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# Achieving Net Zero Through a Multi-Dimensional Approach to Carbon Management in Mining and Metals Processing–A Case Study of Rio Tinto

Alison Knoblauch *, Paul Dargusch

School of Earth and Environmental Science, University of Queensland, Australia; E-Mails: a.atkinson@uq.net.au; p.dargusch@uq.edu.au

* **Correspondence:** Alison Knoblauch; E-Mail: a.atkinson@uq.net.au

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**Abstract**

The earth's climate is warming, increasingly straining the Earth's human and environmental systems. Organisations are increasingly committing to net zero emissions by mid-Century to set and communicate their ambition to limit global warming to the peak temperature goals of the Paris Agreement. However, for many companies, the pathway to delivering against this ambition remains unclear – and significant investment in technical, social and economic systems required before this target becomes a reality. This paper analyses the climate commitments and carbon management practices at Rio Tinto, a global extractor and processor of metals and minerals. Publicly available information has been analysed against climate benchmarks, including the Climate Action 100+ framework, to form a view on the nature and sufficiency of their carbon management approach to deliver outcomes in line with their committed ambition. While Rio have established a strong ambition and have invested in a range of initiatives, they face criticism for not setting targets for their Scope 3 emissions and for their moderate investment relative to their total revenue and the scale of change required. However, their internal carbon pricing model and recent links with executive remuneration are positive signs of continual improvement towards achieving net zero by 2050.

**Keywords**
Carbon management; ESG; net zero; corporate sustainability

## 1. Introduction

The earth's climate is changing rapidly as a result of increased greenhouse gas emissions in the Earth's anthroposphere [1]. Climate. The earth has warmed by 1.1°C since 1850-1900 and is expected to reach or exceed 1.5°C of warming in the next 20 years unless there are immediate, large-scale reductions in greenhouse gas emissions [2]. Climate change at or greater than this level will have catastrophic human and environmental impacts, including global temperature rises, sea level rise, increased frequency and extremity of weather events and ecosystem losses [3, 4].

Governments and organisations are facing unprecedented pressure to reduce their contribution to climate change as the evolving science and associated societal and econo-political pressures mount a strong and immediate case for action [5, 6]. Public, political and investor pressure is particularly strong for heavy emitters, including the resources sector [7, 8]. These companies hold significant emissions portfolios for decarbonisation and are increasingly seen as critical enablers for building a climate-resilient future [9].

Greenhouse gas emissions from primary mineral and metal production represented 10% of total global energy-related greenhouse gas emissions in 2018 [10, 11]. In Australia, mining contributes 17% and the resources sector as a whole contributes more than a quarter of Australia's total greenhouse gas emissions (considering scope 1-3 emissions of the top 22 mining, oil and gas extraction, and metals manufacturing companies reporting emissions under Australia's National Greenhouse Gas and Energy Framework). Roughly 80% of emissions are from indirect scope 3 emissions – highlighting the influence the resources industry has more broadly across sectors such as transportation and services [12, 13]. Emissions are reported in accordance with the Greenhouse Gas Protocol as scope 1 (direct emissions), scope 2 (indirect emissions from the use of purchased electricity) and scope 3 (indirect emissions across the value chain) emissions sources.

The transition to a low carbon economy is resulting in decarbonisation efforts across all industries, with $960 billion expected to be spent by corporates alone in 2021-2025 [14]. 50% of this spend is projected to be in renewable energy transition – followed by transport and buildings, industry, agriculture, forestry and land use, and low emissions fuel. The technologies required in the clean energy shift are significantly more material intensive than traditional energy supply systems [6, 15, 16]. This will fundamentally disrupt commodity demands and create a major shift in the global movement of associated raw materials. The anticipated impact on raw materials is demonstrated in Table 1.

**Table 1** Expected shift in commodity demands to enable a low-carbon economy under a two-degree scenario in 2030, compared with business as usual. *Adapted from*: Delevingne *et al.* [17]; The World Bank Group [18].

| Commodity | Headwind[1] | Tailwind[2] | Cumulative demand change[3] | Context |
|---|---|---|---|---|
| Aluminium | | | 180% | Increased recycling rates offset growth from decarbonisation activities. Manganese demand increases due to the penetration of coal and gas carbon capture and storage. |
| Iron ore | | | 160% | |
| Lead | | | 390% | |
| Chromium | | | 130% | |
| Manganese | | | 2590% | |
| Nickel | | | 170% | Large growth presented by the transition to electric vehicles and growth in battery storage |
| Cobalt | | | -40% | |
| Lithium | | | 1060% | |
| Copper | | | 120% | Growth from electric vehicles, renewables and batteries offset by increased recycling rates |
| Coal | | | -50% | Demand declines by >50% in the transition to renewables |
| Uranium | | | 80% | Demand increased by 50-100% to enable nuclear power growth |

*Change in cumulative metal demand compared with a 6°C scenario, 2013-50

This is one example of how the low carbon transition creates both risk and opportunities for mining and metals companies, who must not only focus on decarbonising their own portfolio and value chains, but also analyse and consider other material impacts on the organisation's strategy [9]. Proactively identifying and responding to the changing needs and expectations of consumers as their organisations and sectors decarbonise presents a significant opportunity to secure and retain strategic advantage in such evolving markets [19].

This paper analyses the carbon reporting, mitigation and management practices at Rio Tinto. As one of the world's leading extractors and refiners of raw metals and minerals, Rio Tinto's carbon footprint is substantial – particularly in its high temperature, energy-intensive refining and smelting processes and the use of its commodities in manufacturing [20]. It also produces metals and minerals that are critical to enabling the transition to a low-carbon economy, and hence is

[1] A measure of relative increase in demand under a two-degree climate warming scenario, relative to a business-as-usual scenario.
[2] A measure of relative decrease in demand under a two-degree climate warming scenario, relative to a business-as-usual scenario.
[3] Change in cumulative metal demand compared with a 6$^{OC}$ scenario, 2013-50.

positioned to weather not only some of the most significant risks from a changing climate – but also to take advantage of significant opportunities [7].

Rio Tinto presents a particularly interesting case study due to the large, global scale of its operations, the innovation required for solutions to revolutionise established systems and processes and the need for transitioning old, expensive fixed assets to new ways of operating. It is also under significant pressure from investors, Governments and industry bodies to both reduce its footprint and support the transition to a low-carbon future [17, 21]. Their focus on innovative technological advances to address complex and hard-to-abate elements of their emissions profile and meet increasing stakeholder demand for low-carbon solutions is central to their strategy. The scale of carbon avoidance from these enablement opportunities (particularly in steel manufacturing) is significant and could present a key strategic differentiator for the organisation.

### *1.1 Overview of the Firm*

Rio Tinto was founded in 1873 and is one of the largest operators in the mining and metals sector. Employing 47,500 people across 60 operational sites in 35 countries, Rio Tinto's core business includes the operation of mines, smelters and refineries that together extract, refine and process nine commodities for sale across a Global Client base [22]. These include iron ore, bauxite, alumina, aluminium, copper, borates, titanium dioxide, diamonds and lithium [23]. An overview of operations is in Table 2. Nine of these operations are located in Australia.

