e (Market-based scope 2)**	**14.9 Mt CO2e (Location-based scope 2)**

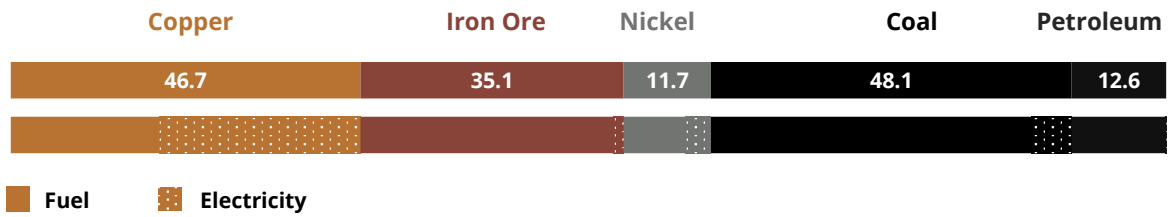


Source: 2021 BHP Sustainability and ESG Navigators Databook, RFC Ambrian analysis

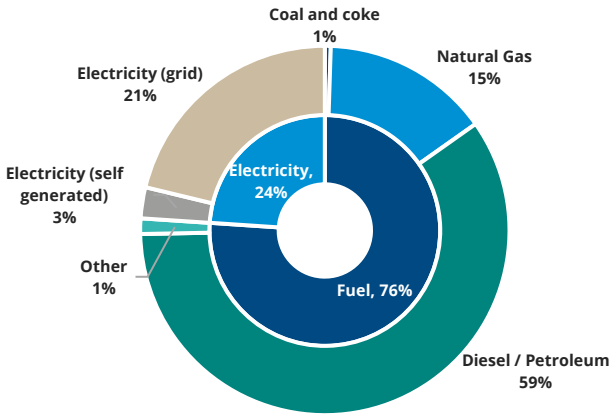
During FY20 BHP changed from a location-based approach to a market-based approach despite a resultant increase in reported emissions in the short term[20]. Since that date, BHP has signed very large renewable PPAs in Chile and so the reported emissions are forecast to fall substantially in future years as the PPAs come into effect.

Energy use is dominated by diesel use (59%), reflective of BHP's exposure to bulk commodities. Electricity use is the next largest energy source (24%), driven predominately by BHP's copper operations. Natural gas usage is the last major source of energy use (15%), driven by petroleum operations.

Figure 6. BHP FY21 energy use by commodity (top, PJe) and source (bottom, %)



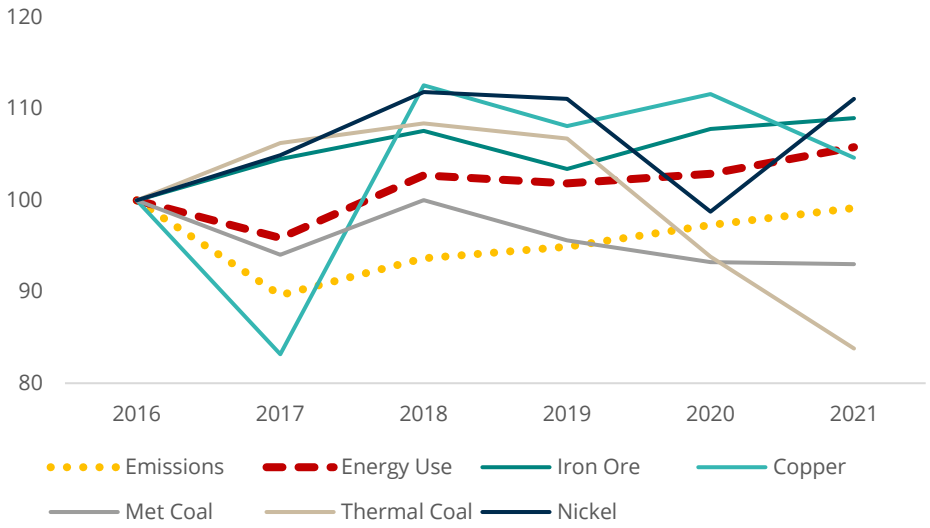
Fuel	117 PJe
Electricity	37 PJe
Total	**154 PJe**



Source: 2021 BHP Sustainability and ESG Navigators Databook, RFC Ambrian analysis

Figure 7 indicates that from 2017, BHP's emissions and energy use has risen over time, roughly in line with increasing production volumes suggesting minimal change in unit intensity over time.

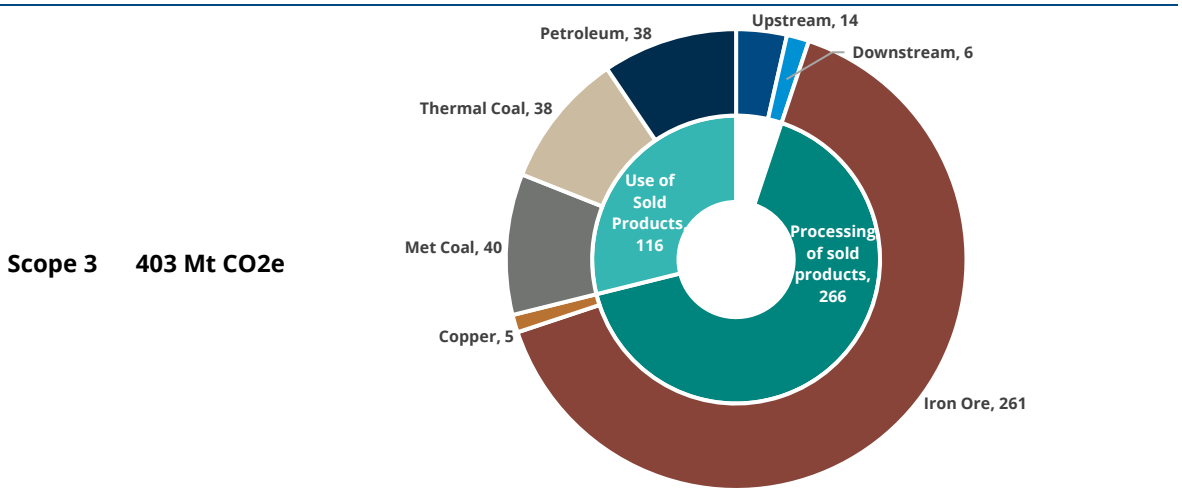
Figure 7. BHP historical emissions and energy use vs. production (indexed to 2016)



Source: BHP company announcements (adjusted for discontinued operations), RFC Ambrian analysis

Despite BHP's existing fossil fuel exposure (noting BHP has recently announced the sale of both its petroleum and coal assets) the single greatest contributor to scope 3 emissions is from processing iron ore into finished products.

Figure 8. BHP FY21 scope 3 emissions (Mt CO2e)



Source: 2021 BHP Sustainability and ESG Navigators Databook, RFC Ambrian analysis

3.2 Emission Reduction Targets

BHP's emissions targets are broadly science based (although not third party verified) and BHP states its targets align with the Paris Agreement. Emissions targets with respect to scope 2 emissions are market-based, and as noted in its emission profile, the timing of BHP's change to a market-based target results in an increase in its FY20 baseline emissions by 1.2 Mt CO2e[20].

BHP has recently announced scope 3 actions to support emissions, albeit heavily disclaimed, in steelmaking and transportation of chartered shipping of BHP products as well as broader scope 3 net zero targets.

Table 1. BHP emission reduction targets and ambitions

Target	Disclosure	Baseline year	Year announced	Science based?	The fine print
Long-term ambition	Net zero by 2050 (scope 1 and scope 2)	n/a	2017	Yes (not approved by SBT initiative)	• Carbon offsets will be used as required • Baseline adjusted for material acquisitions and divestments based on GHG emissions at the time of the transaction • Operational control approach • Market based scope 2 emissions
Medium-term target	At least 30% absolute reduction by 2030 (scope 1 and scope 2)	FY20	2020	Yes (not approved by SBT initiative)	
Short-term target	Maintain absolute emissions in FY22 at or below FY17 baseline	FY17	2017	No	
Scope 3 goals	Support Industry to develop technologies and pathways capable of 30% emissions intensity reduction in integrated steelmaking (expected post 2030). Support 40% emissions intensity reduction of BHP chartered shipping of its products	2020	2020	n/a	• Steel carbon intensity and nautical miles travelled intensity target to be lowered via low-carbon energy sources • 40% reduction in shipping emissions consistent with IMO's targets
Scope 3 targets	Pursuing the long-term goal of net zero Scope 3 emissions by 2050. To progress towards this goal targeting net zero for: • Operational emissions of direct suppliers • Emissions from maritime shipping of BHP products		2021		• Subject to widespread availability of carbon neutral goods, services, and marine fuels • Carbon offsets as required • Marine target excludes purchased goods • Operational emissions of direct suppliers includes their scope 1 and 2 emissions

Source: BHP Climate Change Report 2020, BHP Climate Transition Action Plan 2021, RFC Ambrian analysis

3.3 Target Portfolio Allocation

BHP sees significant growth in its future facing commodities - copper, nickel and potash, as well as continued role with more modest growth in iron ore and met coal markets to support infrastructure during the energy transition. BHP divested many of its high emission assets when the S32 demerger was completed in 2015.

Prior to August 2021, BHP had stated its Petroleum business will continue to form a key part of its portfolio. However, the announced merger of BHP's high margin Petroleum business with Woodside Petroleum appears to be strong evidence of the stakeholder pressures the mining industry is experiencing.

BHP also continues to shrink its thermal coal exposure, with the sale of its 33.3% interest in Cerrejón announced June 2021 to Glencore. Sales processes continue for the remainder of thermal and lower quality metallurgical coal assets, Mt Arthur coal mine and BHP Mitsui Coal (BMC), with the former no longer having any material carrying value after a US$1.7bn impairment charge during FY21[21].

Potash is now positioned as a forward-facing commodity in BHP's portfolio and by design, BHP announced the approval of the US$5.7bn Jansen Project Stage 1 on the same date as the divestment of its Petroleum business[22].

BHP is also moving to expand its nickel growth options through its recent bid for Noront Resources and its Eagle's Nest nickel project, whilst also announcing a deal to supply Tesla from its Nickel West operations. As a testament to the speed of transition, BHP was trying to sell Nickel West as recently as 2019[23] and now two years later Nickel West is positioned as a forward-facing growth asset in BHP's portfolio.

Whilst BHP has maintained metallurgical coal as a key business unit, it will be interesting to watch the discourse around metallurgical coal assets evolve in the coming years.

3.4 Strategy and Pathway

BHP has effectively split its decarbonisation strategy and roadmap into two distinct phases; 1) achieving its 2030 target, and 2) achieving its 2050 net zero ambitions.

3.4.1 Medium-term 2030 target

To achieve its 2030 target, BHP will prioritise abatement opportunities that have low capital intensity, are technologically mature and can deliver operating cost benefits to the business. Stated key areas of focus:

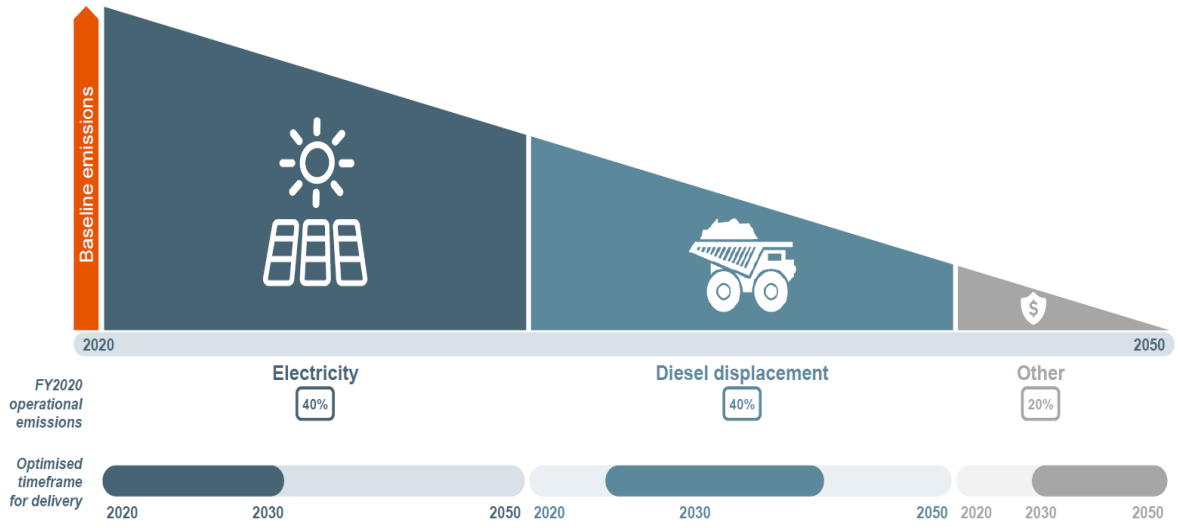
- Decarbonising electricity supply – focus during FY21-FY25.
- Facilitate electrification and diesel displacement – focus during FY26-FY30 (with feasibility studies progressed during FY21-FY25).

3.4.2 Net-zero 2050 target

BHP's net zero roadmap is primarily driven by renewable energy and electrifying material movement:

- 40% of emissions reduction will come from switching to renewable generation, including demand side optimisation, PPA procurement and behind the meter renewable energy installations where grid connectivity is limited.
- 40% from displacing diesel and material movement by leveraging green energy for electrification, collaboration with OEMs to advance material movement and potential advancement of green hydrogen.
- 20% from other – fugitive emissions, alternative heating sources (hydrogen), CCUS and carbon offsets.

Figure 9. BHP's illustrative pathway to net zero



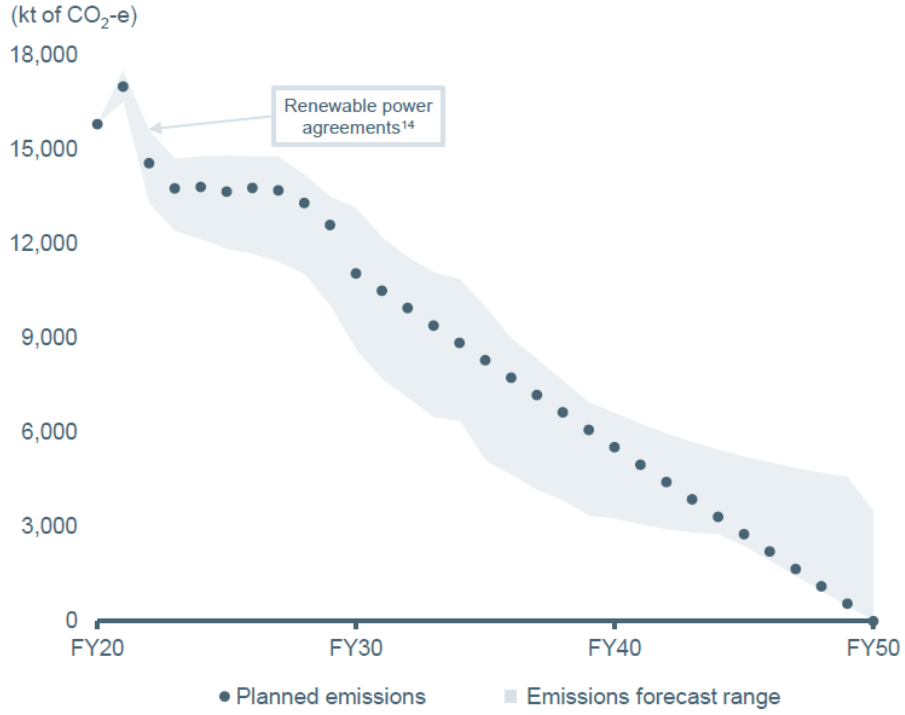
Source: BHP climate change briefing presentation September 2020

With respect to scope 3, BHP engages with its customers, with climate change being integrated into its supplier evaluation processes (56% of suppliers as at 2020). Climate change engagement strategy for customers is centred on an education campaign (77% of customers as at 2020).

No formal plan has been detailed to achieve BHP's scope 3 goals, but it appears to have a strong collaboration component and is supported by BHP's Climate Investment Program (CIP), detailed in the capital allocation section below.

BHP has provided an indicative emissions trajectory forecast as illustrated in Figure 10. The initial up-tick in emissions forecast followed by the rapid decline is attributable to the switch from location-based to market-based scope 2 emissions, coinciding with the start date of renewable energy contracts in Chile during FY22. From FY23 to FY27 emissions are forecast to remain flat before a rapid fall to achieve the stated 2030 target, presumably achieved through further decarbonisation of electricity and some diesel displacement. The emissions trajectory then follows a straight-line reduction, presumably by pursuing further diesel displacement and other hard-to-abate processes. It is clear BHP has prioritised electricity decarbonisation to enable diesel displacement via electrification in the future.

Figure 10. BHP scope 1 and 2 emissions reduction forecast range



Source: BHP climate change briefing presentation September 2020

3.4.3 Technology strategy

Overlaying BHP's 2050 net zero target is its Low Emissions Technology ("LET") strategy, which includes three elements based on technology maturity:

1) Adapt mature technologies such as light electric vehicles, in order to integrate them safely and effectively into operations.
2) Create road maps for development and adoption of LETs that support BHP's goal of net-zero emissions, which may include trials and demonstrations of technology in production environments.
3) Look for early stage LETs that hold high potential for future results, and seek opportunities for collaboration, research and other ways to accelerate its development and adoption.

3.4.4 Carbon offset strategy

BHP state its priority as the reduction of its operational GHG emissions, however it is simultaneously furthering its approach on using carbon offsets and support for market functionality. It expects to utilise offsets to deliver its net zero goal, in particular to address hard-to-abate emissions. It states that carbon offsets are included in most credible pathways to a global net zero emissions position. In addition to scope 1 and scope 2 emissions, it also expects voluntary and/or regulatory offsets to play a role for its customers. It is also considering the supply of offsets to complement its customers' decarbonisation strategies, which may include 'low carbon' product offerings or a standalone supply of offsets.

BHP intends to incorporate its carbon offset strategy via a forecast offset price and comparing against its MACC. During FY21, BHP retired 300kt of carbon offsets which it states to be additional and permanent, and therefore high quality[21].

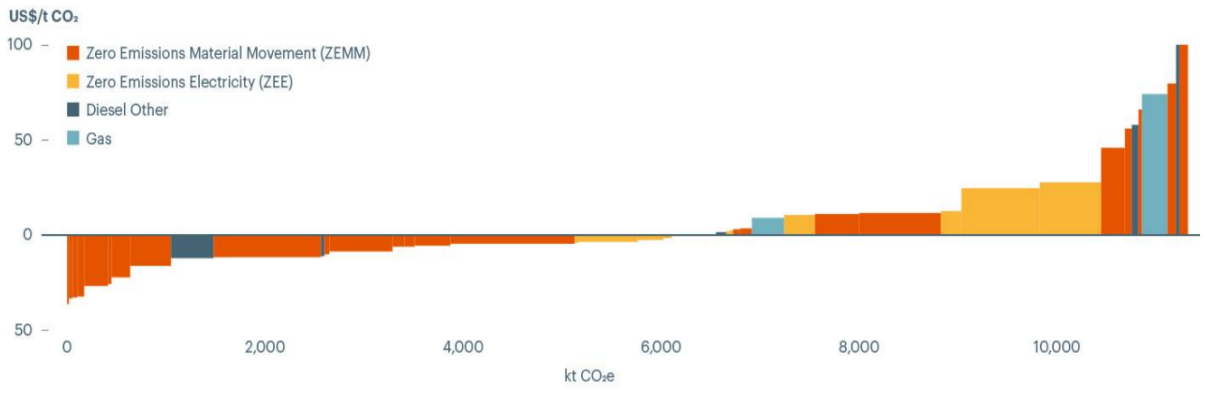
3.5 Implementation Plan

3.5.1 MACC and carbon price

BHP has developed the MACC in Figure 11 which works within its capital allocation framework. The MACC contains four categories; zero emissions material movement, zero emissions electricity, diesel/other, and gas; with the former two categories comprising the bulk of abatement volume. BHP acknowledges its abatement opportunities are at varying technical and commercial readiness levels and continues to study new abatement opportunities.

