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3 ***Environmental improvement initiatives in the coal mining industry:***  
4 ***Maximisation of the triple bottom line***  
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### *Abstract*

Mining is an economically important industry which faces several environmental and social challenges. Other than operational improvement activities, mining companies are increasingly paying attention to reduce greenhouse gas emissions (GHGs) and maximise social welfare to satisfy multiple stakeholders and the rise of corporate social responsible initiatives. Based on a case study analysis of coal mining companies we develop a triple bottom line (TBL) initiatives framework that provides a starting point for mining companies to develop a strategic approach to environmental improvement initiatives that can positively impact all elements of the TBL. We highlight that four types of process and offset-based initiatives are available to mining companies to reduce their GHGs, each having differential effects on elements of the TBL. Our findings suggest the importance of company-wide strategies of looking at initiatives through all rather than individual elements of the TBL. Such a strategy would provide an appropriate estimate of the costs and benefits of the initiatives and result in a balanced approach that takes care of operational improvement, reduces GHGs and improves the social welfare of people engaged in mining operations and wider society.

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**Keywords:** Coal mining, Greenhouse gas emissions, Operational improvement, Social welfare, Triple bottom line

## 1. Introduction

The mining industry is an important economic sector globally and it is a predominant income generating source for several countries, such as Australia, South Africa, Zambia and Mongolia. At the same time mining activities has been criticised for environmental damage and pollutants. The mining industry also, however, produces a huge range of the material necessary to facilitate any future transition to a low-carbon economy. For example, it supplies the base and rare earth metals required for renewable energy production and a variety of minerals required for batteries and electronic components used in electric cars, electric motors and smart houses. Given the importance of the mining industry in the world economy and in addressing the global problem of climate change, the challenge therefore is to facilitate its continued operation and growth whilst reducing its greenhouse gas emissions (GHGs).

Previous studies report the negative consequences of mining towards environmental damage in terms of pollution of water sources (Tiwary, 2001), dust and air pollution (Ghose & Majee, 2001), deforestation (Joshki et al., 2006), damage to biodiversity (Pond et al., 2008), GHGs from the energy it consumes to extract, process, refine and transport minerals and additionally fugitive emissions that occur as part of many mining activities (Burnham, et al., 2011). Mining companies are being subjected to critical scanning and have come under increasing pressure, internally from shareholders and externally from non-governmental organisations and community groups, to reduce their environmental footprint (Mutti et al., 2012). In addition, there are conflict minerals whose systematic exploitation and trade involves human violations in the country of extraction and surrounding areas (Hofmann et al., 2015). This has led to mining companies to explore wider improved operational practices that could reduce environmental impact and improve social welfare activities. Industry organisations such as the International Council of Mining and Metals (ICMM), (a grouping of twenty-three of the largest multinational mining firms and thirty-four regional and commodities association) have helped to promote operational improvements in the industry through requiring their members to commit to a number of environmentally-related principles such as: improve supply chain due diligence, integrate sustainable development in corporate strategy and decision-making processes, pursue continual operational improvement practices that takes care of water stewardship, energy use and other climate change issues, contribute to the conservation of biodiversity and integrated approaches to land-use planning (ICMM, 2015). A priority therefore for the mining sector is seeking for operational practices that would result in reduced overall GHGs from mining and greater social welfare activities.

In addition to these operational improvements, many mining companies have also invested in different types of offset-based environmental improvement initiatives in order to reduce their overall GHGs. The theory of offsetting arose from the concept of 'No Net Loss' – whereby any environmental damage can be made up for by restoration or reclamation elsewhere (Gibbons & Lindenmayer, 2007; Gardner, et al., 2013). Offsetting has occurred with a range of environmental media including biodiversity (McKenney & Kiesecker, 2010), GHGs (Grubb, Laing, Counsell, & Willan, 2011) and wetlands (Robertson, 2000). It is a controversial activity, with authors raising questions of additionality and remarking that it does not necessarily achieve overall reductions in pollutants (Maron, et al., 2012; Wara, 2007) but has formed a key part of the environmental strategy of many firms in the mining