**Table 2** Summary of Operational Rio Tinto Sites. *Source:* Rio Tinto 2021 [24].

| | **Iron Ore** | **Aluminium** | **Copper** | **Minerals** |
|---|---|---|---|---|
| Mines | 17 | 4 | 4 | 6 |
| Smelters | 0 | 14 | 1 | 0 |
| Processing plants and refineries | 0 | 4 | 0 | 4 |
| Other core operations | 4 port terminals | 2 port and rail facilities | - | - |
| Rio Tinto share of production | 266.8 Mt | 54.3 Mt bauxite<br>3,151 kt aluminium | 493.5 kt mined copper | 1014 kt titanium dioxide slag |
| Underlying EBITDA | $27.6 bn | $4.4 bn | $4.0 bn | $2.6 bn |
| $CO_2$ emissions | 3.0 Mt | 21.9 Mt | 2.2 Mt | 3.4 Mt |

In 2021, made $66.6 billion in revenue (up from 44.6 billion in 2020) [23, 24]. Its most significant commodity is iron ore and its largest clients are based in China. An overview of key revenue streams in the 2020 reporting period is in Figure 1 and Figure 2.

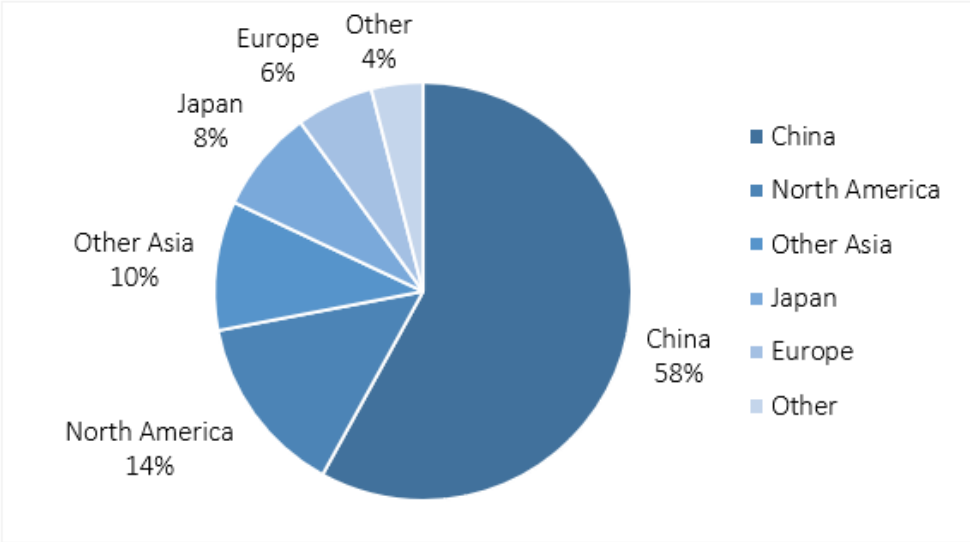


**Figure 1** Rio Tinto 2020 Breakdown of its $44.6 bn revenue by destination. *Adapted from:* Rio Tinto [25].

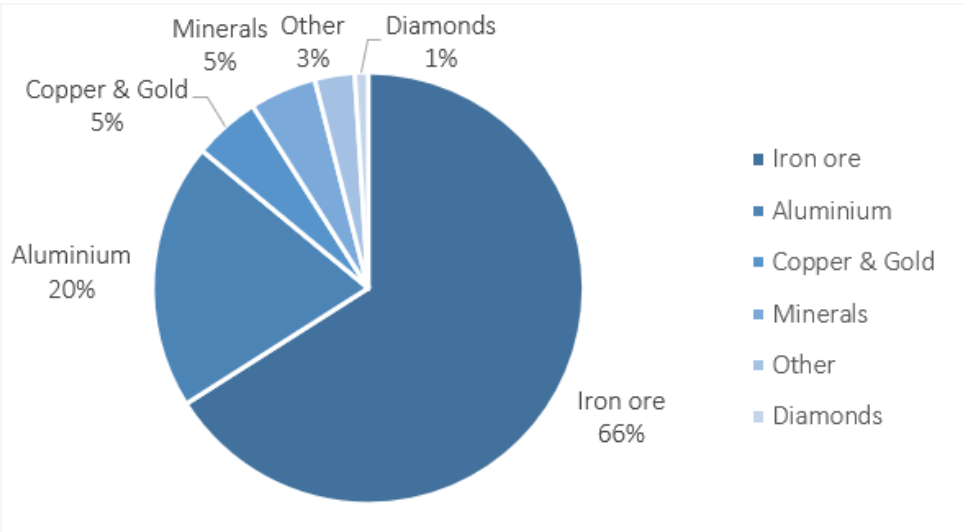


**Figure 2** Rio Tinto 2020 Breakdown of its $44.6 bn revenue by commodity. *Adapted from:* Rio Tinto [25].

Rio Tinto's climate change challenges are significant and varied. As are all large, Global conglomerates in the resources sector, they are under substantial pressure from Governments and industry groups to address their emissions profile under various National governance frameworks – including in Australia [12].

A key challenge in doing so is addressing the emissions in Rio Tinto's value chain (indirect scope 3 emissions) - a large proportion of which are associated with hard-to-abate activities such as steel manufacturing. Pressure to set and work towards measurable targets for this component of their emissions profile is a particular focus of activist and other industry groups analysing the sufficiency of their climate response. While challenging to set targets for such a large indirect emissions portfolio, addressing these emissions relies on partnerships, influence and long-term strategic engagement across the organisation's value chain [26].

Many of the organisation's direct emissions are generated from old, fixed assets and established processing activities (e.g. smelters and mines). Updating these to reduce emissions requires substantial investment and innovations, including in technological solutions that may not yet be available or commercially viable [27]. The scope, breadth and energy intensity of Rio Tinto's fixed assets also present challenges to accessing and leveraging renewable energy at the scale and reliability required to effectively run the operations [28, 29].

## 2. Methodology

This paper summarises a review of Rio Tinto's climate strategy to inform a view on the sufficiency of their ambition and approach, and review progress against their committed targets. Rio Tinto's performance against the Climate Action 100 + benchmark has been reassessed as at June 2021 to inform a new perspective on the maturity of their approach against this global framework. Publicly available information from primary sources (such as Rio Tinto's climate data) and secondary sources have been leveraged.

This research aims to contribute a case study of current proactive to academic literature which can further inform perspectives on the sufficiency of corporate action in response to the climate challenge. Such perspectives are important in determining whether there is adequate accountability, determination and collective ambition across society to enable the transition to a low carbon future - and, in doing so, limit global warming in accordance with the peak temperature goals of the Paris Agreement. Corporates can also benefit from this research, particularly when assessing their own strategies and performance against academic resources.

## 3. Results

### *3.1 Emissions Reduction Commitments*

Rio Tinto have committed to achieving net zero emissions in their operations by 2050. In their 2020 climate change report, they also set interim targets to reduce emissions intensity by 30% and absolute emissions by 15% by 2030 (relative to a 2018 baseline) [30]. This absolute emissions reduction represents a 45% reduction from 2010 levels, consistent with a 1.5 degree global warming pathway described by the IPCC [2, 13, 30]. In their 2021 report, they set a new, more ambitious commitment for scope 1 and 2 emissions, committing to a 15% reduction by 2025 and a 50% reduction by 2030 [24].

To address the carbon footprint of their value chain (and address their scope 3 emissions), Rio Tinto have pledged to invest in technology and steel decarbonisation pathways that deliver at least a 30% reduction in the carbon intensity of steelmaking by 2030. They have also committed to exploring potentially carbon neutral steelmaking pathways by 2050 [30]. Further, Rio Tinto have pledged investment in technological advancements to produce zero-carbon aluminium smelting by 2025 (through the ELYSIS process) and to achieve net zero emissions product shipping by 2050 [30].