BHP uses an internal carbon price for asset valuations, to assess new investments, and in the future to guide carbon abatement investments.

Figure 11. BHP operational emissions marginal abatement cost curve



Source: BHP Climate Transition Action Plan September 2021

3.5.2 Capital allocation and resourcing

BHP has indicated potential capital spend of US$100-$200m p.a. over FY21-FY25 to pursue decarbonisation of its electricity supply - US$29m was spent in FY21 with a further US$65m committed[21]. Its spend in the FY26-FY30 phase is still uncertain, however BHP have indicated a total spend of US$2-4bn. These allocated funds sit under maintenance capital within BHP's capital allocation framework.

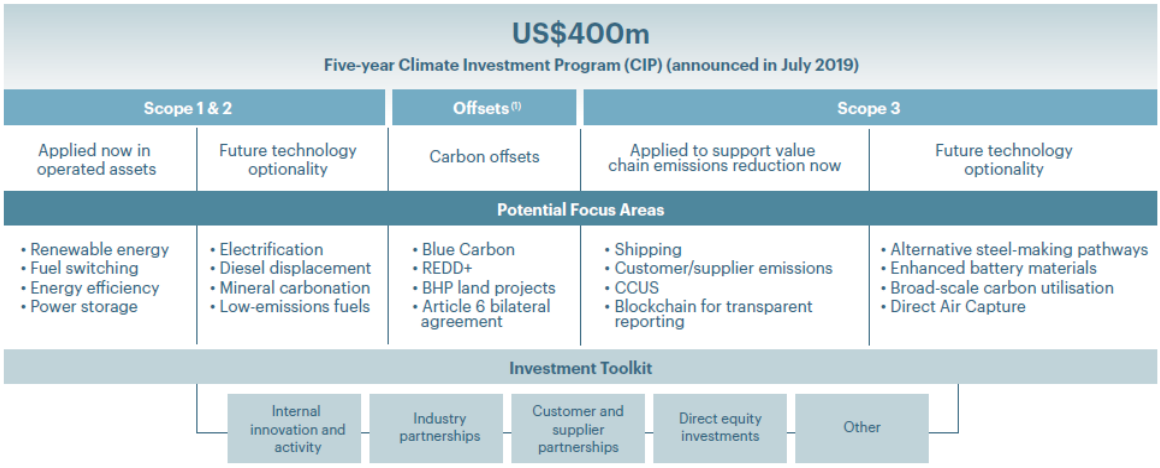
BHP has identified a pipeline of operational decarbonisation projects with capital spend expected to be in the range of US$100-$200m p.a., however details of operational decarbonisation projects have not been provided to date.

BHP also introduced a Climate Investment Program ("CIP") falling into its annual corporate planning process, sitting under BHP's Investment Review Committee. The process guides BHP's development of plans, targets, and budgets. The CIP totals US$400m over 5 years (from 2019), and states the following focus:

- Initial focus on Minerals division (Australia and Americas) operated assets and addressing scope 3 emissions in the Steelmaking sector.
- Invest to scale up LETs, invest in natural climate solutions and support partnerships to address scope 3 emissions via projects, partnerships, and investments in a range of products at different stages of technology maturity and risk.
- Develop a framework to identify and prioritise potential investments.
- Establish a robust pipeline of eligible projects to drive prioritisation across operated assets and value chain.
- Intend to allocate a meaningful proportion of capital to early and growth stage technologies aligned with the CIP's long-term objectives, which will be managed by BHP Ventures.

Some opportunities have replicable features that enable some projects to be rolled out to other BHP operated assets.

Figure 12. BHP's 5 year Climate Investment Program



(1) Our approach is not only to invest in projects that generate carbon offsets, but to prioritise investment in projects, initiatives or finance mechanisms that stimulate the market for additional offsets.

Source: BHP Climate Change Report 2020

Finally, BHP Ventures was set up in November 2020 as an internal venture capital unit to invest in early-stage companies targeting critical global challenges, particularly in relation to decarbonisation and sustainable resource extraction. BHP has not yet disclosed the amount of funding provided to BHP Ventures or if it interacts with the CIP.

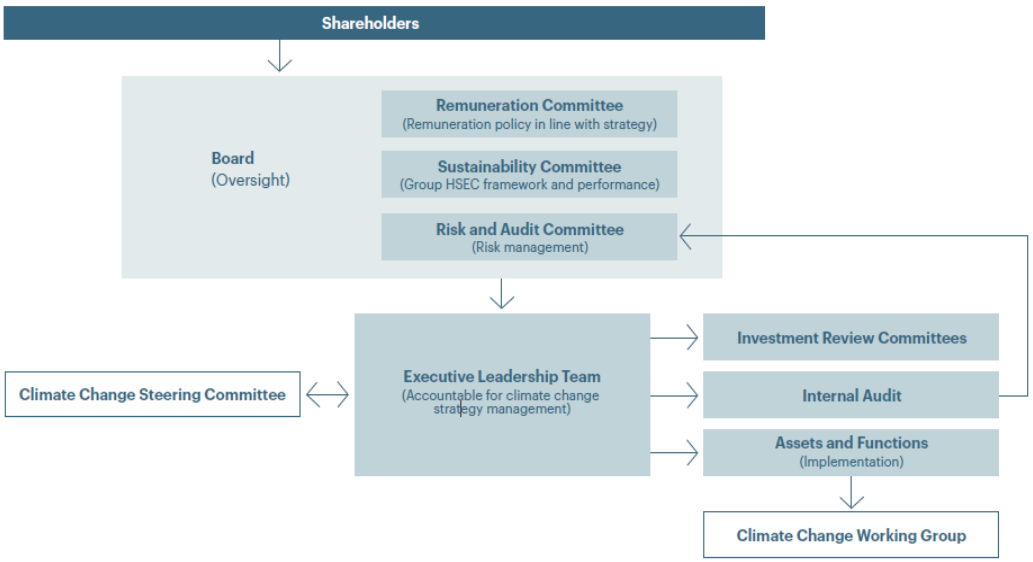
3.6 Governance

BHP's Sustainability Committee reports directly to the BHP board as per Figure 13. BHP also has a dedicated Climate Change Team (sitting within its external affairs function) which collaborates with asset and function teams, external partners, and industry to develop practical climate change solutions. The solutions are designed to preserve and unlock long-term value for BHP. The Climate Change Team informs the board and related committees with respect to climate strategy risks and performance.

Climate related activity is also undertaken across the BHP Group, with activities overseen by the Climate Change Steering Committee. In turn a Climate Change Working Group coordinates and supports the Climate Change Team and Climate Change Steering Committee.

Remuneration incentives include a 10% climate change component which include reductions in scope 1 and 2 emissions, short- and medium-term actions to reduce operational GHG emissions and scope 3 GHG emissions.

Figure 13. BHP's climate change governance



Source: BHP Climate Change Report 2020

3.7 Track Record and Initiatives

3.7.1 Implemented initiatives

Relative to other major miners, BHP has disclosed a relatively small number of implemented initiatives to the CDP, listed in Table 2.

Table 2. BHP CDP initiative track record (2018-2020)

CDP reference	Initiative description	Est. CO2e (ktpa)	Project lifetime	Scope	Year implemented
2020 (1)	Using one PAX pump instead of two reduces fuel usage and GHG emissions	10.5	Ongoing	Scope 1	FY19
2020 (2)	Enabling of gas buy-back capacity increase and updating of flowline Hydrate Management Plan	4.9	Ongoing	Scope 1	FY20
2020 (3)	Flared gas is captured and exported instead of flaring	39.8	1-2 years	Scope 1	FY20
2019 (1)	Ramp down of insitu leaching at closed sites	2.0	1-2 years	Scope 2	FY19
2018 (1)	Reduce natural gas flaring at US onshore oil and gas operations	203.0	1-2 years	Scope 1	FY18
2018 (2)	Greenfield natural gas plant at Mejillones Chile (using natural gas instead of coal)	203.3	>30 years	Scope 2	FY18

Source: CDP Worldwide - BHP Climate Change CDP Reports 2018, 2019, 2020 (Response C4.3b), RFC Ambrian analysis

BHP has also announced the following completed or advanced initiatives:

- Awarded world's first LNG-fuelled Newcastlemax bulk carrier vessel tender in FY21.
- FY18 implementation of GHG emissions vetting criteria for marine fleet BHP charter.

3.7.2 Renewable energy

BHP is forecast to make significant head way into its 2030 emissions reduction from the renewable PPAs listed in Table 3, and as BHP uses the market-based allocation method for scope 2 emissions it will count the reductions. The new renewable PPAs in Chile alone are forecast to contribute 3.0 Mtpa of CO2e abatement, with half of this abatement attributable to new renewable generation. Similar moves can be seen at its QLD Met coal operations (progressing to 50% new renewable generation) and Nickel West (no new generation). Consequently, of the total >3.4 Mtpa CO2e abatement, an estimated 1.7 Mtpa is abated by installing new generation and 1.7 Mtpa is effectively redistributed to other participants in the Chilean and Australian electricity networks.

Table 3. BHP renewable energy

Business unit / Asset	Supplier	Size	% of Power	Start date	PPA length	CO2e displaced	New generation?
Copper (Chile) Escondida and Spence	Enel	3 TWh p.a.	Not disclosed	2021	15 yr	1,500 kt from 2022	BHP state half of the PPA capacity will be met by new renewable capacity
	Colbun	3 TWh p.a.	Not disclosed	2022	10 yr	1,500 kt from 2022	BHP state half of the PPA capacity will be met by new renewable capacity
Met coal (QLD, Aus)	CleanCo	Not disclosed	Not disclosed	2021	5 yr	1,700 kt (total) ~340 ktpa	First 2 years – 100% existing hydro and gas. New solar and wind from 2022 and 2023 respectively to progressively contribute 50%
Nickel West (WA, Aus)	TransAlta	28 MW solar + 10.1 MW battery	~12%	~2024	10 yr	540 kt (total) ~54 ktpa	Yes
	Risen Energy	Not disclosed	Up to 50% of refinery	2021	10 yr	364 kt (total) ~36 ktpa	From established 132 MW Merredin solar farm
	Southern Cross Energy	Not disclosed	Not disclosed	2023 (extension)	15 yr	Not disclosed	Study phases for renewable energy supply underway, including 18.5 MW solar PV
Olympic Dam (SA, Aus)	Iberdrola	210 MW wind + 107 MW solar PV	?	2022	?	50% of emissions by 2025	Yes - Port Augusta renewable energy park (BHP primary offtaker)

Source: BHP announcements, RFC Ambrian analysis

3.7.3 Technology investments and initiatives

BHP and BHP Ventures have been actively investing in early-stage technologies as shown in Table 4. Jetti Resources is the standout investment which could be physically incorporated into BHP's operations to reduce its scope 1 and scope 2 emissions.

Table 4. BHP and BHP Ventures announced transactions and funded partnerships

Investment / Partner	Date	Type and size	Technology stage	Technology description / purpose
POSCO	Oct 2021	US$10m over 5 years Partnership	R&D	MOU to jointly study GHG emission reduction technologies in integrated steelmaking (no specific technologies outlined)
BlueVein	Aug 2021	Not disclosed	R&D	Rail electrification and dynamic charging of underground and surface fleet
Circulor	Jun 2021	Not disclosed - total funding size US$14m Series A	Revenue generating / pre-profit	Supply chain traceability
Jetti Resources	Jun 2021	Not disclosed - total funding size US$50m	Pre-commercial	Copper leaching technology targeting low grade sulfide waste dumps
Global Centre for Marine Decarbonisation	Apr 2021	S$10m Investment	R&D / Early stage	Centre will collaborate with start-ups, experts and industry to develop new technologies and co-create innovative solutions
Boston Metals	Jan 2021	~US$10m Investment Series B via BHP Ventures	Early stage	Molten oxide electrolysis technology - producing steel from molten oxides using electricity
Baowu, JFE and HJBIS	Nov 2020	Partnership – Up to US$65m over 5 years	Early stage	Reduction in steel emissions e.g. Hydrogen use to substitute coking coal in steel making
Carbon Engineering	Mar 2019	US$6m Investment	Early stage	Carbon dioxide Direct Air Capture ("DAC") and air to fuels
CO2CRC	2003 (ongoing)	Partnership/founding member US$4m in FY20	R&D / Early stage	CO2 sequestration, storage, and utilisation

Source: BHP announcements, RFC Ambrian analysis

3.7.4 Other announced initiatives, pilots/trials, partnerships, and R&D

BHP has a long list of partnerships, collaborations, and R&D across a variety of technologies at various earlier stages of development. When considering pre-commercial technology, there are a few notable demonstrations and pilots (for example EV trials). The following list includes recent publicly announced early-stage initiatives and partnerships:

- Studying the potential of mineral carbonation of tailings at Nickel West (2021).
- Partnership with Southwire completing its first 'carbon neutral' copper transaction (2021) based on Circulor blockchain technology.
- Founding member of Komatsu's GHG Alliance (2021).
- 2021 Biofuel bunkering trial with Oldendorff and Goodfuels, using an advanced drop-in biofuel blend with conventional fossil fuels.
- Charge on innovation challenge partnerships with Austmine (2021) – competition for technology innovators to develop new concepts for large scale haul truck electrification systems.

- Study potential of using an electrolyser alongside renewable power at its Kwinana nickel refinery (2020).
- FY19 – three-year knowledge sharing partnership to demonstrate large scale battery storage to a grid solar project QLD.
- FY19 CSIRO partnership to determine viability of measuring fugitive methane emissions in near real time from open-cut coal mining environments.
- FY18-ongoing trial of EVs at Olympic Dam, Queensland Coal, and Nickel West.
- Southern Innovation partnership - multiyear partnership to study borehole logging, offline minerals analysis, ore sensing and sorting.
- Collaboration with San Diego State University and Manaaki Whenua Landcare Research to assess the viability of using methane eating bacteria for abatement of methane in underground and open cut mines (stated as hard-to-abate).
- Member of Green Hydrogen Consortium.
- Toyota Partnership to trial EV Landcruiser at BHP Nickel West.
- Member of Low Emissions Technology Australia (LETA, formerly COAL21), which focuses on reducing GHG emissions from mining and use.
- Establishment of International CCUS Knowledge Centre to share lessons from SaskPower's Boundary Dam CCUS project in Canada.
- Participation in ICMM's Innovation for Cleaner Safer Vehicles programme which aims to introduce GHG emission free surface mining vehicles by 2040.
- GeoQuest research collaboration to support fundamental research into long-term storage of CO2 in sub surface locations.
- Other stated R&D: Rail fleet electrification development, insitu mineral resource preconditioning and extraction.

In addition, BHP has stated the following low carbon R&D investments in its CDP 2020 responses, which contains some overlap with the above public announcements:

- Monitoring systems for fugitive methane from open-cut coal mines.
- Improving methane capture via enhanced biofiltration.
- Decarbonisation planning.
- Development of green hydrogen technology (no specific details provided).
- Development of method to convert rail fleet locomotives to hybrid/electric.
- Innovative ore extraction methods, including in-situ resource preconditioning and extraction.

RFC Ambrian has endeavoured to produce a broad list of initiatives, but the list is not comprehensive. There may also be other projects and organisations with which BHP is involved, which may or may not be public information.

3.8 RFC Ambrian Evaluation

BHP has many notable industry partnerships, R&D programs, and technology investments. There is a clear effort to commit funding to decarbonisation initiatives from the ground up via its CIP and support for several trials and pilots have started. However, from the public disclosure, BHP's initiatives are yet to translate to operational impact. More time may be needed to progress technologies to a state whereby technology initiatives are translated to the site level, or to mature its rollout strategy.

BHP emissions accounting changes were made in 2020, the same as its baseline year used for its 2030 targets. The selection of market-based scope 2 accounting for the 2020 baseline year increases

emissions in the short term compared with location-based (FY20 & FY21). Around the same time BHP announced a number of large renewable PPAs which has provided a 3.4 Mtpa CO2e abatement from FY22 onwards. As a result, BHP is forecast to reduce its reported emissions by more than 20% vs. the 2020 baseline. If BHP had stayed with location-based scope 2 accounting these actions would have been comparatively modest. As BHP is forecast to effectively score two thirds of its 2030 emissions reduction target in one year there is a risk that the incentive to pursue other emission reduction technologies is greatly diminished, which in turn suggests the medium 2030 target lacks credibility.

BHP's strategic focus aligns well with its stated targets. It has communicated a strong desire to decarbonise material movement and has instigated multiple initiatives, partnerships, and R&D. BHP's MACC identifies ample initiatives to meet their decarbonisation targets, however it lacks breadth of abatement opportunities such as energy efficient abatements and a corresponding abatement timeframe.

BHP has baked in a carbon offset strategy to meet its targets and has stated it will only consider quality (additional and permanent) offsets after operational reductions. Accordingly, the 0.3 Mt CO2e carbon offset in FY21 implies BHP was unable to reduce its operational emissions by 2% for the year. BHP's MACC indicates approximately 6 Mt CO2e of negative cost abatement opportunities, and whilst its likely most opportunities have not yet reached technical maturity, there is a valid argument that such capital would be better allocated to early stage abatement opportunities. It's worth noting BHP's absolute emissions increased by 2% in FY21, and therefore BHP's 2030 30% GHG reduction target looks ambitious if carbon offsets are excluded. Whilst BHP's carbon offsets are additional and permanent, they pertain to agriculture, forestry and other land use; and therefore, do not afford any benefit towards the mining industry value chain.

DOES WELL	NEEDS IMPROVEMENT	TOO EARLY TO JUDGE
• Support for R&D, partnerships and other early-stage initiatives. • US$400m CIP, BHP Ventures and other investments. • Focus on decarbonising material movement in the medium to long term. • Stated scope 3 actions and scope 3 targets (albeit with disclaimers). • MACC identifies adequate abatement opportunities to meet stated targets.	• Management of scope 2 emissions reporting and setting genuine medium-term emissions targets. • Relative contribution of new renewable generation support in achieving renewable targets. • Lack of clarity around hard-to-abate emission strategy and carbon offset 'plug' which appears to take precedent over operational emissions. • MACC lacks technology breadth with only four categories, the inclusion of more technologies including energy efficiency technologies which is completely absent.	• Ability to convert investments and early-stage initiatives into scope 1 and 2 reductions and execute a timely rollout strategy. • Ability to impact scope 3 emissions via early-stage investments and other customer driven actions. • Ability to address, manage and reduce fugitive methane emissions from metallurgical coal operations (if they are not divested). • 2021 Operational emissions reduction plan.

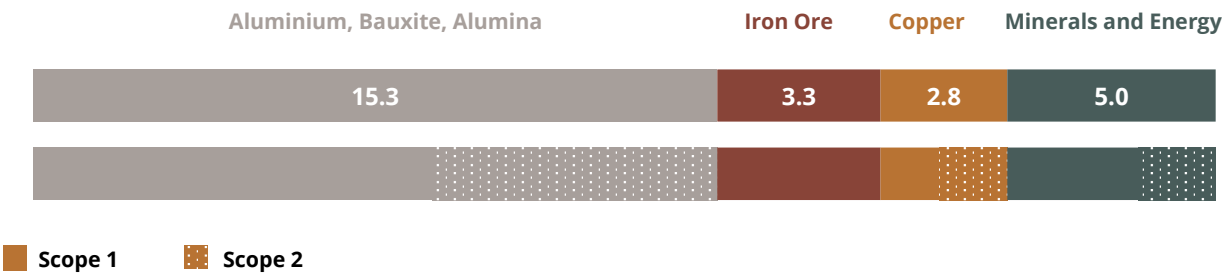
4. Rio Tinto

4.1 Existing Emissions and Energy Use Profile

Rio Tinto reports its emissions using the equity allocation method in its annual sustainability reports, despite it resulting in higher reported emissions (31.5 Mt CO2e) as compared with the operational method (26.2 Mt CO2e)[24]. For comparison, the emissions presented in Figure 14 are on an operational basis.

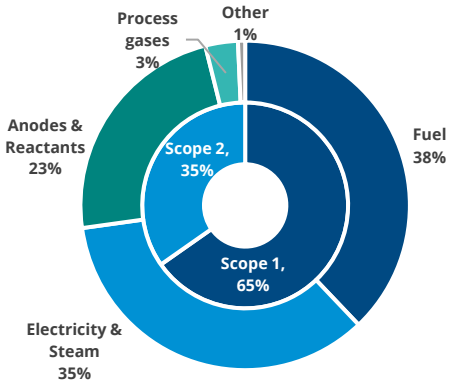
Rio Tinto's scope 1 and 2 emissions are dominated by its aluminium business unit as its operations extend downstream into alumina refining and aluminium smelting. The electricity required for downstream aluminium processing results in total energy use of 402 PJe. Fortunately for Rio Tinto, 40% of its energy needs are supplied by hydroelectricity, predominately in Canada, resulting in reasonable emissions intensity given the quantum of energy involved. Rio's Pacific aluminium business is predominately powered and heated by thermal coal (with the exception of Bell Bay and NZAS) leading to a significantly higher emissions intensity. Rio Tinto states even when aluminium electricity supply is 100% renewable, the smelting process still produces emissions from the use and degradation of carbon anodes, and indeed this contributes to an estimated 23% of Rio Tinto's scope 1 and 2 emissions.

Figure 14. Rio Tinto 2020 scope 1 and scope 2 emissions by commodity (top, Mt CO2e) and source (bottom, %)



Scope 1	17.1 Mt CO2e	
Scope 2	No market-based measure provided	9.5 Mt CO2e (Location-based)
Total	**26.2 Mt CO2e (Location-based scope 2)***	

*Net of emissions from electricity and heat sales to third parties

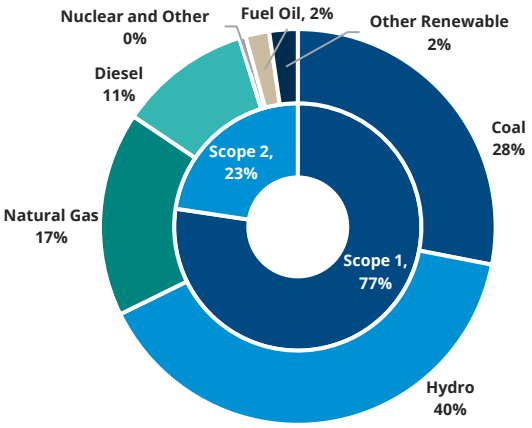


Source: Rio Tinto Sustainability Fact Book 2020 (operational basis), CDP Worldwide - Rio Tinto 2020 CDP Report (% emissions by source), graph excludes emissions from other (0.4) and sales to third parties (-0.6), RFC Ambrian analysis

Rio Tinto uses the location-based method for scope 2 emissions, and does not report separate market-based scope 2 emissions on a consolidated basis (only in the absence of location-based data). Rio Tinto has equity interest in several power stations across the world, providing a greater portion of scope 1 vs. scope 2 emissions and resulting in less flexibility to reduce emissions via contractual market arrangements. Energy use across business units could not be sourced for 2020.

Figure 15. Rio Tinto 2020 energy use (%)

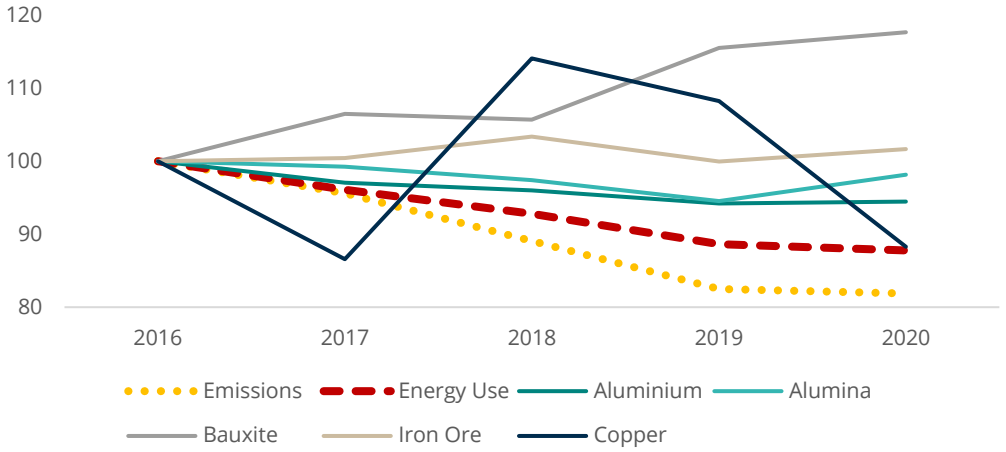
Fuel	311 PJe
Electricity (Purchased only)	91 PJe
Total Energy Use	402 PJe



Source: Rio Tinto Sustainability Fact Book 2020 (operational basis), 2020 Rio Tinto Annual Report, RFC Ambrian analysis (weighted average energy use calculation and adjustments for electricity and heat sold to third parties)

Figure 16 illustrates a consistent decline in Rio Tinto's operational emissions and energy use relative to increases in production over the past 5 years. This may in part be driven by an increase in upstream bauxite relative to downstream alumina and aluminium products.

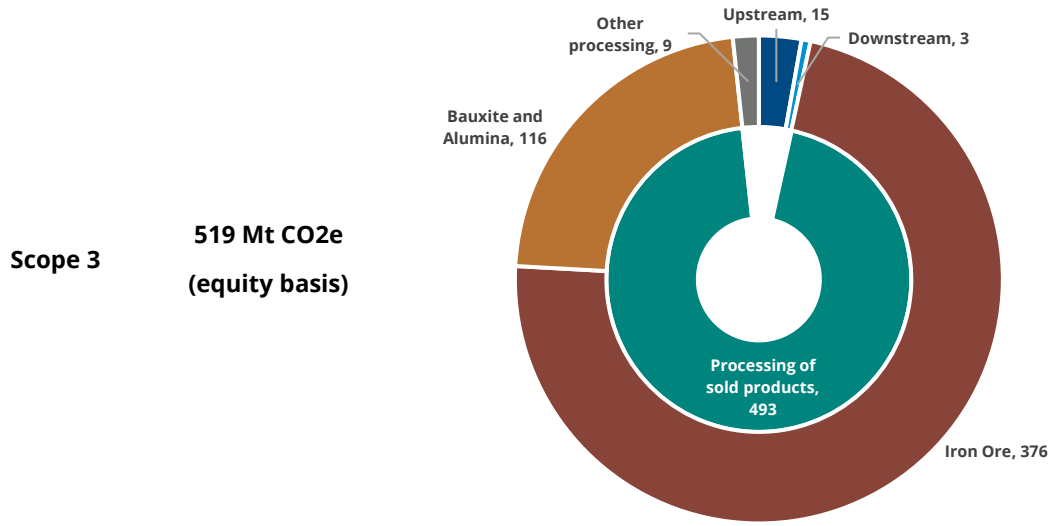
Figure 16. Rio Tinto historical emissions and energy use vs. production (indexed to 2016)



Source: Rio Tinto Company announcements (adjusted for divestments/acquisition but not wind down, expansion or greenfield), RFC Ambrian analysis

Rio Tinto reports its scope 3 emissions only on an equity basis, as shown in Figure 17. They are dominated by iron ore processing, followed by bauxite and alumina processing - a reflection of its exposure to bulk commodities. Rio Tinto has no remaining exposure to thermal or metallurgical coal.

Figure 17. Rio Tinto 2020 scope 3 emissions (Mt CO2e)



Source: Rio Tinto Sustainability Fact Book 2020 (equity basis), RFC Ambrian analysis

4.2 Emission Reduction Targets

In line with its emissions reporting, Rio Tinto has set its targets based on equity emissions, rather than operational control emissions, despite it resulting in a higher absolute emissions figure by around 5 Mt CO2e. This may give it limited scope in influencing its emissions.

Importantly, as Rio Tinto has opted for location-based emissions it will not be able to use contractual arrangements to reduce scope 2 emissions to achieve targets. Thus, there is a reasonably strong alignment between its actual emissions and reportable emissions targets.

Rio Tinto announced a more ambitious medium-term target of 50% absolute reduction in scope 1 and 2 emissions (previously 15%) on 20 October 2021. Its previous reduction target of 15% has been accelerated to a 2025 target.

Rio Tinto has also committed to carbon neutral growth overall, as well as scope 3 ambitions in shipping and steel making.

Table 5. Rio Tinto emission reduction targets and ambitions

Target	Disclosure	Baseline year	Year announced	Science based?	The fine print
Long-term Ambition	Net zero by 2050 (scope 1 and scope 2)	n/a	2020	No	• Equity baseline adjusted for material acquisitions and divestments • Equity approach • Location based scope 2 emissions
Medium-term target	At least 50% absolute reduction by 2030 (scope 1 and scope 2) 15% reduction by 2025	2018	2021	No	
Short-term target	Decrease emissions intensity by 24% by 2020	2008	2008	No	Achieved 29% reduction in 2019
Scope 3 long-term Ambition	Net zero emissions from shipping by 2050	n/a	2020	No	None provided
Scope 3 medium-term ambition	40% reduction in shipping emissions intensity by 2030 Work in partnership with customers on steel decarbonisation pathways and invest in technologies that result in 30% reduction in steelmaking carbon intensity	Not specified	2020	No	None provided

Source: Rio Tinto Climate Report 2020, RFC Ambrian analysis

4.3 Target Portfolio Allocation

Rio Tinto appears to have already positioned for a low carbon future, having divested the remainder of its thermal and metallurgical coal assets in 2018.

It has identified four pillars to position for a low carbon future – iron ore, aluminium, copper, and minerals, and further delineated those into groups with high and low carbon intensive processes. Growth capex is almost entirely focused on copper, aluminium and battery materials going forward. Rio Tinto has also flagged lump and pellet high grade iron ore as a continued focus for short term decarbonisation, while direct reduction route via direct hydrogen reduction will become the focus in the medium- and long-term.

Jadar is Rio Tinto's US$2.4bn lithium growth option, with funding committed, and subject to approvals permitting is expected to start construction in 2022. Full ramp up is expected in 2029, producing around 58 ktpa of battery-grade lithium carbonate, in addition to 160 ktpa of boric acid and 255 ktpa of sodium sulphate[25]. Rio Tinto also has a continued focus on expanding its copper footprint, with Winu and Resolution development projects in the pipeline.

Rio Tinto's Pacific Aluminium business is the highest emitting business unit in the portfolio (and the worse performing), so could be re-evaluated at some stage. Whilst not directly confined within commodity portfolio allocation, Rio Tinto's 42.1% interest in the 1,680 MW, coal-fired Gladstone Power Station is predicted to retire in 2035[26]. Another power generation asset Rio Tinto will need to indirectly manage is Oyu Tolgoi's 300 MW coal fired power station, which will be owned by the Mongolian government, and thus appear as scope 2 emissions.

4.4 Strategy and Pathway

Rio Tinto has effectively split its decarbonisation strategy and pathway into two distinct phases; 1) achieving its 2030 target, and 2) achieving its 2050 net zero ambitions.

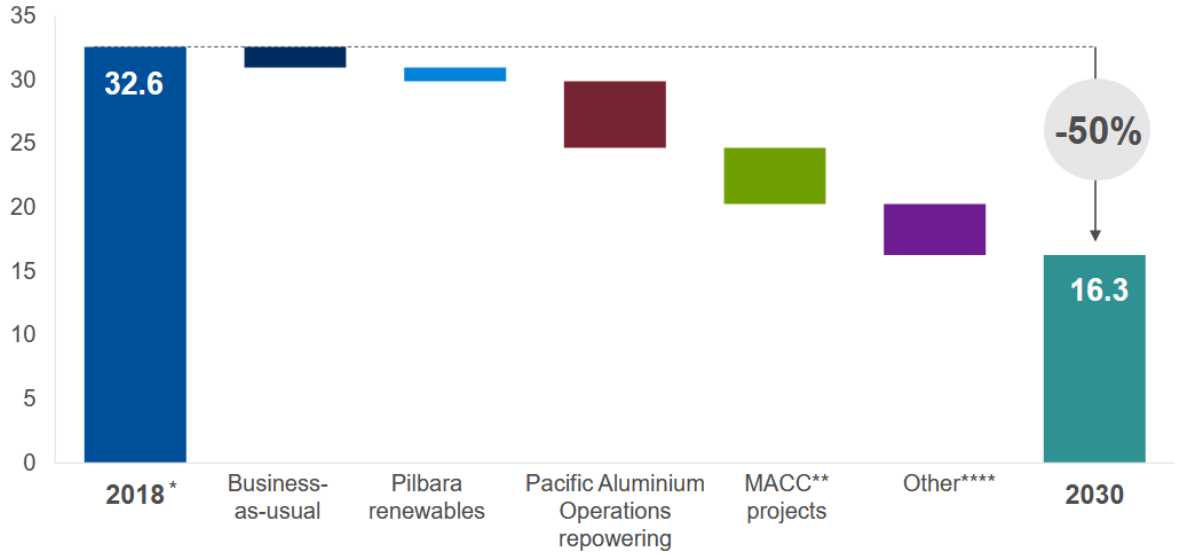
4.4.1 Medium-term 2030 target

Rio Tinto's 2030 targets are informed by a bottom up, asset-by-asset approach, which is aggregated

into a group level MACC in addition to separate renewable initiatives. Its emissions pathway is shown in Figure 18 and key decarbonisation levers to 2030 include:

- Pilbara renewables, include 1 GW of wind, solar and storage support – which includes replacing gas power with early electrification and electrification of diesel in rail and mobile fleet.
- Pacific Aluminium operations repowering – requires 5 GW+ of solar and wind power with robust firming solutions.
- Implementation of abatement projects associated with its MACC.
- Other initiatives, including energy efficiencies and carbon offsets.

Figure 18. Rio Tinto's 2030 emissions abatement pathway



*2018 Scope 1 & 2 emissions baseline has been adjusted for divestments. | **Marginal abatement cost curve, see slide 28 | ***Conceptual view of capital requirements at October 2021. MAC curves will be updated on an annual basis | ****Includes energy efficiencies, ELYSIS™ and carbon offsets

Source: Rio Tinto Investor Seminar 2021

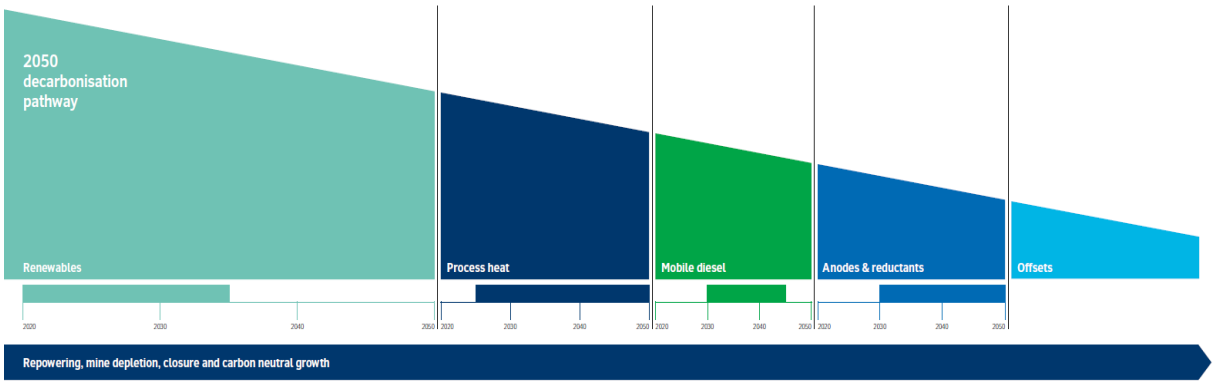
4.4.2 Long-term 2050 target

Rio Tinto's broader strategy to net zero by 2030-2050 is presented in Figure 19, and includes:

- Renewables - including greater electrification and breakthroughs in storage technology.
- Process heat – harder to abate emissions in alumina, iron ore and titanium dioxide processing, with potential for hydrogen and plasma torch technologies to play a role.
- Mobile fleet – preferred decarbonisation route is electric truck haulage, but hydrogen will be considered as an alternative pathway.
- Anodes and Reductants – pursuing the use of inert anodes instead of carbon.
- Offsets – may be used for hard-to-abate parts of the business. Avoiding and reducing emissions will be prioritised before offsets.
- Carbon neutral growth and mine depletion – designing new projects for net zero emissions.

Green hydrogen has also been flagged as substituting natural gas and potentially underpinning 10% of Rio Tinto's group-wide decarbonisation.

Figure 19. Rio Tinto's 2050 decarbonisation ambition



Source: Rio Tinto Climate Change Report 2020

4.4.3 Technology strategy

Rio Tinto recognises technology is key to achieve its ambition of net zero by 2050 and is relying on partnerships and internally generated abatements opportunities to get there. Rio Tinto has several Centre's of Excellence (CoE) including (amongst others) energy and climate, surface haulage and processing. CoEs aim to bring together Rio Tinto's technical experts to work on various issues, including investigating emissions abatement technologies. Its energy and climate CoE develop the technology roadmap post 2030, whilst its group technical CoEs are responsible for developing new abatement technologies and options. Rio Tinto states it also has a key role in finding and coordinating external partnerships that support the development and implementation of technology solutions.