### *3.2 Key Drivers*

Rio Tinto's emissions reduction commitments respond to a number of key drivers. Economic and geopolitical pressures are a strong incentive as Rio Tinto's most strategic trading partners commit to significant emissions reduction targets (such as commitments to net zero by 2050 or sooner made

by China, Japan and South Korea). 88% of Scope 3 emissions (largely associated with the use of Rio Tinto's product) are generated in regions that have committed to carbon neutral targets by 2050 [30]. Rio Tinto can position themselves as either a key enabler of the low carbon transition, or as a big emitter that requires action in order for these stakeholders to achieve their climate commitments. A proactive and aligned strategy can enable positive and sustained partnerships in these regions, and with purchasers and other partners under similar pressures.

The investor community is also increasing pressure on organisations to reduce their emissions, with some lenders and investors committing to decarbonising their portfolios significantly [8, 28, 31]. This is increasing capital costs for heavy emitters such as Rio Tinto and creating a strong impetus for action [32-34].

Other drivers include harnessing competitive advantage through operational efficiency, meeting community expectation, maintaining organisational resilience and meeting Director obligations to manage the associated long term financial and other risks [7, 8, 35].

### *3.3 Emissions Estimates*

#### 3.3.1 Organisational and Product Footprint Emissions

Rio Tinto's Scope 1 and 2 emissions are shown in Figure 3 and totalled 31.5 Mt $CO_2$-e in 2020 (equity basis) [36]. This demonstrates a gradual but consistent reduction in total direct total emissions but an increase in emissions from purchased energy in 2020. Emissions from sites under Rio Tinto's operational control have gradually reduced over time (Managed basis reporting, captured in Figure 4).

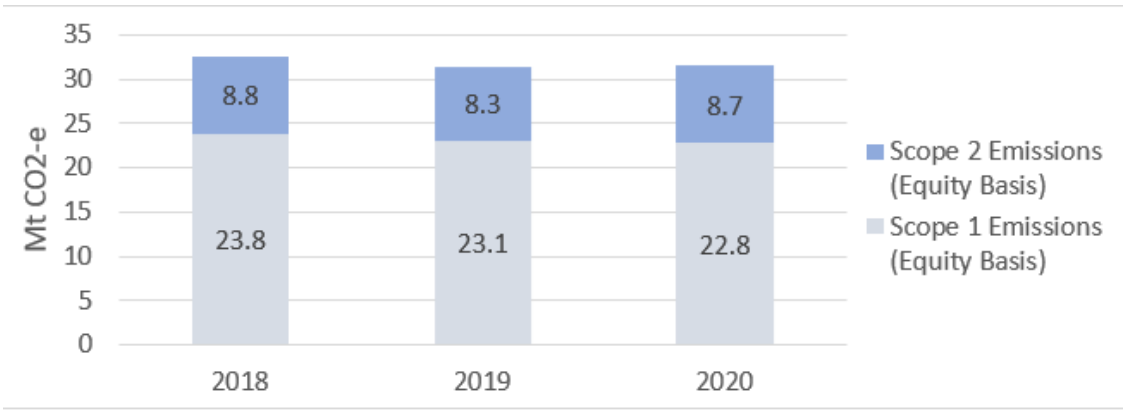


**Figure 3** Rio Tinto's Scope 1 & 2 Emissions[4] Over Time on an Equity Basis[5]. *Adapted from: Rio Tinto [21].*

[4] Rio Tinto's Scope 1 emissions capture all direct and fugitive emissions from operations . Scope 2 emissions are from the generation of purchased electricity for operations

[5] Rio Tinto's emissions profile is reported on using two different basis of calculation - a managed basis (capturing the sites within Rio Tinto's operational control) and an equity basis (all operations of which Rio Tinto has a stake).

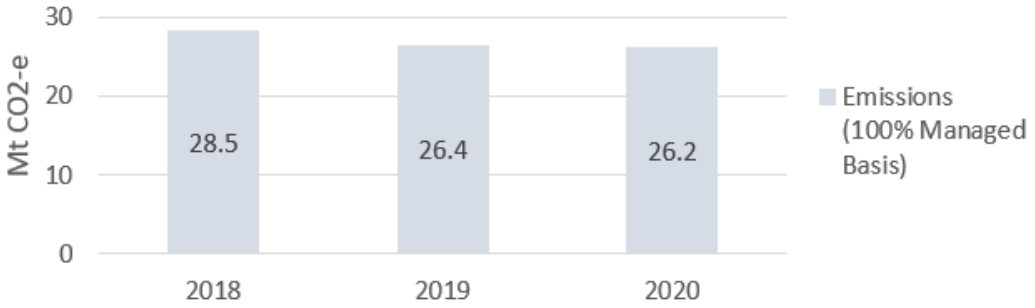


**Figure 4** Rio Tinto's Scope 1 & 2 Emissions[6] Over Time on a Managed Basis[7]. *Adapted from: Rio Tinto [22].*

These emissions reductions may be the result of changes to operations or as a result of emissions reduction initiatives. Emissions intensity reflects the emissions released compared to the scale of operation (e.g. emissions per unit of production). This enables tracking of efficiencies (compared to absolute reductions which can be influenced by actions such as the sale or purchase of assets or other substantial change to operations). Rio Tinto's emissions intensity has remained relatively stable over the previous three years, reducing by 0.1 $tCO_2$-e/t Cu-eq in 2019 (from 6.5 $tCO_2$-e/t Cu-eq in 2018 to 6.4 $tCO_2$-e/t Cu-eq in 2019 and 2020) [22]. This shows that while progress is being made, there has not yet been a material reduction in emissions driven by efficiencies across the organisation. However, across an organisation this large and energy intensive, this is still positive.

Rio Tinto's 2020 scope 1 and 2 emissions have been further broken down by location in Figure 5 to demonstrate the regions under which emissions are captured in National inventories, and where the associated emissions reduction commitments are governed. This shows the significant proportion of emissions are generated in Australia.

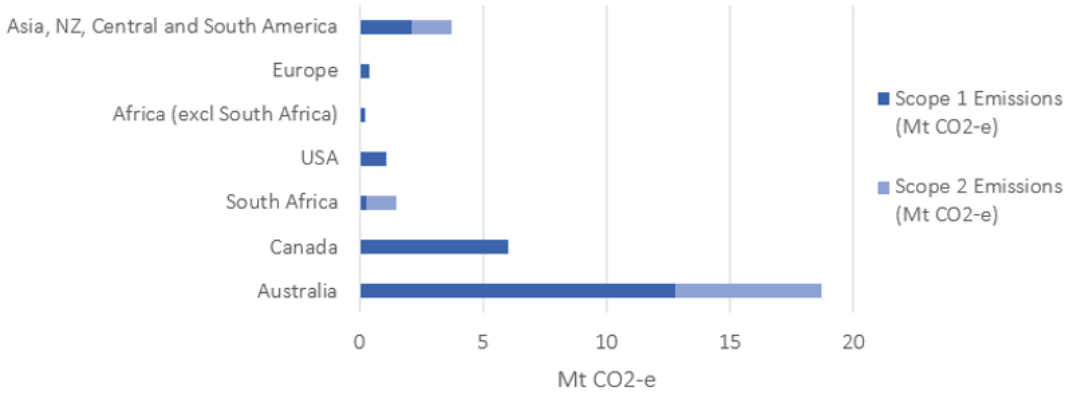


**Figure 5** Rio Tinto's 2020 Emissions Profile by Country. *Adapted from: Rio Tinto [22].*

Figure 6 re-cuts this data by product footprint, showing the contribution of each commodity to the total emissions profile. Aluminium contributes 49% of scope 1 & 2 emissions to the total

[6] Rio Tinto's Scope 1 emissions capture all direct and fugitive emissions from operations . Scope 2 emissions are from the generation of purchased electricity for operations

[7] Rio Tinto's emissions profile is reported on using two different basis of calculation - a managed basis (capturing the sites within Rio Tinto's operational control) and an equity basis (all operations of which Rio Tinto has a stake).

portfolio (Pacific and Atlantic operations). This is largely due to the carbon produced during the degradation of anodes in the smelting process, the heat and calcination required in alumina refining and the power required to run these operations [30]. Two major smelters operating in Australia are supplied by coal power which contributes signficantly towards this portfolio.