Figure 20. Rio Tinto's technology strategy

Source: Rio Tinto Climate Change Report 2020

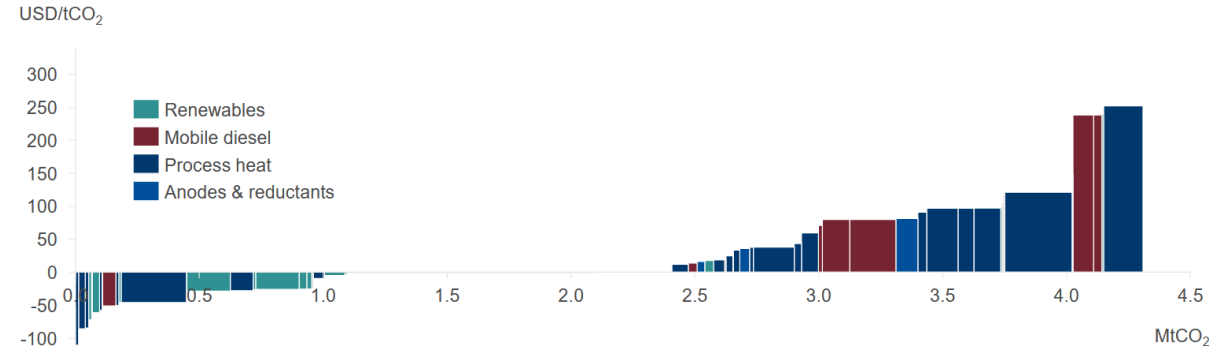
4.5 Implementation Plan

4.5.1 MACC and carbon price

Rio Tinto has developed a 2030 MACC curve which includes multiple projects for total potential abatements of approximately 4.25 Mt CO2e, including approximately 1.2 Mt of positive NPV projects as shown in Figure 21. Rio Tinto's MACC produced in 2020 contained only 5% of technologies which are viable and have reached the prefeasibility/feasibility. It's unclear what portion of the updated MACC abatements are commercial. Rio Tinto has stated that it has identified surplus abatement options to meet 2030 targets, however it faces continuing challenges to improve the commercial returns and overall readiness of many of abatement projects.

Rio Tinto has yet to update their MACC following its revised 2030 emission target, however they have stated the intention to update their MACC on an annual basis.

Figure 21. Rio Tinto's MACC as of 30 September 2021 (2030 horizon)



Source: Rio Tinto Investor Seminar 2021

Rio Tinto uses an internal carbon price to guide capital allocation decisions of US$75/t to incentivise MACC projects. Based off their 2030 MACC curve as at September 2021, a $75/t carbon price is sufficient to incentivise approximately 3.0 Mtpa of carbon abatements.

4.5.2 Capital allocation and resourcing

Rio Tinto announced an increase of its decarbonisation funding to US$7.5bn from 2022 to 2030 on 20 October 2021, including:

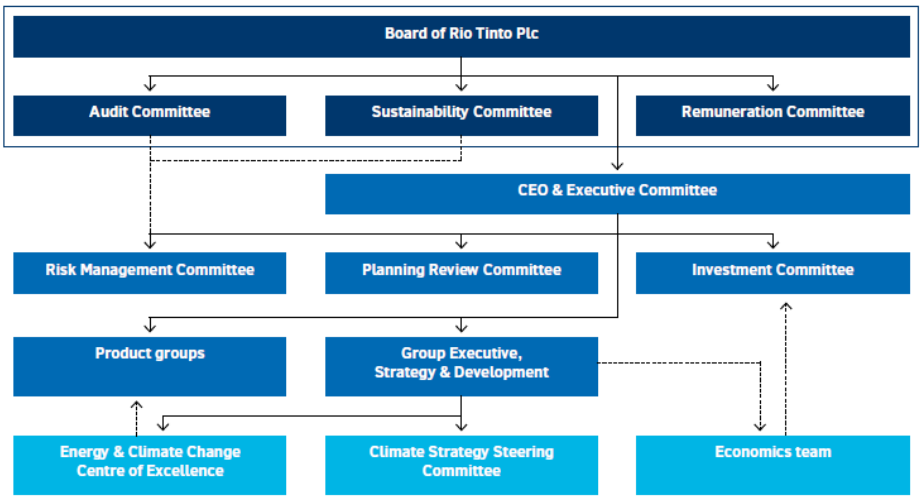
- US$0.5bn p.a. from 2022 to 2030.
- US$200m p.a. incremental operating costs to build new capabilities, energy efficiency initiatives and R&D.

The decarbonisation capital appears to be separate from Rio Tinto's existing capital allocation framework and includes spend for MACC projects.

4.6 Governance

Figure 22 illustrates Rio Tinto's climate change governance. The sustainability committee monitors group and asset performance against targets (approx. 12% of its time is spent on climate change), but the real responsibility is passed through to the product groups, which are responsible for developing and executing decarbonisation roadmaps. The Energy and climate CoE co-ordinates the execution of the climate strategy and provides technical support to product groups (scope 1 and 2 focus).

Figure 22. Rio Tinto climate change governance structure



Source: Rio Tinto Climate Change Report 2020

Executive remuneration (CEO and product group CEOs) includes a 15% ESG component, inclusive of climate change. Climate change performance is assessed against scope 1 and scope 2 emissions reduction (0.5 Mt CO2e over 2020 and 2021) and progress towards scope 3 goals.

Employee engagement is centred on the Pioneering Pitch program - pitching ideas to improve the business (in order to win funding and support to develop the idea). Individual business units also have programs in place to help them identify and promote energy efficiency.

4.7 Track Record and Initiatives

4.7.1 Implemented initiatives

Rio Tinto has disclosed numerous implemented initiatives to the CDP as listed in Table 6. There is a multitude of energy and efficiency initiatives which in aggregate, provide a material reduction in scope 1 and 2 emissions.

Table 6. Rio Tinto CDP initiative track record (2018-2020)

CDP reference	Initiative description	Est. CO2e (ktpa)	Project lifetime	Scope	Year implemented
2020 (1- 4,6 - 9)	31 initiatives at aluminium/alumina sites including, energy and heat efficiency gains at aluminium smelters/furnaces (9), process changes/optimisations at alumina/ aluminium operations (5) and various energy efficiencies (12)	67.0	Various (21- >30 years)	Scope 1, 2	2020
2020 (5)	Reviewed Weipa bauxite mine plan to reduce heavy machinery work hours	16.7	>30years	Scope 1	2020
2019 (1)	Six process energy efficiencies initiatives, including replacing diesel gensets by connecting to grid, installing VFD's on pumps/fans and compressor optimisation	66.8	Ongoing	Scope 1	2019
2018 (1)	20 process energy efficiencies initiatives (not specified)	72.0	Ongoing	Scope 2 (location-based)	2018

Source: CDP Worldwide Rio Tinto Climate Change CDP Reports 2018, 2019, 2020 (Response C4.3b), RFC Ambrian analysis, RFC Ambrian has aggregated similar initiatives

Rio Tinto has also announced the following completed or advanced initiatives:

- Signed a charter agreement with Singapore's ship management company Eastern Pacific Shipping for nine LNG dual fuel Newcastlemax bulk carriers (2021).
- Reduced emissions shipping intensity by >30% by end of 2021 for owned and time-chartered fleet.
- "START" transparency and traceability digital sustainability label using blockchain technology launched 2021.
- Anheuser-Busch partnership (2020) – deliver beverage cans with a low emissions footprint.

4.7.2 Renewable energy

Table 7 shows Rio Tinto has executed relatively few PPAs compared to its peers, potentially a result of its location-based measurement of scope 2 emissions. However, the generation installed can be considered all new and a true displacement of emissions, with no redistribution. The Tom Price renewable installation will have the largest off-grid battery in the world, supplying 15 minutes of capacity at 12 MWh in a step towards a 100% renewable off-grid installation[27]. Rio Tinto has also signed a statement of cooperation with the Queensland government to seize opportunities presented by clean energy.

Table 7. Rio Tinto renewable energy

Business unit / Asset	Supplier	Size	% of Power	Start date	PPA length	CO2e displaced	New generation?
Weipa	EDL	5.6 MW solar + 4 MW/MWh battery	?	Existing (expansion in 2022)	?	20 ktpa	Yes
QMM Ilmenite	Cross Boundary Energy	12 MW Wind + 8 MW solar + 8.25 MW battery	?	2022	20 years	?	Yes
Kennecott Utah Copper operation	Rocky Mountain power	1.5 GWh	100%	?	?	>1 Mtpa	No – however resulted in Rio closing its on-site coal fired generation
Pilbara Iron ore (Tom Price)	Self-generated	34 MW solar + 45 MW / 12 MWh battery	?	2022	n/a	?	Yes

Source: Rio Tinto announcements, RFC Ambrian analysis

4.7.3 Technology Investments and Initiatives

Rio Tinto has announced several funded partnerships as shown in Table 8, investments in external early-stage technologies do not appear to feature.

Table 8. Rio Tinto announced transactions and funded partnerships

Investment / Partner	Date	Type and size	Technology stage	Technology description / purpose
Sumitomo Corporation	2021	Partnership	Pilot	Study the construction of a hydrogen pilot plant at Rio Tinto's Yarwun alumina refinery
Shawinigan Aluminium	2020	Partnership US$7m investment	Commercial	Construction of 30 ktpa recycling facility adjacent to Shawinigan's billet casthouse in Quebec
Baowu/Tinghua university	2019	Partnership US$14.5m investment in 2021	R&D	Improve emissions across steel value chain in China (including lump optimisation, biomass/microwave ore preparation and CCU)
Elysis JV (Alcoa, Rio Tinto, Canada gov't, Apple)	2018	Joint Venture C$27.5m over the next 3 years	Pre-commercial (commercial sale expected 2024)	Novel aluminium smelting process aiming to eliminate all GHG emissions from the aluminium smelting process

Source: Rio Tinto announcements, RFC Ambrian analysis

4.7.4 Other announced initiatives, pilots/trials, partnerships, and R&D

- Small scale pilot to test sustainable biomass in place of coking coal in steelmaking (2021)
- Caterpillar partnership / MOU (2021) for Caterpillar's development of zero-emissions autonomous haul trucks for use at one of Rio Tinto's WA mining operations.
- Founding member of Komatsu's GHG Alliance (2021).
- MOU with Schneider Electric (2021) to develop a circular and sustainable market ecosystem for both companies and its customers.
- POSCO MOU (2021) to jointly explore, develop, and demonstrate technologies to transition to a low-carbon emissions steel value chain.
- ARENA partnership (2021) – $1.2m PFS to study potential of hydrogen to replace natural gas in the calcination process of refining at Yulwan alumina refinery.
- Heliogen MOU (2021) – explore development of Heliogen's solar storage technology at Rio Tinto's borates mine in California.
- ARENA partnership (2021) to study the replacement of natural gas with hydrogen at alumina refineries.
- Paul Wurth and SHS partnership – explore the feasibility of the production of hot briquetted iron with hydrogen using hydroelectricity in Canada (scheduled for completion 2021).
- Trials of plasma torches to displace process heat (2021).
- Nippon Steel partnership / MOU (2020) – jointly explore, develop, and demonstrate technologies to transition to a low-carbon emissions steel value chain (hydrogen as an iron ore reductant).
- InoBat MOU (2021) – work together to accelerate cradle to cradle battery manufacturing and recycling value chain in Siberia.
- Charge on innovation challenge partnerships with Austmine (2021) – competition for

technology innovators to develop new concepts for large scale haul truck electrification systems.

- Waste reprocessing pilot demonstration at Boron operations (California) – during 2019, announced a US$10m investment to reprocess waste rock to produce lithium.
- Shipping partners (undisclosed) – reduced emissions intensity of shipping fleet (owned and time chartered) by 30% (baseline year not provided).
- Participation in ICMM's Innovation for Cleaner Safer Vehicles program which aims to introduce GHG emission free surface mining vehicles by 2040.
- During 2019, Rio Tinto spent US$45m at its six R&D centres worldwide, the portion allocated towards decarbonisation is not disclosed.

RFC Ambrian has endeavoured to produce a broad list of initiatives, but the list is not comprehensive. There may also be other projects and organisations with which Rio Tinto is involved, which may or may not be public information.

4.8 RFC Ambrian Evaluation

Rio Tinto should be commended on its location-based method for scope 2 emissions, with limited scope to manage reportable emissions in the future. As a result, there is a level of confidence in its emissions trajectory imparting a net benefit to society, particularly as their 2030 absolute emissions reduction target is greater than its peers. Rio Tinto has set its targets based on equity emissions, rather than operational control emissions despite it resulting in a higher absolute emissions figure by around 5 Mt CO2e and potentially limiting its ability to influence emissions at minority owned assets.

Rio Tinto's pathway to achieve emission reduction targets is well supported by a bottom-up approach and indicates substantial effort in compiling abatement opportunities and assessing their relative maturity. The effort appears ongoing as approximately 2.0 Mt CO2e of additional abatement opportunities were identified in 2020. The key challenge for Rio Tinto will be advancing the identified pre-commercial technologies to commercial applications which can be deployed on-site. There is a clear reliance on partnerships with established suppliers at this stage as well as internal R&D.

Rio Tinto's energy intensive emissions profile, particularly in Pacific Aluminium, means it is heavily reliant on technology, and the foundation of a good internal strategy looks to be forming. It has assigned its energy and climate CoE to identify new opportunities, and it will be interesting to see how well it does this going forward. However, the lack of a corporate technology venture arm or partnerships with early-stage technologies suggest Rio Tinto may not have a complete picture of the abatement and technology universe.

Rio Tinto has one of the largest funding commitments of peers – US$7.5bn. As a result, Rio Tinto has a lot of dry powder to pursue further partnerships, renewable power, and carbon abatement investments in the following years.

DOES WELL	NEEDS IMPROVEMENT	TOO EARLY TO JUDGE
• Strategy and pathway driven by a bottom-up approach (via a MACC). • Focus on energy, heat savings and efficiencies (operational level). • Partnerships and R&D funding. • Location-based scope 2 emissions measurement and credible targets. • Clear self-owned renewable initiatives do not overtly redistribute emissions.	• Reduce reliance on mine depletion and offsets. • Investing in external technologies – no corporate venture capital or similar arrangements.	• Effectiveness of technology strategy. • Translating R&D and partnerships into real abatements. • Reducing its significant energy footprint (driven by aluminium business). • Ability to execute renewable energy on ambitions in Pilbara and Pacific Aluminium business.

5. Vale

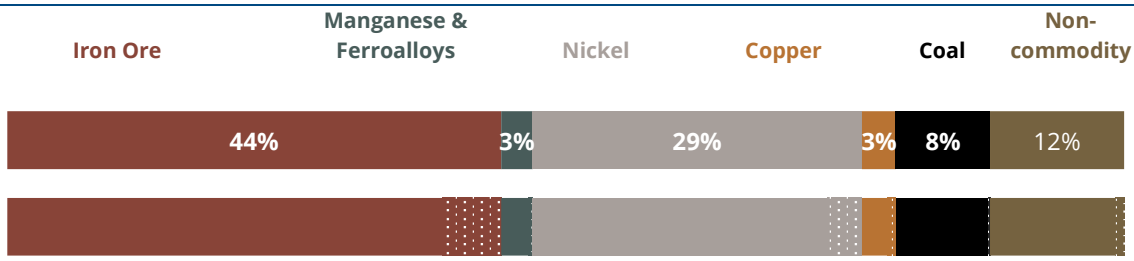
5.1 Existing Emissions and Energy Use Profile

Vale's scope 1 and scope 2 operational emissions are dominated by production of iron ore (44%) and nickel (29%) as shown in Figure 23. Vale reports its emissions using the operational control method and has yet to provide a split of its emissions by commodity for 2020 (note Figure 23 indicates the percentage emissions by commodity for 2019).

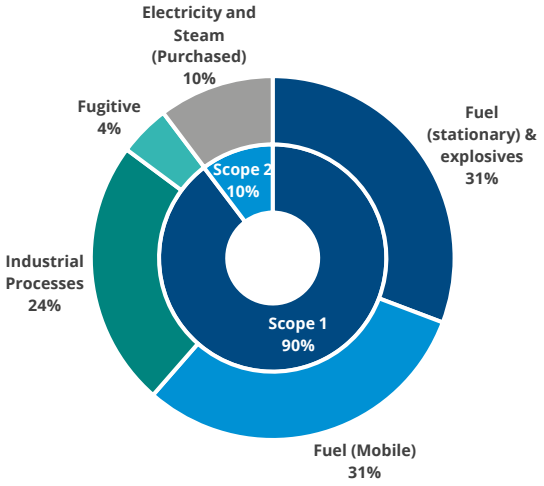
It is not surprising that iron ore is the largest contributor to its emissions due to its major contribution to Vale's revenue. As a bulk commodity, the emissions intensity for iron ore is relatively low, but higher than peers as around 10% of Vale's 2020 iron ore production was pelletised. Similarly, Vale's Nickel business unit also captures more of the downstream processing which increases its relative emissions intensity. Together pelletising and metallurgy processing comprised 57% of Vale's scope 1 and 2 emissions in 2017[28]. Non-commodity emissions include railway freight, and ports.

Figure 23. 2019 Vale scope 1 and scope 2 emissions by commodity (top, Mt CO2e)

2020 Vale scope 1 and 2 emissions by source (bottom, %)



Scope 1	9.6 Mt CO2e	
Scope 2	0.6 Mt CO2e (Market-based)	1.0 Mt CO2e (Location-based)
Total	**10.6 Mt CO2e**	
	(Location-based scope 2)	

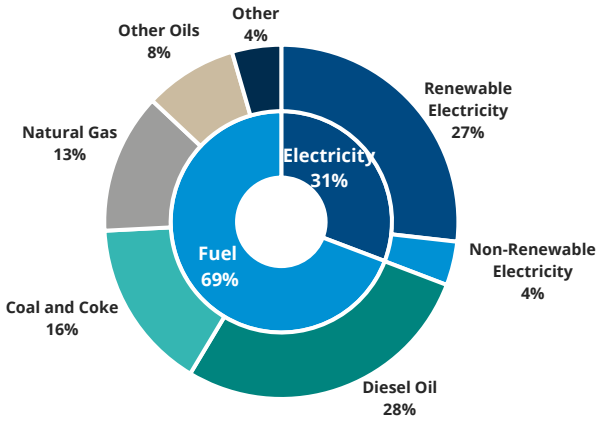


Source: Vale 2020 ESG Databook and Vale 2020 Integrated Annual Report, CDP Worldwide – 2020 Vale Climate Change responses (2019 emissions by commodity), RFC Ambrian analysis (Purchases electricity and steam adjusted for location-based scope 2 emissions measurement)

Vale uses market-based scope 2 emissions reporting for its targets, however location-based values are published as well. In 2020 Market-based emissions were 0.4 Mt lower than Location-Based emissions. Regardless of the measurement basis Vale's scope 2 emissions are relatively low (10% of scope 1+2 emissions), driven by a large proportion of electricity production from predominately self-generated hydroelectric renewable sources in Brazil, Indonesia and Canada. Together these hydroelectric plants comprise 60% of Vale's global energy consumption. The proximity to other large scale renewable projects has also allowed Vale to enter several large scale PPAs to reduce its market-based scope 2 emissions. This is reflected in its energy consumption as shown in Figure 24.