**Figure 6** Emissions source by operation (Scope 1 & 2 emissions on an equity basis). *Adapted from*: Rio Tinto [36].

Scope 1 emissions are generated from several sources, demonstrated in Figure 7. This is important context to understanding the materiality of emissions reductions initiatives on the overall performance for the firm. Emissions are largely generated from 'hard to abate' activities, including the combustion of anodes in titanium dioxide furnaces and aluminium smelters, diesel in the mining and rail fleet, and burning of fossil fuels for steam and heat in refineries [30]. These are considered challenging to abate given society's increasing demand for such activities, the capital intensity required for at-scale infrastructure and process change and the fossil-fuel dependencies embedded in production pathways (such as the emission of $CO_2$ in the process, as well as in the use of energy) [37]. In the organization's scope 2 emissions profile, the largest proportion of electricity is sourced from hydroelectricity (at Canadian, United States and Australian operations), followed by coal and natural gas.

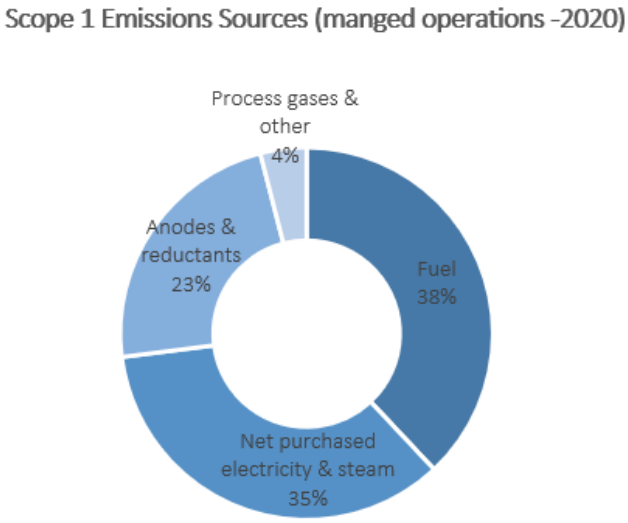


**Figure 7** Scope 1 emissions Sources from Rio Tinto's Managed Operations in 2020. *Adapted from*: Rio Tinto [36].

Rio Tinto's scope 3 emissions include indirect emissions generated in the organisation's value chain, upstream and downstream of its direct operations. In 2020, 75% of Rio Tinto's scope 3 emissions were attributed to the use of extracted iron ore. 98% of iron ore is used in the production of steel, with the remaining 2% used as powdered iron, radioactive iron, iron blue and black iron oxide [38]. 22% of Rio Tinto's scope 3 emissions were also attributed to the use of alumina and bauxite (largely for the production of aluminum). This shows that products produced by Rio Tinto present a significant emissions profile comparative to the goods and services in their supply chain.

### *3.4 Sector Performance and Industry Comparisons*

Rio Tinto's total consumption of electricity is four times that of other global mining companies, largely due to the scale of their operations and the energy intensity of their key processes, such as aluminium smelting [30]. In Australia, Rio Tinto is the 6$^{th}$ largest consumer of energy. It has the largest scope 2 emissions profile and the 12$^{th}$ largest scope 1 emissions (Figure 8). Hence, its operations and its efforts to reduce associated emissions are Nationally material. In the Australian resources sector, it has the largest scope 1 and scope 2 emissions portfolio and the second largest scope 3 emissions portfolio (following BHP) [13].

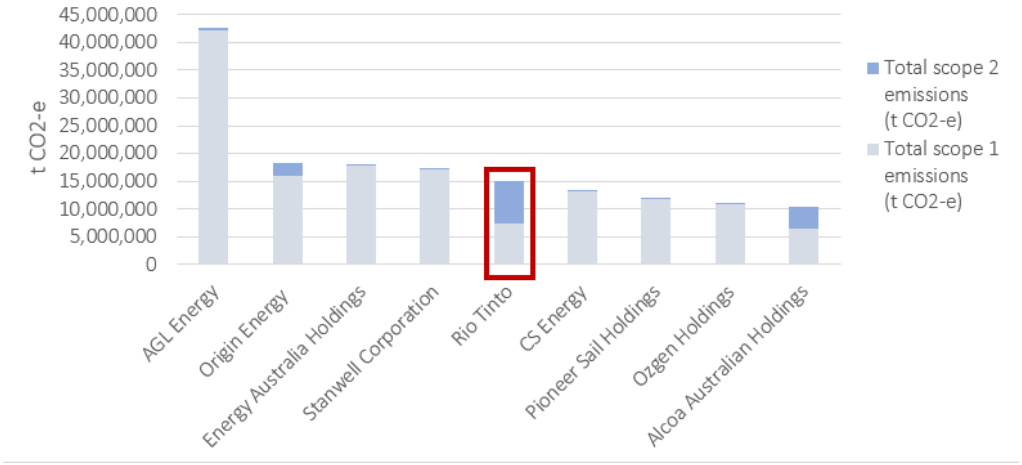


**Figure 8** Top 10 Emitters in Australia (Scope 1 & 2). *Adapted from*: Australian Government Clean Energy Regulator [39].

### *3.5 Emissions Reductions*

To deliver on their targets and manage the associated risks from a low-carbon transition, Rio Tinto have adopted a multi-faceted emissions reduction plan. In 2018, Rio Tinto exited the coal mining business, recognising the transition to a low carbon economy will result in a significant reduction in the demand for thermal coal [16, 25, 35]. Their more recent strategy has focussed on asset-specific decarbonisation roadmaps including renewable energy sourcing and low-carbon technological solutions to reduce emissions from coal and natural gas for process heat [40]. While carbon offsets form part of the strategy, this is largely directed at offsetting residual 'hard to abate' scope 1 and 2 emissions. An overview of Rio Tinto's emissions abatement pathway is in Figure 9.

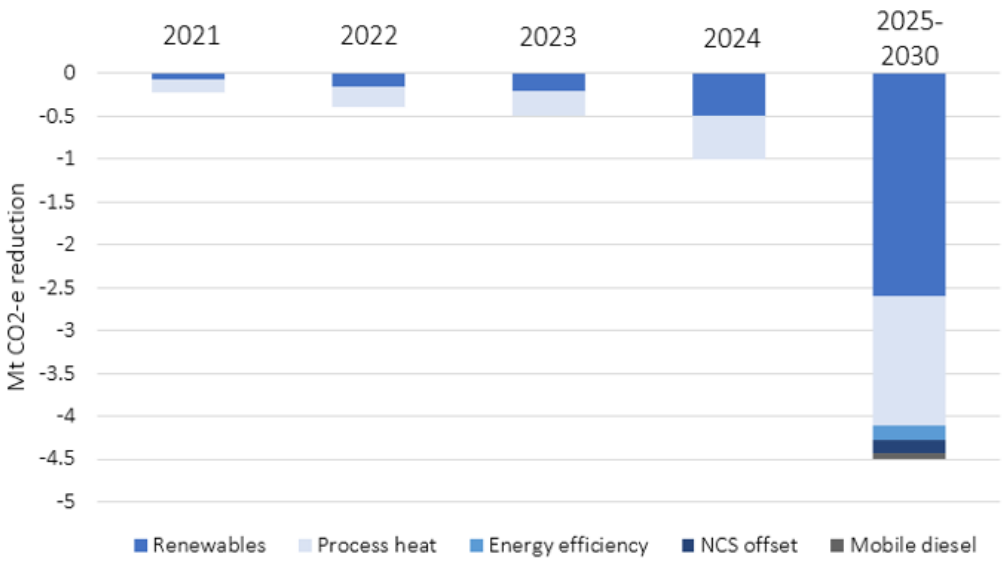


**Figure 9** Rio Tinto's 2030 Emissions Abatement Pathway. *Adapted from: Rio Tinto [30].*

In Rio Tinto's 2020 climate change report, they note a committed $1 billion for emissions reduction initiatives from 2020-24 [30], with $140 m approved for spend in 2020. In their 2021

report, they note an expected operational expenditure of $200 m for energy efficiency work, up to $3 b growth capital in materials enabling the low carbon transition (2023-2024) and $7.5 bn capital for carbon abatement projects to 2030 ($2.5 bn in 2022-2024) [23](Rio Tinto, 2021).