Figure 24. Vale 2020 energy use (%)

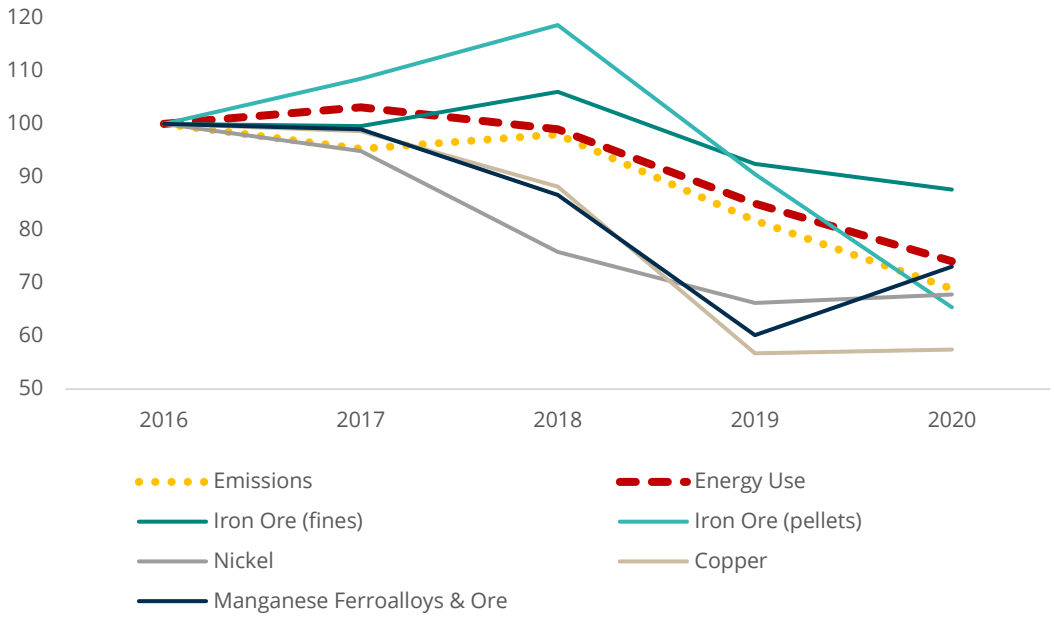
Fuel	**99 PJe**
Electricity	**44 PJe**
Total Energy Use	**143 PJe**



Source: Vale 2020 ESG Databook and Vale 2020 Integrated Annual Report, RFC Ambrian analysis

Whilst Vale has recently reduced its absolute emissions, only a small portion can be attributed to lowering its emissions intensity, rather it is largely attributable to lower production as indicated in Figure 25.

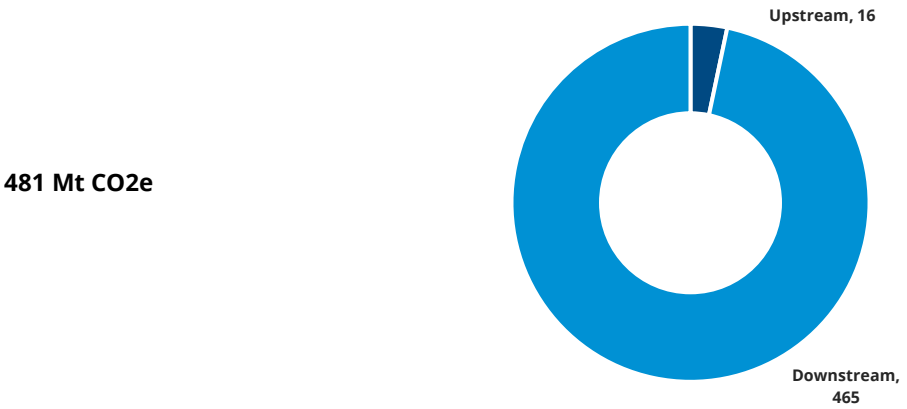
Figure 25. Vale historical emissions and energy use vs. production (indexed to 2016)



Source: Vale company announcements (no disclosure on adjustments stated), RFC Ambrian analysis

For 2020, Vale has not reported a breakdown of scope 3 emissions by commodity, regardless, its emissions are completely dominated by downstream processing and use of products. This is driven by steel processing which constitutes more than 90% of Vale's scope 3 emissions[29].

Figure 26. Vale 2020 scope 3 emissions (Mt CO2e)



Source: Vale 2020 ESG Databook and Vale 2020 Annual Report, RFC Ambrian analysis

5.2 Emission Reduction Targets

Vale has set targets in line with the Paris agreement to reduce emissions to zero by 2050. It is worth noting that it initially set an emissions intensity reduction medium-term target in 2018, but changed its approach a year later to absolute emissions target. Its emissions reduction targets is based on the Science Based Target Initiative (SBTI) calculation tool, Absolute Contraction Approach, and thus states its targets can be considered science based, but has not yet been approved[30]. Vale has also announced a scope 3 medium-term target but has not made any longer-term scope 3 commitments. Vale has also stated an energy target to consume 100% of electric energy from renewable energy sources by 2030 globally and 100% self-sufficient renewable generation by 2025 for Brazil.

Table 9. Vale emission reduction targets and ambitions

Target	Disclosure	Baseline year	Year announced	Science based?	The fine print
Long-term ambition	Carbon Neutral by 2050 (scope 1 and scope 2)	n/a	2019	Yes, but not approved	After reaching the medium-term target, Vale will assess the possibility of reducing remaining emissions via carbon offsets
Medium-term target	33% reduction in carbon emissions by 2030 (scope 1 and scope 2)	2017	2019	Yes, but not approved	In 2018 a medium-term target of 16% reduction in GHG emissions intensity was set. Revised to absolute reduction in 2019
Scope 3 medium-term ambition	15% absolute reduction from 2018 levels by 2035	2018	2020	Yes, but not approved	Committed to revising its scope 3 target every 5 years to re-evaluate technology developments

Source: Vale 2020 Integrated Report, RFC Ambrian analysis

5.3 Target Portfolio Allocation

In contrast to its peers, Vale appears to be focusing on high grading its assets and product mix over outright changes in commodity positioning. Notwithstanding, it has announced several planned divestments. It is expected to divest its Moatize and Mozambique coal assets by year end and intends to also divest its interests in California Steel Industries, Companhia Siderúrgica do Pecém, and Mineração Rio do Norte[31].

Vale clearly has a continued focus on high quality iron ore and nickel assets. Vale is already well positioned with respect to nickel, with Vale one of the largest nickel producers and 68% of its nickel products being of higher quality Class I nickel[31]. As mentioned, hydroelectric power provides approximately 60% of Vale's global electricity use, so its nickel portfolio is well positioned to produce nickel with a relatively low scope 1 and 2 emissions intensity.

Vale sees the requirement to decarbonise steel production as an opportunity to extract premia from the iron ore market resulting from a 'flight-to-quality'. As a result, it is positioning for higher value in use ores which it sees as critical in the future where fuel costs are higher and the shift to electric arc furnaces accelerates. As a part of reducing its scope 3 footprint, Vale is also pursuing new processes to produce innovative iron ore products such as agglomerates. As a part of the product differentiation strategy, Vale is building three iron ore briquette plants with a further five under analysis for up to 50 Mtpa capacity. Further adding to the strategy, Vale acquired New Steel in 2018, a company dedicated to developing iron ore beneficiation technologies.

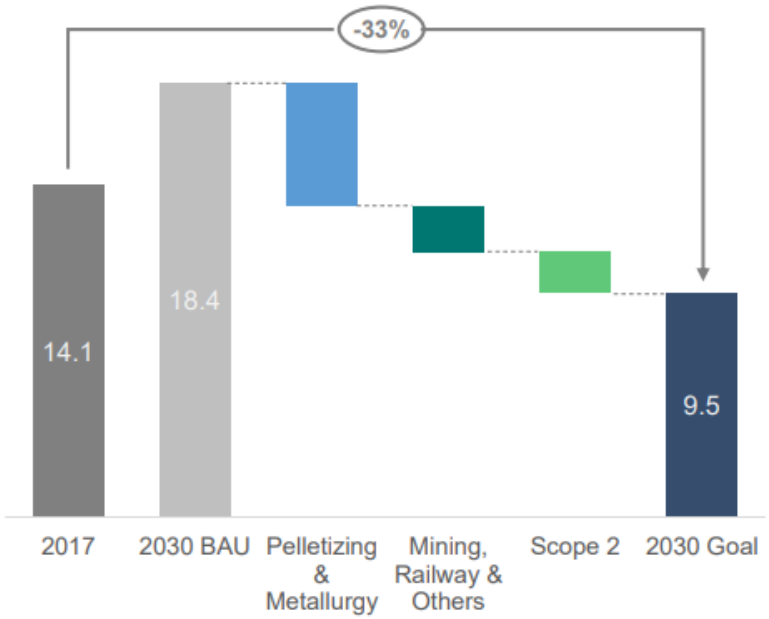
Vale has divested a number of assets which could be considered forward facing commodities. These include Canadian potash projects, fertiliser assets in Brazil and Peru, Potássio Rio Colorado (Argentina potash) and Goro nickel. Most of these divestments were driven by economics or operational difficulties more so than emissions or ESG pressure. However, it is worthwhile mentioning that Goro produces products for battery manufacture (nickel oxide and cobalt carbonate) and thus appears to be a strong fit for the Vale portfolio. Despite its operational difficulties and poor return to date, the decision may have also had environmental drivers as Goro is powered by the 100 MW Prony coal fired power plant and utilises heavy fuel oil to produce steam for the HPAL process[32], resulting in a high emissions intensity.

5.4 Strategy and Pathway

Vale's pathway to reach its 2030 medium-term goal is visualised in Figure 27. Vale indicates its main technology routes to drive decarbonisation include:

- Energy efficiency and renewables, including achieving self-sufficiency in renewables energy (i.e. zero scope 2 emissions)
- Electrification to replace diesel consumption
- Bioenergy and biofuels
- New processes

Figure 27. Vale's scope 1 and 2 emissions reduction pathway to 2030 (CO2e Mt)



Source: Vale 2021 ESG Webinar

Vale has not plotted a path to net zero explicitly, but broadly outline a pathway consistent with its existing scope 1 and 2 emissions profile:

- Processing: metallurgy and pelletizing - 57% of Vale's emissions.
- Mining and logistics - 32% of Vale's emissions.
- Electricity - 11% of Vale's emissions.

After reaching its medium-term target, Vale will assess the possibility of reducing remaining emissions, including considering carbon offsets.

Vale has not outlined a specific technology strategy, but has demonstrated some technology focus through various programs, specially the Powershift program. Powershift is an internal program created to support sustainability goals, focusing on the transition to a low carbon economy. The Powershift initiatives are expected to contribute approximately 40% of Vale's 2030 target. Its focus and aims include:

- Renewable energy.
- Alternative fuels.
- Greater energy efficiency (Vale Energy-Efficiency Program).
- Forrest promotion.

Vale also has stated it seeks to establish and engage in partnerships for transformational solutions, especially in steel and base metal production. Additional technology programs include:

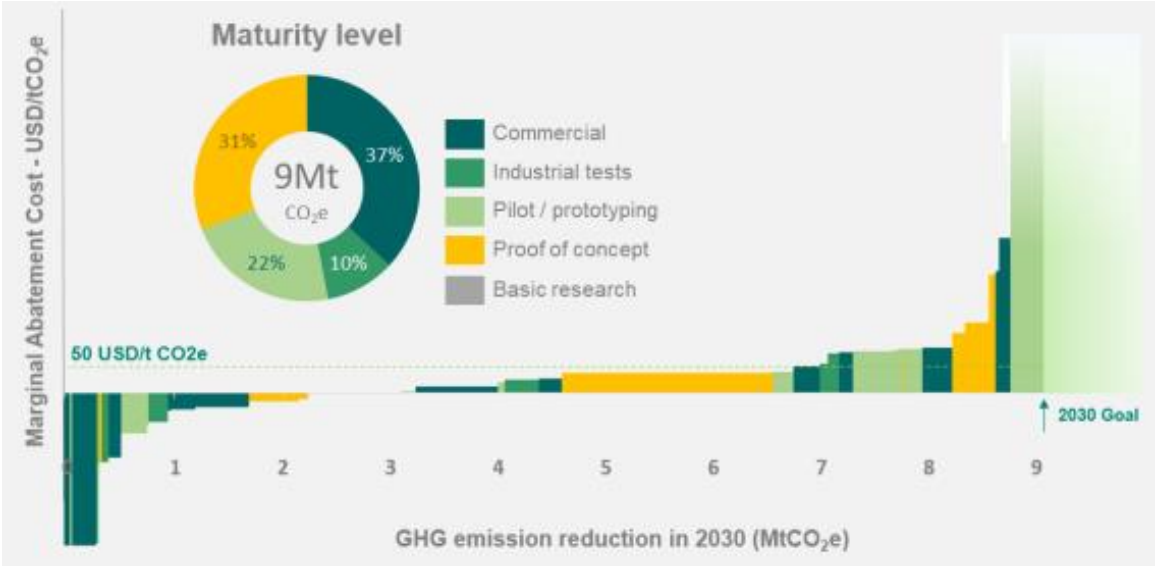
- Centre for Advance Climate Studies in partnership with the Espírito Santo Government and the University of Espírito Santo.
- Vale Base Metal Technology Development Team in Ontario.
- The Vale Technology Institute – researches and develops technology for sustainability mining.
- Sentinela Project – focusing on AI, including reducing energy usage.
- Vale Fund – supports innovative business models and arrangements that facilitate a more sustainable economy.

5.5 Implementation Plan

5.5.1 MACC and carbon price

Vale has also implemented a process to evaluate projects using a MACC. It has published its evaluation of over 40 projects for a total of 9 Mt CO2e of possible carbon abatement in 2030. Vale's MACC also indicates the commercial maturity and technological readiness of abatement opportunities across five categories. Approximately 37% of abatements are considered commercially ready, with 31% still in the proof-of-concept stage as indicated in Figure 28. Many of Vale's negative cost abatements are indicated as commercial and Vale states approximately 80% of initiatives are NPV positive at the proposed US$50/t carbon price.

Figure 28. Vale's updated 2021 MACC



Source: Vale 2021 ESG Webinar

In 2020 Vale adopted 2 shadow carbon prices to guide capital allocation decisions.

- US$50/t CO2e price for new projects and investments; and
- US$10/t CO2e for carbon sequestration projects.

Vale's carbon price difference between investments prices the trade-off of avoiding emissions vs. removing them as five times more valuable in favour of avoiding emissions. A US$50/t carbon price implies Vale could provide approximately 6.5-7 Mtpa of CO2e abatement when overlaid with its MACC. Given Vale's medium-term target implies an 8.9 Mt CO2e reduction from its 2030 business-as-usual emissions, it appears its shadow carbon price is sufficient to meet the medium-term target.

5.5.2 Capital allocation and resourcing

Vale has announced US$4-6bn of investment by 2030 for scope 1 and 2 emissions reduction[33] (a figure which appears to be guided by its MACC), and substantial increase over its previous US$2bn commitment over the next 10 years. It appears Vale has aligned its MACC and carbon price to fit directly within its capital allocation framework.

In 2020 Vale invested US$80m into a range of initiatives across energy efficiency and renewable electricity, bioenergy, electrification, and general implementation of innovative technologies.

5.6 Governance

Vale's Sustainability Committee and Board of Directors are responsible for validation and monitoring of low-carbon guidelines. Oversight is given to the Executive Director of Sustainability and Institutional Relations (or Chief Sustainability Officer), who is a legal representative of the company responsible for day-to-day operations and implementation of sustainability planning, guidelines and targets including "Vale Sustainable". Vale Sustainable is an annual plan which outlines sustainability ambitions for Vale for the next year. Managing carbon initiatives is achieved via the Low Carbon Forum which has C-level monthly meetings to track performance and delivery. The forum is coordinated by the Sustainability Committee.

Vale's CEO and executive vice presidents have the following climate-related compensation incentives:

- 5% of short-term (out of 10% related to sustainability)
- 6% of long-term compensation (out of 20% ESG-related)

Vale also provides monetary incentives to all employees, with climate change performance KPI's providing at least a 1.50% variation of each employee's remuneration. Further employee engagement includes an online emissions inventory and climate change course.

5.7 Track Record and Initiatives

5.7.1 Implemented initiatives

Vale has disclosed a number of initiatives that it has implemented to reduce carbon emissions over the past few years as shown in Table 10. There are a number of initiatives resulting in material abatements, the bulk of which come from process optimisations. The use of truckless mining at Vale's S11D reportedly reduced emissions by 50% when compared to conventional truck and excavator operations.

Table 10. Vale CDP initiative track record (2018-2020)

CDP reference	Initiative description	Est. CO2e (ktpa)	Project lifetime	Scope	Year implemented
2020 (1)	Fuel switch	27.7	1-2 years	Scope 1	2019
2020 (2)	Process optimisation	17.4	Ongoing	Scope 1	2019
2020 (3)	Machine/equipment replacement	11.9	21-30 years	Scope 1	2019
2020 (4,5)	Electrification and HVAC	0.03	6-10 years	Scope 1	2019
2020 (6)	Lighting	0	3-5 years	Scope 2	2019
2019 (1)	Process optimisation – installing long distance conveyor belts	21.5	30 years +	Scope 1	2018
2018 (1)	Machine & process optimisation	110.5	Ongoing	Scope 1	2017
2018 (2)	New equipment – Truckless mining at S11D	43.5	30 years +	Scope 1	2017

Source: CDP Worldwide – Vale Climate Change CDP Reports 2018, 2019, 2020 (Response C4.3b), RFC Ambrian analysis

Vale has also announced the following completed or advanced initiatives:

- 2021 "Green Briquette" product which facilitates a 10% reduction in emissions.
- By the end of 2021, Vale would have deployed 40+ battery electric vehicles underground in Canada.
- Reduced specific natural gas consumption by 9.3% and thermal power consumption by 4.3% at pelletizing furnaces in Brazil.
- 2018 clean atmospheric emissions reduction project in Sudbury, Canada, reducing GHG emission by 40%.
- Valemax 2G Vessels (2018) reduced emissions in shipping by 41% vs. 2011 Capesize vessels.
- Integrated carbon emissions into annual supplier monitoring for key suppliers.

5.7.2 Renewable energy

As mentioned, Vale already has a substantial hydroelectric energy portfolio, having a direct interest in three large hydroelectric plants, three smaller plants and indirect participation in other hydroelectric plants. Vale's existing self-generation electricity portfolio in Brazil is already 99% renewable, and this affords Vale low scope 2 emissions. Regardless Vale's self-sufficient clean energy target for Brazil means it will implement renewable initiatives and the multiple self-generated large scale renewable projects shown in Table 11 are good evidence of progress. All its renewable energy contracts initiated appear to support new generation, rather than existing.

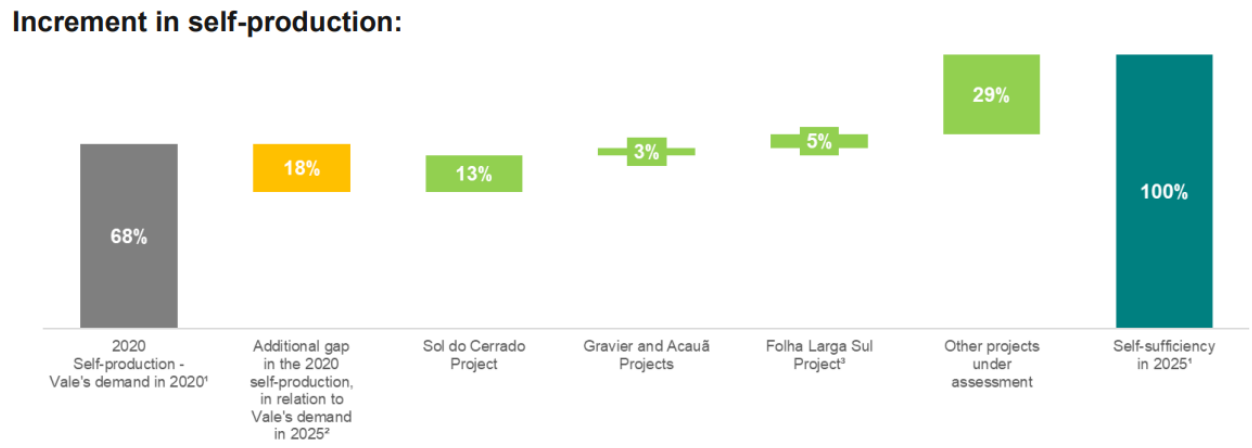
Table 11. Vale renewable energy

Business unit / Asset	Supplier	Size	% of Power	Start date	PPA length	CO2e displaced	New generation?
Guaiba Port Terminal Battery	Self-generated	5 MW/ 10 MWh	n/a	2020	n/a	n/a	Yes (lithium ion battery storage)
Sol do Cerrado Solar Project	Self-generated	766 MW	13% of Vale Brazil demand	Q4 2022	n/a	136.5 ktpa	Yes
Acauã and Gravier wind farms	Self-generated	181 MW	3% of Vale Brazil demand	2021	n/a	?	Yes – 55% of new generation allocated to Vale
Folha Larga Sul Project	Casa dos Ventois [Call option to purchase]	150 MW	5% of Vale Brazil demand	2020	23 years	?	Yes – 60% of new generation allocated to Vale
Santo Inácio wind farm	Self-generated	99 MW	?	Operating	?	?	Yes

Source: Vale announcements, RFC Ambrian analysis

Figure 29 indicates Vale is on the way to achieving its self-sufficient renewable energy target in Brazil, granted it is certainly starting from a high base. There are not yet any significant changes to its global electricity consumption target of 100% renewable by 2030. Vale's rollout in Brazil will be near impossible to replicate in other countries where renewable projects, particularly hydroelectric, are not as available. As Vale uses market-based scope 2 emissions targets, it may seek to address this via renewable PPAs, so it will be key to ensure these support new generation as demonstrated in its Brazil rollout.

Figure 29. Vale's forecast progress towards self-sufficient renewable generation in Brazil



¹ Vale's demand for electricity is estimated at approximately 1,000 MW in 2020 and 1,400 MW in 2025.
² An increase in consumption is considered due to the increase in production, in particular, with the resumption of operations in the Iron Ore business (suspended after the rupture of the Brumadinho dam) and with operational improvements.
³ Purchase options subject to the approval of the Company's Board of Directors.

Source: Vale Press Release: Vale informs on the Sol do Cerrado Solar Project, 2 December 2020

5.7.3 Technology investments and initiatives

Vale has a handful of investments, all related to iron and green steel as shown in Table 12. Interestingly it has already acquired two firms, most recently New Steel for US$500m. New Steel's technology portfolio was said to support the development of Vale's high grade pellet initiatives and also reduce tailings. New Steel is expected to put its first dry magnetic iron ore concentration plant (1.5 Mtpa) into operation in 2022.

Table 12. Vale announced transactions and funded partnerships

Investment / Partner	Date	Type and size	Technology stage	Technology description / purpose
BlueVein	Aug 2021	Not disclosed	R&D	Rail electrification and dynamic charging of underground and surface fleet
Boston Metals	Jan 2021	US$6m Investment (Series B)	Early stage	Molten oxide electrolysis technology – producing steel from molten oxides using electricity
Tecnored® Technology (now Vale subsidiary)	2008 – Ongoing	Unknown	Pre-commercial (front end engineering started 2020)	Developing a low carbon pig iron process through the use of energy sources, such as biomass and syngas, that emit less CO2 than the coal and coke the traditional iron-making processes
New Steel	2018	US$500m Acquisition	Commercial	Dry processing concentration and other iron ore beneficiation technologies

Source: Vale announcements, RFC Ambrian analysis

5.7.4 Other announced initiatives, pilots/trials, partnerships, and R&D

- (2021) Vale and Ternium MOU to develop steelmaking solutions focused on reducing CO2 emissions.
- Vale's Powershift® Program seeks to implement alternative fuels and boost forest initiatives and technological innovation.
- Charge on innovation challenge partnerships with Austmine (2021) – competition for technology innovators to develop new concepts for large scale haul truck electrification systems.
- (2021) Bioenergy industrial tests in Vale pelletizing plants.
- (2020) Progress Rail partnership to develop a new, 100% electric battery powered shunting yard locomotive (part of PowerShift program).
- (2020) Undefined involvement with SuSteel (investigating hydrogen-based metallurgy) and Primetals (Maximising use of scrap in blast furnaces).
- Non-binding heads of agreement with Koba Steel and Mitsui & Co (2020) to establish a new venture to supply low CO2 steel making solutions, such as Tecnored® and Midrex® technologies.
- Center for Advanced Climate Studies in partnership with the Espírito Santo Government and the University of Espírito Santo ($1.8m approved budget to finance 21 projects that are under development).
- (2019) Vale Technology Institute – US$10m committed across 17 self-developed technology initiatives.
- Sentinel artificial intelligence partnership with University of Queensland to optimise off-highway truck usage to lower fuel usage.
- Autonomous trucks operated at Brucutue mine assists with reducing emissions.
- Centre for Advance Climate Studies in partnership with the Espírito Santo Government and the University of Espírito Santo.

RFC Ambrian has endeavoured to produce a broad list of initiatives, but the list is not comprehensive. There may also be other projects and organisations with which Vale is involved, which may or may not be public information.

5.8 RFC Ambrian Evaluation

Vale has a fortunate head start on its peers with respect to decarbonisation, principally afforded to the location of its key assets in jurisdiction with ample hydroelectricity. The head start advances further once taking into account Vale's self-sufficiency with respect to renewables as it has many direct and indirect interests in renewable generation – not just market-based PPAs which require renegotiation at a later stage. Vale clearly recognises this competitive advantage and has sought to become completely self-sufficient in Brazil.

Vale appears to have a good focus on energy efficiency as well via its Powershift® program. It will be interesting to see if the initiative is adequate to reduce absolute emissions considering its shifting product mix which emphasises upgrading to produce premium products. This effectively moves it further downstream, potentially capturing more scope 1 and 2 emissions – but reducing scope 3 emissions. Measuring Vale's absolute energy use will be critical for this reason, as its use of market-based scope 2 emissions reporting could lead to adverse outcomes, albeit of relatively small magnitude given location-based reporting results in an additional 0.4 Mt CO2e of scope 2 emissions.

Vale's MACC is also to be commended, and is the only miner covered in this paper that states its intention to explicitly apply a shadow carbon price in assessing abatement opportunities. Further, its difference in carbon pricing for avoiding carbon (US$50/t) and offsetting carbon (US$10/t) incentivises the former over the latter. The shadow carbon price is backed up with a US$4-6bn commitment to reach its 2030 target. As a result, Vale's 2030 targets appear credible and genuine with adequate initiatives and resources in place if executed correctly. This is a stark contrast to its 2050 carbon neutral target, which has no discernible pathway or long-term strategy at this stage.

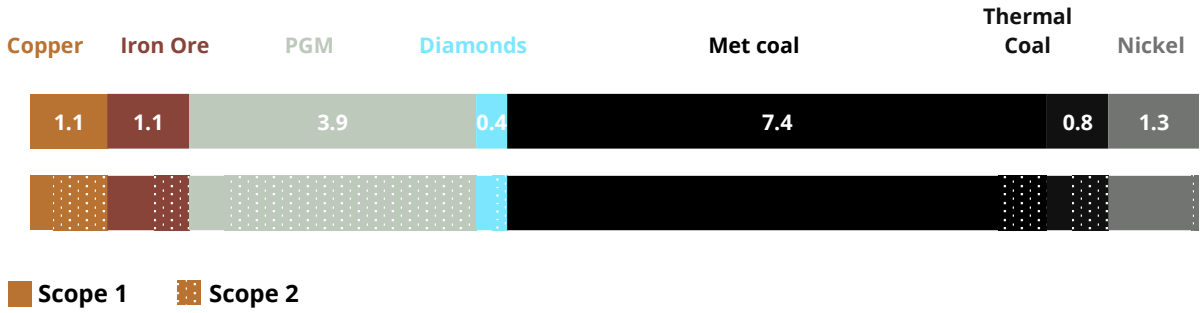
DOES WELL	NEEDS IMPROVEMENT	TOO EARLY TO JUDGE
• Well-developed MACC with consideration given to relative technical/commercial readiness of abatement opportunities. • Shadow carbon price is explicitly used to evaluate abatement opportunities and more broadly capital allocation decisions. • Large commitment to invest US$4-6bn by 2030 to reduce scope 1 and 2 emissions. • Focus on self-owned renewable energy (partially attributable to proximity to hydroelectric power and other renewable resources).	• No strategy or pathway outlined to reach net zero 2050 target.	• If its proposed global renewable rollout can match the quality of its Brazil renewable energy rollout. • Ability to pipeline further MACC opportunities and pursue pilots and demonstration projects to mature opportunities where appropriate. • Improving energy efficiency and absolute energy use via the Powershift® program, in light of its product focused strategy.

6. Anglo American

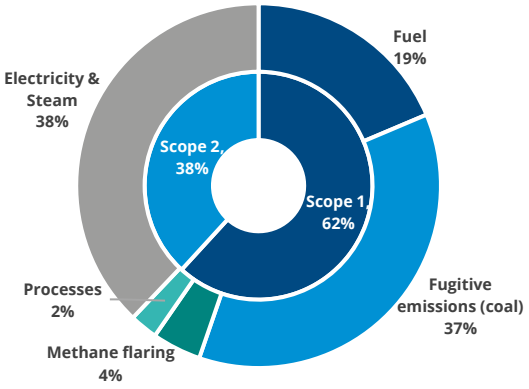
6.1 Existing Emissions and Energy Use Profile

Anglo American report its emissions on an operational basis and uses location-based emissions for scope 2 emissions. Anglo American's metallurgical coal portfolio is the largest component of its emissions, a result of fugitive methane emissions (37% of scope 1 + 2 emissions). Another significant source is its PGM smelting and refining operations, which carry a large processing, and thus, energy footprint. The resultant scope 2 emissions are significant and partly owed to South Africa's grid being predominately powered by thermal coal.

Figure 30. Anglo American 2020 scope 1, scope 2 emissions by commodity (top, Mt CO2e) & source (bottom, %)



Scope 1	9.9 Mt CO2e	
Scope 2	No market-based measure provided	6.1 Mt CO2e (Location-based)
Total	**16.1 Mt CO2e (Location-based scope 2)**	

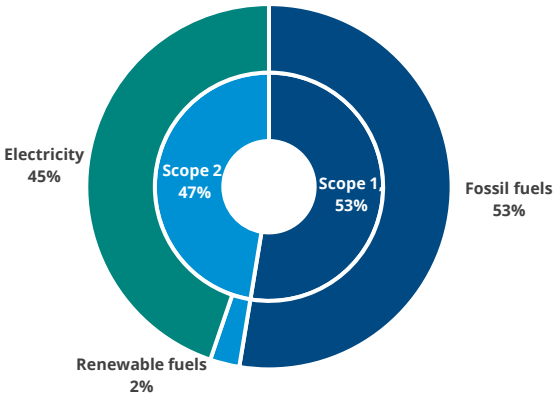


Source: 2020 Anglo American Sustainability databook, RFC Ambrian analysis

Anglo American's energy use is split approximately 50/50 electricity to fuels, led by nickel, PGM, Iron ore and copper. Whilst Anglo American's lateritic nickel assets utilise the largest portion of energy across its business units, the use of hydroelectric power from Brazil's grid results in a relatively small emissions footprint.

Figure 31. Anglo American 2020 energy use by commodity (top, PJe) and source (bottom, %)

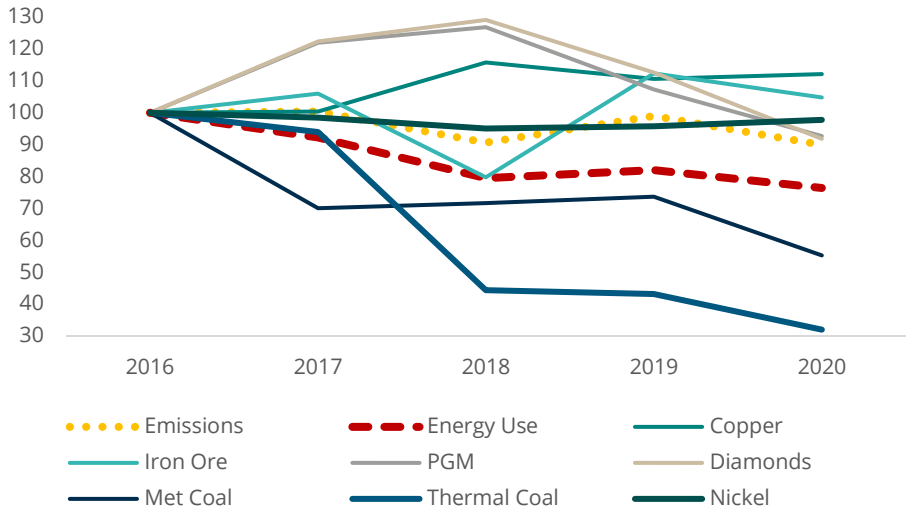
Fuel	**42 PJe**
Electricity	**38 PJe**
Total	**81 PJe**



Source: 2020 Anglo American Sustainability databook, RFC Ambrian analysis

Figure 32 indicates Anglo American has made steady material reductions in their energy use as well as some reductions in emissions over time despite increasing production (note the emission and energy figures have been adjusted for divestments and acquisitions).

Figure 32. Anglo American historical emissions and energy use vs. production (indexed to 2016)

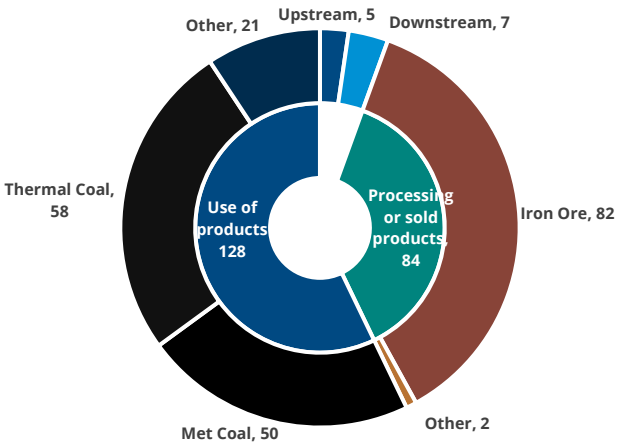


Source: Anglo American company announcements (as adjusted for acquisitions and divestments), RFC Ambrian analysis

Anglo American last disclosed its complete scope 3 emissions in 2018 as per Figure 33. Scope 3 emissions are driven by further processing of iron ore, with a large portion of scope 3 emissions also attributable to the use of thermal coal and metallurgical coal.

Figure 33. Anglo American 2018 scope 3 emissions (Mt CO2e)

Scope 3 **225 Mt CO2e**



Source: 2020 Anglo American Sustainability databook, RFC Ambrian analysis

6.2 Emission Reduction Targets

Anglo American has stated an ambition to run carbon neutral operations and has set out an aggressive timeline to achieve this – 2040. It has set a medium target of 8 carbon neutral operations by 2030, supported by absolute reductions in emissions and energy efficiency improvements.

Anglo American has stated that during 2021 it will share more details around its roadmaps towards carbon neutrality, and its work towards scope 1 and scope 2 emissions will act as levers in a customer partnership approach to reducing Anglo American's scope 3 footprint.

Table 13. Anglo American emission reduction targets and ambitions

Target	Disclosure	Baseline year	Year announced	Science based?	The fine print
Long-term ambition	Carbon neutrality across operations by 2040	n/a	2020		
Medium-term target	By 2030: • Net 30% absolute reduction in emissions • 30% improvement in energy efficiency • 8 operations carbon neutral	2016	2017	Yes, not verified by SBT initiative	• Location-based scope 2 emissions
Short-term target	By 2020 vs projected BAU: • 22% reduction in emissions • 8% energy reduction	2015	2015	No	• Achieved 24% reduction in emissions vs 22% target • Achieved 7.4% reduction in energy use vs 8% target

Source: Anglo American announcements, RFC Ambrian analysis

6.3 Target Portfolio Allocation

As a part of its decarbonisation routes, Anglo American has included an ongoing transition towards those metals and minerals which support a greener, cleaner, and more sustainable world – copper, PGMs and nickel.

Anglo American's demerger of its South African thermal coal business will occur over an approximate two-year time frame, and combined with the recent divestment of its interest in Cerrejón, it will have effectively removed pure play thermal coal from its portfolio. Bulk exposure will remain focused on high quality steel and metallurgical coal, with bulks collectively providing the largest contribution to EBITDA in the first half of 2021. Anglo American has signalled bulk volumes growth in the long-term[34].

Anglo American is also looking to increase its exposure to crop nutrients in the long-term, as evidenced via the acquisition of Sirius Minerals in 2020 to gain the Woodsmith polyhalite project. Other growth options supporting the energy transition include the greenfield Quellaveco copper development expected to complete construction in 2022 and Collahuasi growth options[34].

6.4 Strategy and Pathway

Anglo American has plotted several pathways to decarbonisation as shown in Figure 34: improving efficiency, investing in innovation, switching to renewables, and balancing residual emissions. 'Transitioning the portfolio' is a portfolio decision described in Section 6.2. Anglo American has not outlined specific pathways to achieve the separate 2030 and 2040 targets.

Figure 34. Anglo American's decarbonisation pathways

Source: Anglo American Sustainability Report 2020

Anglo American further describes five routes to scope 1 and 2 decarbonisation, which will be used to varying degrees over varying timeframes:

- Improving energy efficiency by 30% by 2030, through its FutureSmart Mining™ programmes, incorporating a range of new technologies, and through digitalization.
- Replacing fossil fuel-based energy with renewables, or self-producing energy where purchasing renewables is not appropriate.
- Hydrogen generation and energy storage.
- Methane capture.
- Using nature-based solutions on managed land.
- Using offsets, although Anglo American expect there to be a limited role for market-based offsets going forward.

6.4.1 Technology strategy

FutureSmart Mining™ is Anglo American's approach to sustainable mining innovation with a focus on technology, digitisation, and sustainability.

Underpinning Anglo American's innovation and technology ideology is the recognition of the challenge presented to increase production in a sustainable manner in the face of declining ore grades. Identified initiatives include:

- Concentrating the Mine™ - bulk ore sorting, coarse particle recovery, ultrafine recovery, and microwave preconditioning.
- Waterless Mine - novel leach approaches.
- Modern Mine - hydrogen trucks and plant, continuous rock-cutting vehicles.
- Intelligent Mine - advanced process control.