To prioritise their investment, a marginal abatement cost curve model has been applied to assess and prioritise projects. Rio Tinto have also developed an internal carbon price of $75/t$CO_2$e to incentivise mitigation projects in capital allocation and have linked their climate commitments to executive remuneration (announced in their 2021 strategy). These initiatives are critical initiatives towards systemising emissions reduction opportunities as part of the organisation's financial model [20].

3.5.1 Overview of Emissions Reduction Initiative Costs

Rio Tinto's emissions reduction initiatives include projects from large-scale, long-term strategic 'future innovations' to smaller scale, site-specific projects. Table 3 summarises the costs and planned/ achieved outcomes for five key projects, further discussed in Section 5.2.

**Table 3** Overview of emissions reduction project costs and outcomes.

| Category | Project | Cost | Outcome | Reference |
|---|---|---|---|---|
| Renewable Energy | Gudai-Darri solar project (Australia) | $98 m (build) | 90,000 t $CO_2$-e emissions reduction | Rio Tinto [22] |
| Energy Conservation | ELYSIS project | $50 m build (R&D phase) | 7 million t $CO_2$-e emissions reduction (Canada)<br>Potential to reduce greenhouse gas emissions at Rio Tinto's Boyne Smelter by ~1.3 million tonnes | ELYSIS [41]; Ratcliffe *et al.* [42] |
| | Aluminium casting furnace efficiency – Boyne Smelter, 2015 (Australia) | $685 m (plant upgrade | $45 800 savings per month<br>15% decrease in specific energy consumption<br>10% improvement in energy efficiency<br>20,000 t $CO_2$-e emissions reduction annually | Goutiere, Fortier & Dupris [43] |
| | Boyne smelter bus bar re-design, 2018 (Australia) | $23 m | 5% total reduction in energy<br>9,200 t $CO_2$-e emissions reduction annually | Corby *et al.* [44]; Himmelreich *et al*. [45] |
| Industry Partnerships | China Baowu & Tsinghua research and development projects | $14.5 m | Unquantified but significant long-term opportunities to decarbonise the steel manufacturing value chain | Rio Tinto [30] |
| | Nippon research and development projects | TBC | | |

| | |
|---|---|
| Paul Wurth and SHS – Stahl-Holding-Saar (Dillinger/ Saarstahl/Rogesa) | TBC |

3.5.2 Emissions Reduction Initiatives

Renewable Energy Investment. Renewable energy sourcing provides the most significant opportunity for emissions reduction – representing a major proportion of the emissions profile. It also provides opportunity to build resilience to the impacts of a changing climate, particularly as processes and fleet become increasingly electrified [17].

Rio Tinto are targeting 1 GW power from solar and wind in the Pilbara region, and from green repowering solutions for Boyne Island and Tomago smelters [24]. They have invested $98 m in the Gudai-Darri solar project to deliver intermittent renewable energy through open cycle gas turbines; scheduled for completion at the end of 2021 [23]. This includes the construction of 100 000 photovoltaic cells providing 34 MW and a 45 MW/ 12 MWh lithium ion battery. Future expansion into wind energy is also being considered. This project will supply Gudai-Darri's electricity demand during peak production times and 65% of the mine's average electricity demand – saving 90,000 tonnes $CO_2$-e emissions per year [30, 42].

In Rio Tinto's broader portfolio, 75% of electricity used at managed operations is from renewable sources, including hydro and wind power [24]. Renewable energy certificates are purchased for several other sites where direct renewable power is not accessible. Relative to industry, this investment in renewables is eight times that of Rio Tinto's peers [30].

Energy Efficient and Low Carbon Technology (Energy Conservation)**.** Energy reduction and efficiency initiatives have also been implemented to improve operational efficiency at a site and process level, driving both emissions reductions and cost savings. As an example, at Boyne Smelter in Queensland, retrofits to improve efficiency in busbar and furnace operation have reduced 29,000 tonnes $CO_2$-e emissions reduction annually at a cost of $708 m [44]. High costs are associated with retrofitting the large, old fixed assets in a complex plant environment [46].

Rio Tinto have committed $28 m and progressed the development of the ELYSIS project which aims to enable carbon-free aluminium smelting process by replacing activated carbon with inert anodes which last 30 times longer [13, 23]. The work involves testing and patenting the required technology, constructing and operating test capability and managing the rollout of the new technology once proven. While a longer-term project, this technology has the potential to reduce GHG emissions by 7 million tonnes in Canada alone [41]. Hence, its impact is significant for not only Rio Tinto's emissions reduction goals but on a Global scale. In their 2021 report, Rio Tinto announced their commitment to scale up this technology for installation from 2024 [24].

In 2021, a further $8 m has also been invested across 25 research and development projects and studies covering renewable energies, alternative fuels, and process efficiency improvements [23].

Electrification/ Fuel Switching. Rio Tinto have also electrified their processes, haul truck and rail fleet to address their Scope 1 emissions from fuel burning. Their 2021 commitment is to phase our the purchase of diesel haul trucks and locomotives by 2030. While this results in an increase in Scope

2 emissions (from energy purchases to power the electric vehicles), there are a number of benefits for realising emissions reductions across the fleet. Electric truck motors are more efficient than diesel engines at 77% conversion efficiency compared to 12-30% for internal combustion engines. While this is in part counter-balanced by the generation of electricity to charge the trucks, they also have fewer moving parts and are able to achieve a greater up-hill haul rates. This means they require less maintenance and are able to complete each haul cycle in a shorter time period, enabling a reduction in overall fleet size [11, 47].

These benefits, coupled with the ability to leverage renewable energy to power the fleet, present significant emissions reduction opportunity – up to 100% reduction in scope 1 & 2 emissions from fleet and 26% reduction in all emissions [11]. However, there remains some issues with this transition that need to be carefully understood and managed. The two key issues are managing charging times and controlling the impact of battery weight on material haul weights [48]. Rio Tinto have partnered with BHP and Vale in an innovation challenge to solve these challenges. The electrification rollout will start driving emissions reductions post-2025.

Partnerships for Innovation. Rio Tinto have established several industry partnerships to explore longer term solutions across processes, systems and technologies to decouple growth and productivity from emissions. $14.5 m has been invested over two years with the worlds largest steel producer, China Baowu Steel group, and Tsinghua University to support low-carbon steelmaking projects and research [30]. Rio Tinto is also partnering with Japan's largest steel producer, Nippon Steel, to further investigate low-carbon technology solutions in the steel value chain [25]. Rio Tinto, along with several other resource companies, has also launched an innovation challenge to develop new solutions for large-scale truck electrification systems to help cut emissions further [40].

### 3.5.3 Comparison of Climate Change Strategy to Industry

Climate Action 100+ assesses companies' management of climate risk using a Net-Zero Company Benchmark. This framework provides an effective mechanism for objectively analysing the comprehensiveness of Rio Tinto's strategy and comparing across industry in Australia (based on their global position) - captured in Table 4 and Table 5.

**Table 4** Climate Action 100+ Performance Assessment of the Top 10 Emitters in Australia. *Adapted from*: ClimateWorks Australia [13].

| | Disclosure Indicator | Rio Tinto | Alcoa Australian Holdings | Chevron Australia Holdings | Woodside Petroleum | Glencore Holdings | Santos | Inpex Holdings Australia | Bluescope Steel | SOUTH32 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Net-zero GHG Emissions by 2050 (or sooner) ambition |  | |  |  |  |  | |  |  |
| 2 | Long-term (2036-2050) GHG reduction target(s) |  | |  |  |  |  | |  |  |
| 3 | Medium-term (2026-2035) GHG reduction target(s) |  | |  |  |  |  | |  |  |
| 4 | Short-term (up to 2025) GHG reduction target(s) |  | Not available |  |  |  |  | Not available |  |  |
| 5 | Decarbonisation strategy |  | |  |  |  |  | |  |  |
| 6 | Capital allocation alignment |  | |  |  |  |  | |  |  |
| 7 | Climate policy engagement |  | |  |  |  |  | |  |  |
| 8 | Climate Governance |  | |  |  |  |  | |  |  |
| 9 | Just transition |  | |  |  |  |  | |  |  |
| 10 | TCFD Disclosure |  | |  |  |  |  | |  |  |

**Table 5** Climate Action 100+ Assessment of Rio Tinto Against the Net-Zero Company Benchmark (based on January 2021 data) and Re-Assessment of Performance at July 2021. *Adapted from*: ClimateWorks Australia [13].

| Disclosure Indicator | | Performance (Climate Active 100+) | Sub-Indicator/ Metric | Performance (Climate Active 100+) | July 2021 Analysis[8] |
|---|---|---|---|---|---|
| **1** | Net-zero GHG Emissions by 2050 (or sooner) ambition | 🟠 | 1.1 The company has set an ambition to achieve net-zero GHG emissions by 2050 or sooner | 🟠 | 🟠 No change |
| | | | A. The company has made a qualitative net-zero GHG emissions ambition statement that explicitly includes at least 95% of scope 1 and 2 emissions | 🟢 | |
| | | | B. The company's net-zero GHG emissions ambition covers the most relevant scope 3 GHG emissions categories for the company's sector, where applicable | 🔴 | |
| **2** | Long-term (2036-2050) GHG reduction target(s) | 🟠 | 2.1 The company has set a target for reducing its GHG emissions by between 2036 and 2050 on a clearly defined scope of emissions | 🟢 | 🟠 No change |
| | | | 2.2 The long-term (2036-2050) GHG reduction target covers at least 95% of scope 1 & 2 emissions and the most relevant scope 3 emissions (where applicable) | 🟠 | |
| | | | A. The company has specified that this target covers at least 95% of total scope 1 and 2 emissions | 🟢 | |
| | | | B. If the company has set a scope 3 GHG emissions target, it covers the most relevant scope 3 emissions categories for the company's sector (for applicable sectors), and the company has published the methodology used to establish any scope 3 target. | 🔴 | |
| | | | 2.3 The target (or, in the absence of a target, the company's latest disclosed GHG emissions intensity) is aligned with the goal of limiting global warming to 1.5°C. | 🔴 | |

[8] Completed by the Authors as part of this assessment.

| | | | | |
|---|---|---|---|---|
| **3** | Medium-term (2026-2035) GHG reduction target(s) | 3.1 The company has set a target for reducing its GHG emissions by between 2026 and 2035 on a clearly defined scope of emissions.<br>3.2 The medium-term (2026 to 2035) GHG reduction target covers at least 95% of scope 1 & 2 emissions and the most relevant scope 3 emissions (where applicable).<br>A. The company has specified that this target covers at least 95% of total scope 1 and 2 emissions.<br>B. If the company has set a scope 3 GHG emissions target, it covers the most relevant scope 3 emissions categories for the company's sector (for applicable sectors), and the company has published the methodology used to establish any scope 3 target.<br>3.3 The target (or, in the absence of a target, the company's latest disclosed GHG emissions intensity) is aligned with the goal of limiting global warming to 1.5°C.* | No change |
| **4** | Short-term (up to 2025) GHG reduction target(s) | 4.1 The company has set a target for reducing its GHG emissions up to 2025 on a clearly defined scope of emissions.<br>4.2 The short-term (up to 2025) GHG reduction target covers at least 95% of scope 1 & 2 emissions and the most relevant scope 3 emissions (where applicable).<br>A. The company has specified that this target covers at least 95% of total scope 1 and 2 emissions.<br>B. If the company has set a scope 3 GHG emissions target, it covers the most relevant scope 3 emissions categories for the company's sector (for applicable sectors), and the company has published the methodology used to establish any scope 3 target.<br>4.3 The target (or, in the absence of a target, the company's latest disclosed GHG emissions intensity) is aligned with the goal of limiting global warming to 1.5°C.* | No change |

| | | | | | |
|---|---|---|---|---|---|
| **5** | Decarbonisation strategy |  | 5.1 The company has a decarbonisation strategy to meet its long and medium-term GHG reduction targets.<br>A. The company identifies the set of actions it intends to take to achieve its GHG reduction targets over the targeted time frame. These measures clearly refer to the main sources of its GHG emissions, including scope 3 emissions where applicable.<br>B. The company quantifies key elements of this strategy with respect to the major sources of its emissions, including scope 3 emissions where applicable.<br>5.2 The company's decarbonisation strategy includes a commitment to 'green revenues' from low carbon products and services.<br>A. The company already generates 'green revenues' and discloses their share in overall sales.<br>B. The company has set a target to increase the share of 'green revenues' in its overall sales OR discloses the 'green revenue' share that is above sector average. |  <br>  <br>  <br>  <br>  <br>  | <br>No change |
| **6** | Capital allocation alignment |  | 6.1 The company is working to decarbonise its future capital expenditures.<br>A. The company explicitly commits to align future capital expenditures with its long-term GHG reduction target(s).<br>B. The company explicitly commits to align future capital expenditures with the Paris Agreement's objective of limiting global warming to 1.5° Celsius.<br>6.2 The company discloses the methodology used to determine the Paris alignment of its future capital expenditures.<br>A. The company discloses the methodology it uses to align its future capital expenditures with its decarbonisation goals, including key assumptions and key performance indicators (KPIs).<br>B. The methodology quantifies key outcomes, including the share of its future capital expenditures that are aligned with a 1.5° Celsius scenario, |  <br>  <br>  <br>  <br>  <br>  | <br>Commitment for future growth to be carbon neutral. Methodology not disclosed |

| | | | | | |
|---|---|---|---|---|---|
| | | | and the year in which capital expenditures in carbon intensive assets will peak. | | |
| **7** | Climate policy engagement | 🟢 | 7.1 The company has a Paris-Agreement-aligned climate lobbying position and all of its direct lobbying activities are aligned with this.<br>A. The company has a specific commitment/position statement to conduct all of its lobbying in line with the goals of the Paris Agreement.<br>B. The company lists its climate-related lobbying activities, e.g., meetings, policy submissions, etc.<br>7.2 The company has Paris-Agreement-aligned lobbying expectations for its trade associations, and it discloses its trade association memberships.<br>A. The company has a specific commitment to ensure that the trade associations the company is a member of lobby in line with the goals of the Paris Agreement.<br>B. The company discloses its trade associations memberships.<br>7.3 The company has a process to ensure its trade associations lobby in accordance with the Paris Agreement.<br>A. The company conducts and publishes a review of its trade associations' climate positions/alignment with the Paris Agreement.<br>B. The company explains what actions it took as a result of this review. | 🟢<br>🟢<br>🟢<br>🟢<br>🟢<br>🟢<br>🟢<br>🟢<br>🟢<br>🟢 | 🟢 No change |
| **8** | Climate Governance | 🟠 | 8.1 The company's board has clear oversight of climate change.<br>A. The company discloses evidence of board or board committee oversight of the management of climate change risks via at least one of the following:<br>- There is a C-suite executive or member of the executive committee that is explicitly responsible for climate change (not just sustainability performance) and that executive reports to the board or a board level committee, and/or; | 🟢<br>🟢 | 🟢 Executive remuneration is being aligned to delivery of climate |

- The CEO is responsible for climate change AND he/she reports to the board on climate change issues, and/or;
- There is a committee (not necessarily a board-level committee) responsible for climate change (not just sustainability performance) and that committee reports to the board or a board-level committee.