Its approach also consists of operational aspects, which intend to leverage technology to improve efficiency:

- Operating Model – Anglo American's approach to achieving operational excellence by decreasing operational variance.
- P101 – productivity program to achieve industry leading performance, encompassing aspects such as mine design, blasting practices and processing optimisation.

Figure 35. Anglo American's FutureSmart Mining™

Source: Anglo American Sustainability Report 2020

6.5 Implementation Plan

6.5.1 MACC and carbon price

Anglo American does not publicly state if it has constructed or utilises a MACC to consider abatement opportunities. Its technology strategy outlines four broad initiatives.

Anglo American uses an internal carbon price only for budgeting process for scope 1 emissions in South Africa and as a downside risk for scope 2 emissions. An internal carbon price does not appear to be established for carbon abatement investments.

To assist with achieving performance targets, Anglo American has also implemented the ECO2MAN energy efficiency program (launched in 2011), a bottom-up program which identifies where energy is being used in operations to enable better practices for each site. Recent public disclosure on the framework is limited.

6.5.2 Capital allocation and resourcing

Anglo American is investing $200-$500m p.a. of discretionary capital into technology and innovation related initiatives, which includes decarbonisation. Anglo American has explicitly mentioned that each business unit is required to budget for projects, including capital requirements, to meet its energy and carbon emissions savings targets which have been decided through the implementation of ECO2MAN.

Anglo American has also contributed US$100m to AP Ventures, a spin out fund established by Anglo American to invest in platinum-based technology companies. AP Ventures now operates as an independent fund.

6.6 Governance

Anglo American's sustainability committee is responsible for overseeing climate change related topics on behalf of the board. Responsibility falls under the Group's Technical Director and Group

Management Committee, which in turn comprises of the CEO, group CEOs and group directors of corporate functions and is supported by several committees. The Group Management Committee in turn delegates various climate change responsibilities to sub committees. Anglo American also has a Group Energy/Climate Forum to share energy and environmental practices and ideas across the group.

An undisclosed portion of Anglo American's long-term incentive plan is awarded based on achievement of GHG emissions and energy savings. The environmental/sustainability manager also has remuneration linked to GHG emissions and ECO2MAN targets.

6.7 Track Record and Initiatives

6.7.1 Implemented initiatives

Anglo American appears to have a rigorous initiative scheme, reporting hundreds of initiatives under investigation each year. Table 14 indicates multiple efficiency initiatives resulting in a meaningful aggregate reduction in emissions. The largest reduction is attributable to reducing fugitive methane emissions at its underground coal operations, principally by capturing waste coal seam gas for power generation, which combine to 5 Mtpa CO2e when aggregating previous year initiatives.

Table 14. Anglo American CDP initiative track record (2018-2020)

CDP reference	Initiative description	Est. CO2e (ktpa)	Project lifetime	Scope	Year implemented
2020 (1 & 2)	Fuel saving initiatives (13 total)	9.2	Ongoing	Scope 1+2	2020
2019 (1)	Fuel reduction initiatives (numerous initiatives)	57.3	Ongoing	Scope 1	2019
2019 (2)	Electricity reduction initiatives (numerous initiatives)	18.1	Ongoing	Scope 2	2019
2018 (1)	Various unnamed initiatives	25.3	Ongoing	Scope 1	2018
2018 (2)	Various unnamed initiatives	50.5	Ongoing	Scope 2	2018
2018 (3)	Fugitive emissions reductions	1,412.4	Ongoing	Scope 1	2018

Source: CDP Worldwide - Anglo American Climate Change CDP Reports 2018, 2019, 2020 (Response C4.3b), RFC Ambrian analysis. RFC Ambrian has aggregated similar initiatives

Anglo American has also announced the following completed or advanced initiatives:

- 2021 commissioning of the first green hydrogen station for zero carbon vehicles in Chile, with production capacity of 2kg/day.
- Co-funded construction of seven hydrogen fuel stations in California (2017-2020).
- Novum Energy partnership (2020/21) construction of two rubber recycling plants in Queensland to reduce waste.

6.7.2 Renewable energy

Anglo American has announced a number of renewable energy PPAs some of which can be linked to new generation as shown in Table 15. Anglo American's operations in South America have ample access to renewable power resources enabling sizeable renewable generation. Anglo American's 2030 targets are based on the location-based methodology and thus the renewable PPAs are unlikely to impact reportable emission targets, unless the methodology is changed retroactively.

Table 15. Anglo American renewable energy

Business unit / Asset	Supplier	Size	% of Power	Start date	PPA length	CO2e displaced	New generation?
Los Bronces, El Soldado, Chagres	Enel	3 TWh p.a.	100%	2021	10 years	70%	Not specified
Collahuasi	Enel	1 TWh p.a	88%	2020	10 years	?	Not specified
	Sonnedix	150 GWh p.a.	12%	?	?	?	Not specified
Brazil operations	Casa dos Ventos / self-generated	195 MW	100%	2022	20 years	70%	Yes – 504 MW Rio do Vento wind farm
	AES and Atlas Renewable	140 MW	100%	2022	15 years	?	Yes – 330 MW Casablance PV plant
Mogalakwena	Self-generate	75 MW	?	?	n/a	?	Yes
Quellaveco	Engie	187 MW	100%	2029	8 years	?	Yes

Source: Anglo American announcements, RFC Ambrian analysis

6.7.3 Technology investments and initiatives

Anglo American's technology investments have primarily occurred via its AP Venture fund manager spin off. AP Ventures primarily targets PGM and hydrogen focused high growth companies and has made approximately 20 investments to date.

FutureSmart Mining™ Initiatives and associated partnerships are shown in Table 17. Anglo American has also detailed the expected timing of the FutureSmart Mining™ Initiatives and rollout to sites throughout its recent announcements.

Table 16. Anglo American announced transactions and funded partnerships

Investment / Partner	Date	Type and size	Technology stage	Technology description / purpose
Lion Battery Ventures	2019	Seed	R&D	Anglo American Platinum and Platinum Group metals launched the new JV in partnership with Florida International University to accelerate the development of next-generation battery technology using platinum and palladium
AP Ventures	2018	Venture Capital Investment US$100m	From early stage to pre-commercial	Fund manager spin off of Anglo American Platinum's investment arm. Targeting investments in hydrogen (and PGM) focused, high growth companies

Source: Anglo American announcements, RFC Ambrian analysis. Only investments which are climate / decarbonisation related have been included

Table 17. Anglo American FutureSmart Mining™ initiatives

Initiative	Partners / Suppliers	Announce date	Type	Site	Technology description / purpose
Microwave preconditioning	n/a	2021	Pilot	Amandelbult	Ore microwave preconditioning (PGM and copper), expected to reduce energy. Rollout to other sites expected
Hydrogen haul truck	ENGIE, Ballard, Nel, WAE, Plug Power	Oct 2019	Pilot	Mogalakwena (PGM)	Fuel cell EV pilot for Komatsu 291t 930E, with 3.5 MW electrolyser. Full scale Rollout timeline – Mogalakwena (2024); Copper (assessing for 2025); Diamonds and iron Ore (assessing)
Bulk ore sorting	CRCOre	c2018	Transitioning to operational	El Soldado, Barro Alto, Los Bronces, Mogalakwena	Bulk ore sorting (XRF, PGNNA), trials at El Soldado indicate a circa 10% reduction in energy and water intensity. Mogalakwena unit operational and being integrated. Full scale Rollout timeline – Barro Alto (2022-23); Los Bronces (2021-23)
Coarse particle recovery	Eriez	c2018	Pilot / Transitioning to operational	El Soldado, Los Bronces, Mogalakwena, Quevalleco, Minas-Rio	Hydro float recovery to recover metal at large particle sizes. Expected to improve recoveries by ~3% over the life of mine. Full scale Rollout timeline – Mogalakwena Q4 2021; Quellaveco (2022); Los Bronces and Minas-Rio (no date given)

Source: Anglo American announcements, RFC Ambrian analysis

6.7.4 Other announced initiatives, pilots/trials, partnerships, and R&D

- MOU with Salzgitter Flachstahl to collaborate on the decarbonisation of the steelmaking industry by exploring ways to reduce carbon emissions (2021)
- Project Minera (2016 – ongoing) – R&D program in collaboration with several universities to investigate the carbon storage potential of processed kimberlite.
- 100% sustainable biofuels trial for chartered ships conducted in 2021 in a vessel owned by NYK Line.
- Founding member and participant of South Africa Centre for Carbon Capture and Storage, currently piloting small-scale CCS (2014-2020).
- Founding sponsor of World Bank's Climate Smart Mining Facility (2019), US$1m over 5 years.
- Floating solar panel trial at Los Bronces (2019).
- Founding member of Hydrogen Council.
- Vent air methane abatement – Australia Coal 21 Fund (part of $10m total investment into clean coal technology).
- CarbonVault™ – trials commenced to utilise mineral carbonation to extract carbon dioxide from the air and store within kimberlite minerals (part of $10m total investment into clean coal technology).
- R&D collaboration with Columbia University to investigate potential to capture CO2 from flue gas streams as well as air.

RFC Ambrian has endeavoured to produce a broad list of initiatives, but the list is not comprehensive. There may also be other projects and organisations with which Anglo American is involved, which may or may not be public information.

6.8 RFC Ambrian Evaluation

Anglo American places operational efficiencies and energy savings at the forefront of its decarbonisation strategy. Anglo American considers many abatement initiatives each year, presumably a result of its ECO2MAN program which focuses on energy reduction, and consequently there are numerous meaningful abatement initiatives implemented at the operational level each year. The ECO2MAN program appears to be an effective program for implementing bottom-up changes from the site level – further details on the program would be welcomed.

Anglo American's decarbonisation pathway is not clearly linked to its existing emissions profile and therefore it is difficult to discern if current actions will be sufficient to meet its stated targets. Furthermore, it has not provided a detailed framework to execute its strategy and has not disclosed a MACC, or broader assessment and capital allocation framework. Its focus on developing technologies is excellent, however the link with its decarbonisation strategy is missing.

The FutureSmart Mining™ program was launched in 2018 and it has outlined a rollout schedule for the various technologies across multiple sites. Its pilot, prove and rollout strategy appears to now be in the rollout phase for ore sorting, coarse particle recovery and hydraulic dry stacking. The rollout for hydrogen trucks is planned but still in development. The initial pilot results of the initiatives have been announced, so the final challenge for Anglo American is translating the pilot results to real operational impact. Regardless, the commitment to a timeline to implement technologies at the site level is to be commended.

DOES WELL	NEEDS IMPROVEMENT	TOO EARLY TO JUDGE
• Set targets on energy savings (not just emissions), and recognition of the challenge of sustainability mining in light of declining ore grades. • Location-based scope 2 emissions and targets. • ECO2MAN program focuses on energy saving at the operational level, evidenced by numerous implemented initiatives. • Self-generated renewable power and increasing renewable PPAs (although no transparency as to how much contributed to new generation). • Technology rollout strategy is detailed with timelines of expected deployments across sites. • Material investment into AP Ventures to pursue early-stage adjacent technology.	• Lack of a roadmap to link initiatives to decarbonisations targets and current emission profile, for example there appears be some deficiency in addressing its biggest emission source – fugitive methane emissions. • Framework for assessing and selecting initiatives does not appear to be guided by a standard MACC. • Transparency with respect to carbon abatement capital allocation process and indicative funding commitments.	• Translation of FutureSmart MiningTM initiatives from pilot results to real operational impact.

7. Discussion

Having applied the framework to miner's decarbonisation efforts at a high level, there are several trends which have emerged. Every company covered in this report has declared an ambitious net zero target by 2050 at the latest, and meaningful medium-term targets. Each has embraced renewable energy and stated a plausible pathway to decarbonisation. Each company has also demonstrated its commitment to decarbonisation as evidenced from the multitude of initiatives, partnerships, and investments to date. In many ways the industry has taken leadership with respect to scope 3 emissions and in recognising its key role in supplying materials critical to the energy transition.

Turning to the details highlights some inadvertent trends with the potential to derail the credibility of the industry to execute on its decarbonisation targets and ambitions in the long term. These trends could be categorised as sustainability pitfalls, whereby the underlying impact of a strategy fails to consider the bigger sustainability picture. On an individual company basis, such pitfalls may result in the realisation of the consequences outlined in Section 1 and on a collective basis may contribute to a failure to meet the goals of The Paris Agreement. These trends and their potential impacts are discussed below.

We finish the discussion with a high-level comparison of each company covered today based on RFC Ambrian's framework.

7.1 Decarbonisation Trends

Renewable PPA procurement

The most common, and arguably the largest carbon abatement opportunity for the mining and metals industry is to substitute fossil fuel sourced electricity for renewable electricity. There is no disputing that building new renewable energy generation to displace fossil fuel generation is an excellent carbon abatement which should be pursued where technically possible. As highlighted throughout, the key is ensuring there is an explicit impact with a resultant net reduction in societal emissions resulting from the initiative, and not just a redistribution. The underlying rationale - procuring renewable PPAs supports renewable energy generation and thus the renewable energy market - is well understood, but the incentives for companies to reduce or eliminate their actual carbon emissions is removed with such broad based easy-wins. The clear preference is for renewable PPA procurement to support new renewable power installations, in particular those which would not otherwise be constructed without a large user underpinning demand. This is equivalent to requirement of the "additional" principal for quality carbon offsets, and it is concerning the discussion is not yet widespread. This pitfall applies across all sectors, however the mining and metals industry, with its relatively outsized power demand, has a greater capacity to impart a net positive change.

Scope 2 measurement methodologies

There is quite often an inherent misrepresentation which occurs when a mine site declares they are powered by "100%" renewable energy. Whilst a mine site can enter into a renewable PPA (which may or may not have supported new renewable power generation), the physical electrons being used at the mine site may still be generated by the local thermal power plant. The market-based approach to measuring scope 2 emissions is certainly responsible for such misrepresentation and is highly susceptible to double counting. This pitfall will become more evident in the future as stakeholders become increasingly sensitive, or sceptical, towards such claims and the net benefit to society. A potential outcome in the medium term is a stakeholder driven overhaul in reporting methodologies to prevent manipulation of scope 2

measurement methodologies for the purpose of massaging reportable emissions to achieve targets. To avoid such perceptions, best practice would suggest reporting both methods to enable analysts to evaluate the validity of claimed emission reductions.

Lack of focus on energy storage

Currently, variable renewable energy benefits from the positive externalities of grid stability, which in the absence of significant hydro generation, is principally afforded by thermal generation (supply response and inertial response). As the portion of variable renewable energy in electricity grids increases and thermal generation decreases, electricity grids will need to significantly expand energy storage, inertial response, transmission network infrastructure and integrated variable renewables storage such as solar thermal electricity. Stability of electricity supply is paramount for mining and metals operations, in particular smelting operations where demand profiles can have significant instantaneous changes in load. There have been several brown- and black-outage events with root causes stemming from instability of variable renewable energy generation, such as BHP's Olympic Dam mine in South Australia having to shed 70 MW of load during one such event in 2016 for 3 hours[35].

Whilst technology advancements will help bring the cost down, and improve stability over time, it is likely the marginal cost of electricity will ultimately increase worldwide as significant storage and additional inertial response is added to grids. The recent run up in European gas demand and thus prices, demonstrate the structural weakness of electricity grids which have transitioned rapidly to large portions of variable renewable energy without an equivalent build out of energy storage. Whilst there are multiple factors contributing to the increases in recent European energy prices, this structural weakness cannot be dismissed.

Consequently, decarbonisation pathways with a significant focus on renewable power and without a corresponding focus on energy storage are likely to fall short in the long term. The technical developments required to firm up and integrate variable renewable energy into mining and metals operations are significant, so effort is required through a dedicated technology strategy. This is particularly true with respect to remote off-grid operations as well as mining and metals operations with large power requirements, such as alumina and aluminium smelters, lateritic nickel smelting operations, large porphyry copper mines and refractory gold ores. Such operations are likely to require new technologies with limited application to other sectors.

Going all-in on electrification - energy use vs. emissions reported

Working alongside renewable energy efforts is the ability to leverage zero carbon energy (whether that energy is emission free or not is addressed above) to electrify or decarbonise material movement and displace fossil fuel atoms with green electrons. This certainly is a good move to decarbonise and, in most instances, should afford a benefit to societal emissions. The pitfall resides with the potential increase in gross energy usage caused by a desire to leverage low, or no, market-based scope 2 emissions by converting scope 1 emissions to scope 2 (and where location-based emissions may be relatively high).

Increases in energy usage occur when the electrification technology is less efficient than thermal, such as heating applications or some methods of material movement decarbonisation (Electric or hydrogen haul trucks). This may result in a net negative environmental impact – especially in locations where the average grid emission intensity is high. Such tunnel vision can have an immense impact on the bigger sustainability picture in the pursuit of meeting stated targets.

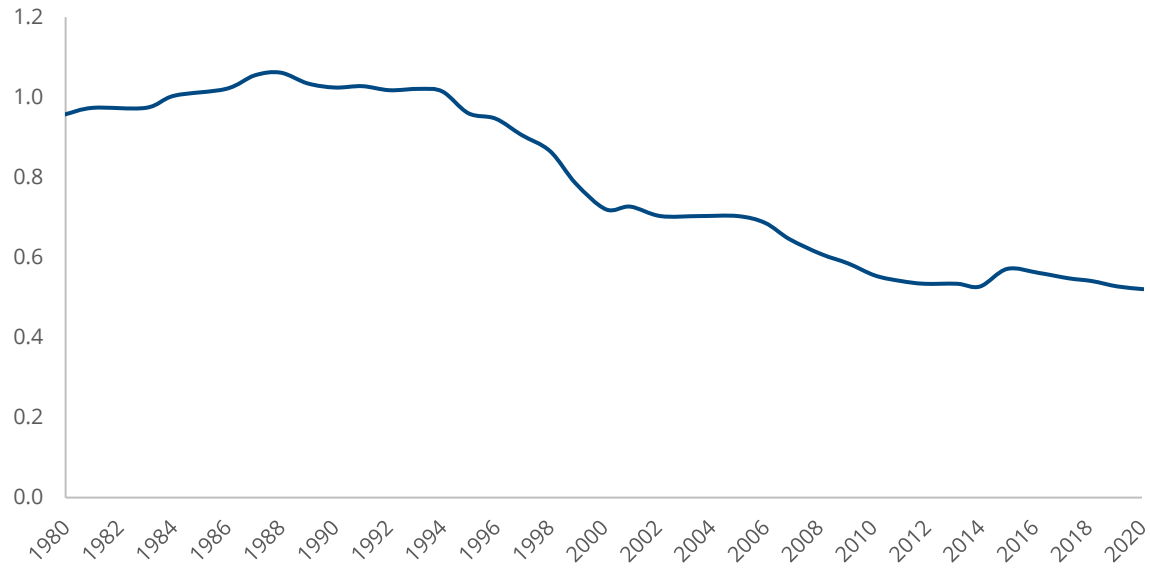
An overbuild of renewable power for an incremental reduction in emissions will have massive flow on impacts such as increased land displacement, loss of biodiversity, and of course –

mining of more materials to build additional renewable power generation. Fortunately, such abatements are likely to be relatively higher cost in the long term and the pitfall is relatively easy to identify by comparing energy usage vs reportable emissions. Note that companies with an overreliance on renewable PPAs and market-based scope 2 emission reporting can be identified using this method as well.