B. The company has named a position at the board level with responsibility for climate change, via one of the following:

- A board position with explicit responsibility for climate change, or;
- CEO is identified as responsible for climate change if he/she sits on the board.

8.2 The company's executive remuneration scheme incorporates climate change performance elements.

A. A. The company's CEO and/or at least one other senior executives' remuneration arrangements specifically incorporate climate change performance as a KPI determining performance-linked compensation (reference to 'ESG' or 'sustainability performance' are insufficient).

B. The company's CEO and/or at least one other senior executives' remuneration arrangements incorporate progress towards achieving the company's GHG reduction targets as a KPI determining performance linked compensation (requires meeting relevant target indicators 2, 3, and/or 4).

8.3 The board has sufficient capabilities/competencies to assess and manage climate related risks and opportunities.

A. The company has assessed its board competencies with respect to managing climate risks and discloses the results of the assessment.

B. The company provides details on the criteria it uses to assess the board competencies with respect to managing climate risks and/or the measures it is taking to enhance these competencies.

change targets

| | | | | | |
|---|---|---|---|---|---|
| **9** | Just transition | ● | - | ● | ● |
| **10** | TCFD Disclosure | ● | 10.1 The company has committed to implement the recommendations of the Task Force on Climate-related Financial Disclosures (TCFD).<br>A. The company explicitly commits to align its disclosures with the TCFD recommendations OR it is listed as a supporter on the TCFD website.<br>B. The company explicitly sign-posts TCFD aligned disclosures in its annual reporting or publishes them in a TCFD report.<br>10.2 The company employs climate-scenario planning to test its strategic and operational resilience.<br>A. The company has conducted a climate-related scenario analysis including quantitative elements and disclosed its results.<br>B. The quantitative scenario analysis explicitly includes a 1.5° Celsius scenario, covers the entire company, discloses key assumptions and variables used, and reports on the key risks and opportunities identified. | ●<br>●<br>●<br>●<br>●<br>● | ●<br>No change |

Legend: ● No, does not meet any criteria. ● Partial, meets some criteria. ● Yes, meets all criteria. ● Not currently assessed. ● Not applicable.

3.5.4 Reliability of Emissions Estimates

Rio Tinto's disclosures in accordance with the Sustainability Accountability Standards Board, Sustainability and Responsible Sourcing Certifications and financial disclosure obligations provides some assurance emissions estimates are appropriately tested, verified and reliable [23, 27]. Further, the breakdown of emissions by managed operations and equity share provides visibility across multiple organisational boundaries. Climate and performance data, and alignment to the target of 1.5 ˚C, is also assured by an external third party [24].

There are known industry-wide issues regarding standard accounting methods for carbon emission calculations [10, 49]. These include inconsistencies in combining and reconciling various data sets, the level of error in assumptions regarding scope 3 emissions, and reconciling figures for approaches that vary based on country-specific regulation [3, 50]. Bearing this in mind, however, Rio Tinto's emissions estimates are not considered to be any less reliable that standard industry practice, considering known accounting and comparability issues [51].

## 4. Discussion

Rio Tinto have set a clear ambition to improving its carbon management practices and reducing emissions to net zero by 2050. However, its portfolio of operations is large and diverse – and change must be meaningful, effective, and large-scale to drive real change for a low carbon future. Overall, Rio Tinto have set a strong corporate strategy to realise this ambition, however the scale and scope of their response could be improved.

### *4.1 Climate Change Ambition and Investment*

While Rio Tinto has set a pathway towards achieving net zero by 2050, many meaningful changes are reliant on technology that has not yet been made available or requires substantial capital to improve existing infrastructure and assets. Hence, how the strategy will be operationalised remains unclear. Rio Tinto has also not set an ambition for their significant Scope 3 emissions profile. While understandable for downstream emissions, it is considered insufficient to not set targets and drive improvement in their upstream emissions profile [26, 28, 52]. More clarity at a site and process level would also increase confidence that sufficient progress is being made in the short and medium term. Rio Tinto have faced scrutiny regarding their commitments, with Toscano [52 and Butler [53] noting that a 15% direct emissions target is a third of what is needed.

In the Australian context, five of Rio Tinto's equivalents in Australia's resources sector have set more ambitious public commitments. Anglo American, Santos and Fortescue are seeking to achieve net zero by 2040 [13]. Several competitors have also committed to targets addressing their scope 3 emissions. Glencore is industry leading in its Scope 3 emissions target, committing to reach net zero by 2050 in the downstream use of their products.

Importantly, commodity profiles across the resources sector vary from Rio Tinto and hence a direct comparison on strategic ambition cannot be considered [13]. Further analysis is also required to assess strategic commitments in consideration of the scale, nature and individual characteristics of these operations to inform a view on the strength of the strategy for driving realistic tangible

value (including measured greenhouse gas emission reductions) in the short, medium and long term horizons.

For example, while Rio Tinto haven't established a Scope 3 target, they have invested in technological advancement that could see substantial, long term and wide-reaching emissions reductions in the steel manufacturing industry. Reporting against scope 3 'goals' (rather than targets) is prominent in their 2021 report. This could be considered the best course of action for meaningful contribution to achieving the goals of the Paris Agreement given the complexity of setting meaningful targets for such a portfolio. An alternative view is that ambition and influence over the most significant proportion of the emissions profile has the greatest opportunity to achieve large-scale impact, regardless of whether the detail behind the targets has been determined, and should be central to an effective and holistic strategy.

The operationalisation of these strategic commitments is also of critical importance when assessing comparative effectiveness. Wagner 2022 notes the value that market-based mechanisms such as carbon pricing have on driving targeted investment in emissions reduction. This forms part of Rio Tinto's approach and may lead to greater long-term outcomes compared to a direct capital allocation approach applied in isolation. Developing a model that considers the effectiveness of a strategy by also analysing the nature of the organisation and the proposed operational delivery model remains an area of opportunity for further academic analysis.

In their 2020 report, Rio Tinto had committed to $1 B investment over 5 years towards meeting its climate change commitments, more than double the investment from their competitor BHP who in 2019 committed $400 m over 5 years [54]. While this is positive, the comparative spend of $140 m allocated in 2020 to such initiatives is relatively conservative when compared to the corporation's $44.6 bn revenue of the same year. While this allocation commitment increased in their 2021 climate change report, it is considered that greater allocation will be necessary for meaningful and tangible emissions reductions across the full portfolio [24]. However, it is recognized that the newly introduced carbon price ($75/t$CO_2$e, introduced in 2021) is expected to drive further organic investment through the capital allocation cycle (further to the standalone budget allocation). Positively, investment has been targeted at addressing their most significant emissions at a root cause level (such as through new abatement or emissions reductio technology), which is a positive approach [53].

While there has been some criticism of Rio Tinto's approach by activists and industry groups (particularly in relation to scope 3 ambition which does not meet the criteria for Climate Action 100+ assessment), the strategy has been well received by investors and industry, and hence can be considered to have effectively addressed the risk associated with mounting investor and industry group pressure [55]. Rio Tinto continues to face significant physical and transitional climate risks that need to be managed ongoing as they continue to plan for a 1.5-degree warming scenario [23].

### *4.2 Climate Change Strategy/Framework*

While Rio Tinto have only 'partially' met the Climate Action 100+ criteria for their climate strategy, they were only bested by Glencore when comparing performance across the Australian resources sector. A re-assessment of performance conducted in November 2021 as part of this assessment highlights progress made since the initial assessment in April 2021. In particular, Rio Tinto's efforts in 2021 to integrate a carbon price into capital planning and to link targets with executive

remuneration demonstrate their continual improvement towards integrating their climate strategy into business practice. Other areas of improvement identified in April 2020 (such as setting science-based targets that include scope 3 emissions, establishing clear short-term decarbonisation plans and assessment of 'green revenues') remain unchanged as of November 2021. However, in their 2021 Climate Change report, Rio Tinto did commitment to implement both the TCFD recommendations and the Climate Action 100+ benchmark, which indicates that this continual improvement is likely to be seen again throughout 2022.

The World Business Council on Sustainable Development (WBCSD) establishes a hierarchy for climate mitigation, prioritising avoidance, followed by mitigation and restoration. Offsets can then be leveraged for hard-to-abate emissions to achieve no net loss, and to deliver a net positive impact [56]. Positively, Rio Tinto have applied this approach in their carbon management strategy, prioritising technological advancement to avoid emissions generation both at an operational level and in sourcing electricity from renewable sources.

While this is considered leading practice by the WBCSD, the reliance on technological innovations at scale to achieve emissions reduction commitments can present challenges, particularly in an asset-heavy, geographically diverse organisation such as Rio Tinto. In particular, there can be a significant lag in the realisation of true and material emissions reductions following the development, deployment, commissioning and operationalisation of these solutions. Consideration and accounting for this across short, medium- and long-term goals remains unclear in the publicly available strategy documents released by the organisation. Clarity regarding the scope and nature of Rio Tinto's investment and commitment to deploying climate solutions (relative to the scale and nature of its organisation) is important to avoid perceptions of 'green washing' or distracting stakeholders with projects that could be considered tokenistic, unsubstantial or immaterial when considering the breadth and nature of their emissions profile. A clear link between the deployment of climate solutions and the stated abatement pathway would help build greater credibility that the strategy can be effectively operationalised and drive meaningful value for emissions reductions.

Fankhauser et al. 2022 recognises the inadequacy of current reporting, accountability and reporting mechanisms to determine whether climate strategies are consistent with achieving global climate goals and identifies seven key attributes of a credible net zero strategy. Rio Tinto's strategy performs particularly strongly against two attributes – a comprehensive approach to emissions reductions and the pursuit of new economic opportunities (attributes 2 and 7). Positively, the focus on opportunities in the net zero transition (and associated impacts on the demand for materials and other resources) is discussed in detail in Rio Tinto's 2021 Climate Change report and incorporated as in integrated element to their newly released business strategy.

However, there is limited evidence of a plan that considers how they are able to achieve front-loaded emissions reductions (aside from the transition to renewable energy sources), which is particularly constrained in complex parts of their portfolio where new solutions and technological innovations are required (attribute 1) [57, 58]. The need for short term objectives to support long term ambition is supported in the Climate Action 100+ framework. Rio Tinto's strategy could benefit from further consideration of how an equitable transition to net zero will be achieved, and how their approach aligned with broader socio-ecological objectives captured in other parts of their sustainability strategy (attributes 5 and 6). This would be particularly beneficial for Rio Tinto given the significance of their operations on employment and associated socioeconomic condition of the rural and regional towns in which their operations are based [59]. There is limited information on

how Rio Tinto is considering carbon dioxide removal and the level of cautiousness applied to carbon offset purchases (attributes 3 and 4).

### *4.3 Emissions Reduction Progress*

The sufficiency of Rio Tinto's carbon management progress is best tested by analysing how much progress has been made to reduce emissions. While Rio Tinto have made a 46% reduction in the company's emissions since 2008, much of that is attributed to it selling off operations, including its coal assets [22, 27].

Since 2018, Rio Tinto have reduced their Scope 1 and 2 emissions by 4% (1.1 Mt $CO_2$-e) which is on track to achieve their 2030 target [30]). While 2019-2020 progress remained stagnant with emissions remaining at 31.5 Mt $CO_2$-e, in 2021, they fell slightly to 31.1 Mt$CO_2$e. Overall emissions intensity has only decreased slightly which demonstrates that emissions reductions initiatives have not yet had a material impact. This may be due to the significant proportion of investment being in longer term emissions reduction initiatives, with outcomes expected to materialise after a lag for deployment and operationalisation [5, 30].

It could also be attributed to many of the initiatives required to make a substantial, systemic impact first requiring technological innovation and substantial retrofit of existing large fixed assets (including mines, refineries, and smelters) to make an impact at scale [28]. The sufficiency (or otherwise) of this progress is difficult to determine without a clear roadmap with tangible interim objectives and metrics to measure against. However, it is reassuring that investment is being prioritised on effective long-term solutions rather than short term 'quick wins'.

## 5. Conclusions

This paper analysed Rio Tinto's commitments and carbon management practices to achieve its pledge to reduce emissions to net zero by 2050. An analysis of Rio Tinto's emissions scope 1 and 2 emissions profile (totalling 31.5 Mt $CO_2$-e in 2020) identified electricity, fuel, and carbon combustion in processing to be the most significant emissions sources. Rio Tinto's large Scope 3 emissions profile (equalling 519 Mt $CO_2$-e) is largely associated with the processing of steel from Rio Tinto's iron ore commodity.

To meet their net zero pledge, Rio Tinto have invested in a diverse range of initiatives from site-specific energy efficiency improvements to renewable energy sourcing, and to partnering with manufacturers to re-engineer the steel production process in order to reduce emissions. This multi-faceted approach is required to make meaningful and consistent traction towards addressing climate change across an organisational profile the scale and nature of Rio Tinto's.

While Rio Tinto's progress is positive, there has not been a material improvement in emissions intensity. They have also been criticised for not demonstrating a clear emissions abatement pathway and for not setting targets for their Scope 3 profile. While the ELYSIS project presents a significant and exciting opportunity to help customers to manage emissions associated with the iron Rio Tino produces, the pathway for Rio Tinto's other minerals and metals is not clear.

This analysis is limited by the public evidence available and no analysis of site or process specific abatement plans has been possible. Further investigation into Rio Tinto's upstream and downstream engagement would be valuable to inform recommendations on their scope 3 emissions.

Limited information was also available on the management of emissions sources such as land use change and fugitive emissions from mining operations.

To improve on its carbon management performance, its recommended that Rio Tinto considers setting an emissions reduction target for their contractors and suppliers. It is also recommended that Rio Tinto further analyse the sufficiency of their investment into direct and indirect emissions abatement, particularly considering capital costs and timeframes to implement systemic technological changes and realise emissions reductions across their emissions-intensive fixed assets. A more detailed responsible energy sourcing plan is also recommended for energy intensive sites that continue to rely on coal-fired power to operate.

## Author Contributions

AK: Writing-original draft, analysis; PD: Writing-editing, supervision.

## Competing Interests

The authors have declared that no competing interests exist.

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