No focus on energy efficiency

Correspondingly, energy efficiency is the key aspect of the aforementioned absolute change in energy usage. Energy efficiency should form a core pillar of any decarbonisation strategy, this is especially important for mining and metals as ore grades fundamentally decrease over time. Declining ore grades will result in a significant uphill battle which few mining companies have acknowledged in their sustainability reporting, and yet the inevitable decline in reserve ore grades continues. The decline is particularly evident in copper grades as shown Figure 36, with average reserve grades declining approximately 50% in 30 years. Participants in the mining industry should have an intense focus on their own backyard – mining smarter, processing more efficiently, and using less energy in general. The industry needs to mine more sustainably and technology has a key role to play in preventing such increases in energy usage.

Figure 36. Historical average copper grade of global reserves (Cu %)



Source: Goehring & Rozencwajg (2021) The Problem with Copper Supply

Technology strategy

It's clear a technology strategy is fundamental to achieving decarbonisation targets. The industry clearly agrees – all companies covered in this report have some form of technology strategy with respect to decarbonisation. A meaningful technology strategy is the only way to reduce energy consumption and emissions in the long term. Many new technologies have the potential for huge absolute reductions in emissions at a negative abatement cost, however, may not be technically or commercially ready. The industry should consider a systematic process of pipelining and screening opportunities – both internal and external. The ability to do so will not only impart better

environmental outcomes but also impart financial benefits and general competitiveness.

Some technology strategies appear to be sufficient on the surface, however the track record indicates otherwise. There is generally a poor track record of adopting and implementing new technologies onsite – for example step-change technologies take on average 10-25 years from first mover to technology maturity in the copper industry[36]. This clearly illustrates the difficulty in identifying commercial technologies winners at an early stage and in a reasonable timeframe. A diverse set of skills is needed to assess the operational impacts, technical aspects, business plans and commercialisation strategy of a single technology. Furthermore, continual R&D and reinvestment is required for continuous innovation. The above is difficult to achieve internally in a mining and metals company – and corporate venture capital spin-outs support this thesis as dedicated focus is needed.

Reliance on depletion

As mining assets have a finite life depletion is implicitly (and sometimes explicitly) present in most decarbonisation pathways. A depletion strategy will naturally wind down existing, higher emissions intensity assets and new assets will be designed and constructed for lower emission intensity operations. This pitfall exposes the issue identified above, that new technologies are required to reduce emissions, and so the failure to trial and pilot new technologies at existing operations will result in a company which is ill prepared to implement new technologies at new operations. In turn this goes to the credibility of an organisation to simultaneously satisfy the plethora of challenges for a greenfield or brownfield operation whilst also implementing industry leading low carbon technologies with no prior experience.

MACC and shadow carbon pricing

Most of the miners covered today utilise some form of MACC (some with consideration to technology maturity) to inform their carbon abatement investment opportunities, however the link back to an internal carbon price to drive investment is largely absent. Instead, the industry appears to be waiting for explicit carbon prices to be implemented – instead of getting ahead of the inevitable. A broad carbon price would certainly put a rocket under the industry's efforts in seriously scrutinising and adopting new technologies.

Additionally, whilst information on individual carbon abatement opportunities is rarely publicly available, the categorisations of some MACC's appear to lack technological, or fail to consider technology maturity.

Carbon offsets

As outlined in the Framework, in the first instance carbon offsets should focus on abatement projects relevant to the mining and metals industry to effectively subsidise technologies until a point where they can be commercially competitive. The industry broadly recognises carbon offsets are towards the end of the project abatement priority list, which is certainly positive. The additional dimension of a 'quality' offset should theoretically mean they are only considered once the marginal cost of carbon abatement exceeds the cost of offsetting carbon. This gives rise to the 'linear' representation of carbon reduction to net zero, when it may more closely mimic an S-Curve, with offsets helping to achieve the hardest to abate emissions (often 20% of total emissions).

Stakeholder scrutiny of carbon offsets is increasing, and the sophistication of this scrutiny is only likely to increase over time. The preference is for the mining and metals industry to place greater effort into identifying abatement opportunities in-house and improving the sustainability of the mining industry in the long run, rather than plugging results, smoothing peaks, or simply buying their way to targets. Investing in R&D to progress abatement opportunities will likely bring a greater return to shareholders (and the environment). Both offsets and R&D are explicit costs; the former is a

recurring expense (and therefore liability) to procure offsets, the price of which is likely to increase over time; the latter can offer substantial return via reduced operating costs or improved recoveries for those that can pick the winners from the losers. As a result, shareholders should have a strong preference for companies to pursue abatements, and lower future carbon offsets liabilities.

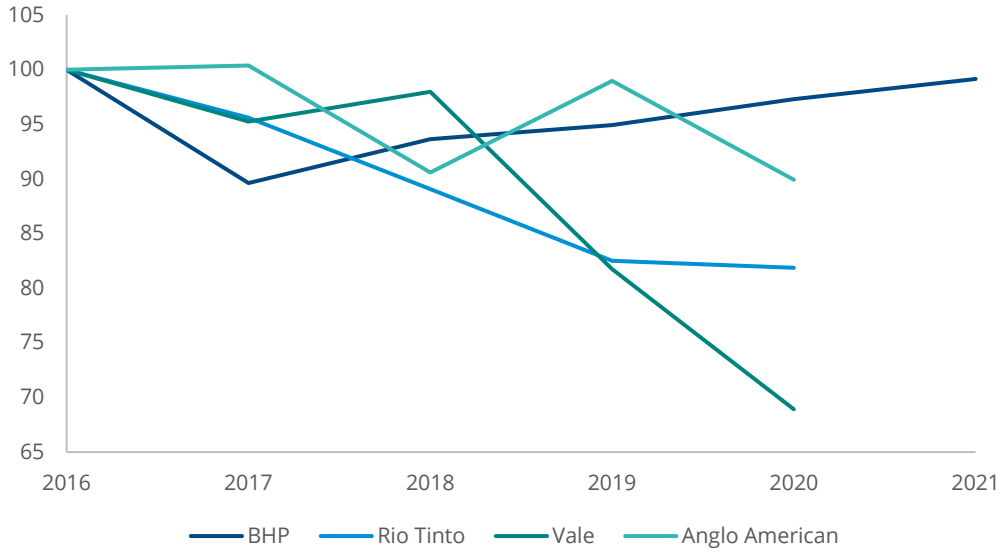
Falling short on the implementation plan

The implementation plan is critical to ensuring a company's decarbonisation strategy is resourced and capable of successful implementation. This admittedly broad category covers board level decisions (governance and capital allocation), to business unit level decisions (rollout strategy) and down to the individual operator on-site (company culture). It is a difficult task to translate decarbonisation strategies across business units, sites, employees and then communicating externally to stakeholders and believe this is a contributing factor for general lack of detail around implementation. Nevertheless, RFC Ambrian's experience with technology commercialisation in the mining industry suggests a chasm often exists between the intentions of corporate – and the translation of those intentions to actions at the site level. A single point of responsibility is often needed, an internal 'technology champion' to drive change at the operation level.

7.2 RFC Ambrian Evaluation - Comparison

RFC Ambrian commends each mining company covered in this report on its ambitious targets as well as the ability of the industry to mobilise at relative speed in relation to a topic which needs attention. Whilst there are some common themes between the companies covered (some good, some less so), each miner has a markedly different strategy and plan to implementation. This is inevitable as miners have different starting asset bases and geographical exposure, this is evidenced in Figure 37 and Figure 38. Despite this they all have the same end goal – net zero.

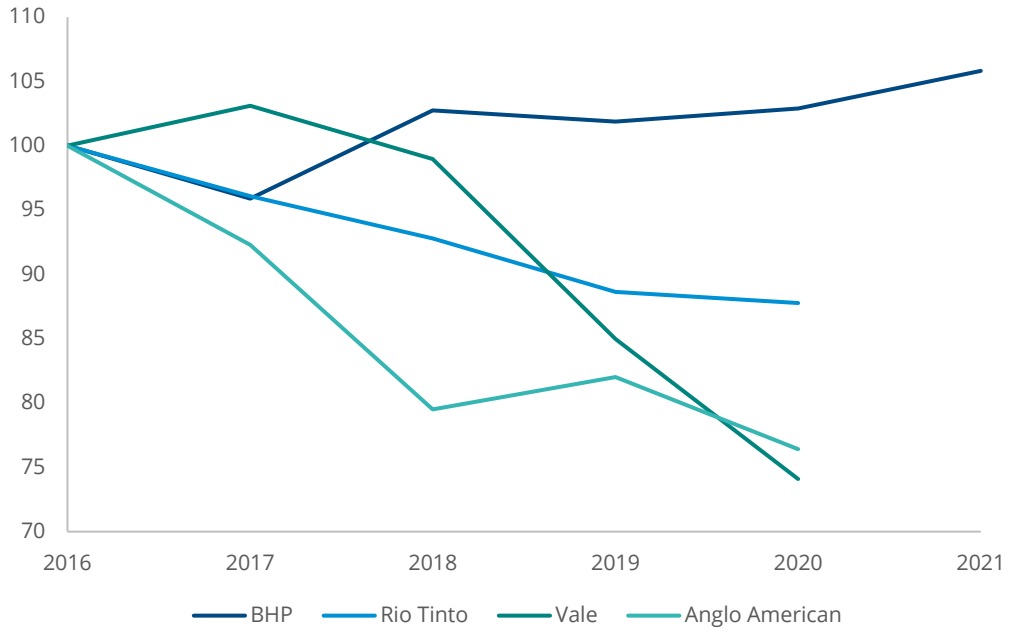
Figure 37. Comparison historical emissions (indexed to 2016)



Note: BHP data based on 30 June financial year, Rio Tinto emissions restated on an operational basis

Source: Company announcements (Data adjusted for material acquisitions and divestments where available), RFC Ambrian analysis

Figure 38. Comparison energy usage (indexed to 2016)



Note: BHP data based on 30 June financial year

Source: Company announcements (Data adjusted for material acquisitions and divestments where available), RFC Ambrian analysis

The mining industry as a whole is not constrained by capital at this point in the commodity cycle. Commodity prices have picked up to relatively high levels across the board in the past 18-24 months and enabled some record dividend returns. This helps channel large budgets towards decarbonisation and between the mining companies covered today, they have committed well over US$10bn towards decarbonisation to 2030.

Continuous improvement is embedded in the industry and this section hopes to aid miners in that process. Miners would benefit from reviewing and analysing each other's strategies to assist with understanding how their strategy or pathway could be improved. Table 18 and the following discussion compiles an evaluation of each's miner's decarbonisation efforts by applying RFC Ambrian's framework and applies a traffic light assessment in relation to the goal of genuinely decarbonisation the mining industry.

The framework presented considers (and stresses) the impact of company actions to societal emissions, not just those that are reported by an individual company. As such an evaluation needs to also consider the authenticity of emissions targets and the corresponding credibility of meeting them.

Table 18. RFC Ambrian mining company evaluation summary table

	BHP	Rio Tinto	Vale	Anglo American
Strategy and pathway				
Redistribution	🟠	🟠	🟠	🟠
Eliminate, reduce, and mitigate (Efficiency focus)	🔴	🟢	🟠	🟢
Carbon offsets	🔴	🟠	🟠	🟢
Technology strategy	🟢	🟠	🟠	🟢
Implementation plan				
Abatement opportunities (MACC)	🟠	🟢	🟢	🔴
Shadow carbon price	🟠	🟢	🟢	🟠
Capital allocation and resourcing	🟢	🟢	🟢	🟢
Governance	🟢	🟢	🟢	🟢
Track record				
Initiatives implemented	🟠	🟠	🟠	🟢
Renewable energy	🟠	🟠	🟢	🟠
Technology and other Initiatives	🟢	🟠	🟠	🟢
Target credibility evaluation				
Medium-term credibility (2030 target)	🔴	🟢	🟢	🟠
Net-Zero target credibility (long-term target)	🟠	🟠	🔴	🟠
Scope 3 ambition/target credibility	🟢	🟠	🟠	🔴
Governance and transparency	🟢	🟠	🟠	🟠

8. Conclusions

Most, if not all, stakeholders already have assessment and screening criteria in place for clients and opportunities. The mining and metals industry is difficult to assess due to the breadth of commodity products, mining methods, and uniqueness of each of asset which constitute a company portfolio. It's status as 'hard-to-abate', means the complexity of solutions required to decarbonise demands a carefully curated decarbonisation strategy and pathway. Ambitious targets are nothing without a corresponding, credible, and sustainable plan to achieve it. Talk without action will only lead to allegations of greenwashing, which many stakeholders want to avoid at all costs. The challenge for the mining industry is massive as it is expected to radically decarbonise whilst simultaneously increase profitability, grow production, and replace reserves in the face of declining ore grades.

RFC Ambrian has presented a framework which stakeholders can use to effectively analyse the credibility and sustainability of a mining company's decarbonisation strategy and pathway. The framework places a focus on the physical processes at play when a decarbonisation decision is made and therefore enables an assessment of the long-term sustainability of such decisions and strategies. This is important for key stakeholders, such as financial institutions and insurers, who wish to minimise their potential medium- and long-term exposure to greenwashing allegations and misaligned counterparties.

The application of the framework to several mining companies has identified areas for improvement and some common pitfalls – some of which are short term issues caused by a lack of alignment between market forces, incentives for the private sector and the societal goal of decarbonisation, and thus may take years to be become evident. Decarbonisation efforts are still in their infancy and the intersection between commodity and energy markets is complex. As stakeholders become increasing knowledgeable, we expect such pitfalls and issues to be repaired, with improved reporting quality and increased accountability.

The mining industry is described as hard-to-abate, which provides a convenient reason for inaction. This paper concludes with a list of 'hard-to-abate' questions, which stakeholders can use to challenge and further assess the mining industry's decarbonisation strategies and ultimately, long-term sustainability.

Some 'hard-to-abate' questions

Emissions reporting:

- Are emission targets predicated on location-based or market-based scope 2 emissions? How do location-based scope 2 emissions compare to market-based scope 2 emissions?
- Why has the scope 2 reporting methodology changed?
- Why has the emissions consolidation methodology changed?

Emissions targets:

- How have you considered the impact of production growth and subsequent credibility of your emissions targets?
- Do you have any corresponding energy intensity and absolute energy reduction targets?

Asset depletion

- What portion of depletion is assumed as a part of the emission reduction pathway?
- Does the company have a plan to implement industry best low carbon and energy efficiency technology for existing assets?

Technology and abatement opportunities

- Do you have a company-wide MACC? How was it constructed?
- What is the estimated implicit carbon price required to achieve your 2030 targets? 2050 targets?
- How have you assessed technology risk and maturity?
- How do you propose to pipeline and assess new technology opportunities?
- Have you identified adequate abatement opportunities to date to meet your stated targets?
- What probability of success are you budgeting for abatement projects which carry implementation risk, such as pre-commercial technologies? How does this impact your ability to reach your stated decarbonisation targets?

Implementation

- How do you propose to drive implementation across sites? Is it a site level decision or a corporate decision? If the former, does the site have the appropriate resourcing and authority to pursue projects?
- What R&D, pilot projects or demonstrations have you initiated to address your largest emission source? How are you going about doing this – partnerships, investee companies or self-developed?
- Do you have end-to-end examples or case studies of implementing abatement technologies from inception through to commercial operation?

Renewable strategy

- What portion of the company's renewable PPAs have contributed to underpinning new generation? What portion is sourced from existing renewable generation?
- What is the company's long-term procurement strategy with respect to replacing existing renewable PPAs?
- Does the company have an energy storage strategy to complement its renewable strategy?

Carbon offsets

- At what marginal abatement price will the company consider carbon offsets?
- Are your carbon abatement projects focussed on the mining value chain?
- Are implemented or proposed carbon offset projects considered additional and permanent?

Implemented projects

- Does the company have a systematic method for identifying and implementing initiatives?
- Does the company consider implemented initiatives to be of high quality?

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Glossary, Definitions and Key Terms

Term	Definition
Additionality (with respect to carbon offsets)	GHG emission reductions are additional if they would not have occurred in the absence of a market for offset credits
Business as usual	Continued operation of a company or underlying assets in the normal or usual way
CCS	Carbon Capture and Storage
CDP	Carbon Disclosure Project Worldwide
CIP	BHP's Climate Investment Program
CoE	Rio Tinto's Centre's of Excellence
ECO2MAN	Anglo American's energy efficiency program
Equity emissions (emissions reporting)	Where a company accounts for the equity share of its emissions
ESG	Environment, Social, and Governance
EV	Electric Vehicle
FutureSmart Mining™	Anglo American's approach to sustainable mining innovation
GHG emissions	Greenhouse Gas emissions
HPAL	High Pressure Acid Leach, process used to extract nickel and cobalt from lateritic ore bodies
HVAC	Eating Ventilation and Air Conditioning
JV	Joint Venture
Location-based scope 2 emissions	Average emissions intensity of electricity grid in which consumption occurs, or emissions from self-generation
MACC	Marginal Abatement Cost Curve. A tool used to quantify, rank and assess carbon abatement opportunities
Market-based scope 2 emissions	Emissions from contractual instruments such as renewable power purchase agreements and any associated renewable energy certificates or credits
Metallurgical coal (or met coal, coking coal)	Coal mined for the purpose of producing carbon for steel making
MOU	Memorandum of Understanding
NPV	Net Present Value
Operational emissions (emissions reporting)	Where a company reports 100% of emissions from assets they control and do not account for GHG emissions from assets they do not control. Can be further delineated into financial control approach
Permanence (with respect to carbon offsets)	GHG emission reductions must be permanent over time and unlikely, or impossible, to be reversed. A reversal occurs if at any point in the future, the

Term	Definition
	rate of GHG emissions accelerates and becomes higher than it would have been if the project had never happened
PGM	Platinum Group Metals
Powershift® program	Vale's energy efficiency program
PPA	Power Purchase Agreement
R&D	Research and Development
Redistribution	Redistributing emissions to other uses or groups in a country of society at large
SBT	Science Based Targets (with reference to emissions reduction target)
Scope 1 emissions	GHG emissions that occur directly from sources attributable to a company or asset
Scope 2 emissions	GHG emissions that occur indirectly from the purchase of electricity, heat, steam, or cooling
Scope 3 emissions	GHG emissions that result from assets not owned of controlled by a company, but indirectly occur within its value chain (i.e., upstream, or downstream of a company of asset)
Societal emissions	Referring to the aggregate actual emissions of a country or the world at large
SX EW	Solvent Extraction and Electrowinning, hydrometallurgical process used to extract copper
Thermal coal	Coal mined for the purpose of combustion to produce steam and generate electricity

Units of measurement	
CO2e	Carbon Dioxide Equivalent
PJe	Petajoule equivalent
kt	thousand (metric) tonnes
Mt	million (metric) tonnes
MW	Megawatt
MWh	Megawatt hour
GW	Gigawatt
GWh	Gigawatt hour
TW	Terawatt
TWh	Terawatt hour

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