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3 sector and otherwise (Nazari & Proebstel, 2009).<sup>2</sup> Mining is susceptible to human right  
4 violations and social problems; the United Nations is engaged in developing a legal and  
5 policy framework to reduce human abuses in the mining sector (Hofmann et al., 2015). A  
6 common perception is that large multi-national companies are green washing and projecting  
7 their communal developing activities in order to cover up potentially negative social and  
8 environmental effects of their activities. Despite these concerns the concept of a 'social  
9 licence to operate' (Bice, 2014; Prno, 2013), whereby firms are required to invest in wider  
10 environmental protection and social development, has become essential and pre-requisite for  
11 major mining companies to meet their shareholders, industry and government expectations.  
12 Mining companies are thus under severe scrutiny and seeking ways to improve their welfare  
13 of workers and local communities surrounding the mining activities as well as wider society  
14 through adoption of advanced operational and fairer practices.  
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18 In addition, technological advancement and competition forces mining companies to dig  
19 deeper into their internal processes and operations to improve operational efficiency. The  
20 booming commodity prices during mid-2000s led to big increase in miners' productive  
21 capacity – but overall the productivity suffered as a result of rise in capital expenditures and  
22 operating costs. According to estimates compiled by McKinsey in 2015 using a new index,  
23 the productivity overall in the mining industry fell by 28 percent compared to the previous  
24 decade (Lala et al., 2015). Raising productivity is now a key focus for the mining industry in  
25 order to improve efficiency and boost faltering profits.  
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28 Mining companies are subjected to three distinct pressures i.e. financial (operational),  
29 environmental and social pressures. This could be well related to the famous triple bottom  
30 line of companies coined by John Elkington (Elkington, 1997). Accounting for this triple  
31 bottom line (TBL) has become increasingly mainstream for many mining companies through  
32 the development of Key Performance Indicators and the development of frameworks by  
33 organisations such as the Global Reporting Initiative (Global Reporting Initiative, 2011).  
34 However, the open question for mining companies is how best to implement initiatives that  
35 can help achieve these three, sometimes complementary but often competing TBL  
36 objectives.<sup>3</sup> Mining companies often implement corporate social responsibility (CSR)  
37 projects in an ad-hoc manner based on short-term budgetary pressures. Environmental  
38 initiatives are often treated as separate from other elements of CSR programmes and  
39 operational improvement initiatives (Laing, Taschini, & Palmer, 2016). Understanding how  
40 integration of these elements together into a holistic strategy for achieving the TBL could  
41 help mining firms achieve all elements whilst improving profitability.  
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45 In this paper we conduct a case study analysis of three major coal mining companies and a  
46 small-scale survey of mining companies and experts in the mining industry to examine  
47 whether environmental improvement initiatives of mining companies have different effects  
48 on the TBL. We divide these initiatives into process and offset-based initiatives and develop  
49 a framework that categorises them into four types based on their impact on the TBL. The  
50 framework can help mining companies plan a strategy of environmental improvements that  
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53 <sup>2</sup> The topic of additionality is one of the most fundamental in the discussion of offsets. It is essentially the  
54 question of whether the project would have happened anyway if it wasn't funded as an offset. If the question is  
55 yes then the project isn't additional.

56 <sup>3</sup> For example, operational improvements may allow for greater levels of production, putting greater strain on  
57 environmental media. Social initiatives may divert resources away from improving environmental performance.  
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3 can potentially improve all elements of the TBL. The paper provides theoretical and  
4 empirical contributions to an emerging literature of TBL performance from the perspective of  
5 mining sector, and provides a tool that mining companies can use to help strategically plan a  
6 suite of environmental improvement initiatives that can help to improve all elements of the  
7 TBL. Our framework highlights that those companies that implement a complementary suite  
8 of investments – especially those targeting business processes directly achieve strongest  
9 improvements in the elements of the TBL per unit of cost.  
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11 The rest of the paper is organised as follows. Section 2 reviews the literature relating to  
12 operational, environmental and social welfare improvement initiatives in the coal mining  
13 sector and their impact on elements of the TBL.<sup>4</sup> Section 3 outlines our methodological  
14 approach. Section 4 reviews the current operational, environmental and social welfare  
15 improvement initiatives made by three large companies in the coal mining sector and  
16 evaluates their impact on elements of the TBL. A TBL framework is developed in Section 5  
17 which presents the outcomes of the study. Section 6 concludes.  
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## 20 **2. Literature**

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22 Coal Industry Advisory Board (CIAB, 2006) documented several cases relating to sustainable  
23 development in the coal industry. Typically the issues reported are acceptance and integration  
24 of sustainable development principles, balancing TBL objectives, role of technology,  
25 differing regional views, collaboration along the value chain and implementation of  
26 government policies and regulations. Specifically the report shared the insights from fifty  
27 case studies that exposed several challenges surrounding people, value chain, environmental  
28 impacts, resource stewardship, communities and management processes and systems in the  
29 coal mining industry. From the CIAB report it is evident that awareness of sustainable  
30 development is picking up and there is growing awareness of reducing GHGs in the coal  
31 industry across the globe.  
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34 Another issue that has been debated in the CIAB report is on trade-off among balancing TBL  
35 objectives with substantial consideration given to economical and financial aspects. The  
36 trade-off worked well for larger firms compared to smaller firms. In terms of technology,  
37 multiple cases revealed improvement of efficiency, health and safety and environmental  
38 performance. A study by Lederwasch & Mukheibir (2013) provided a perspective on trade-  
39 off among TBL objectives in the coal industry based on a case study in Australia. The study  
40 suggested to avoid assigning equal importance to all TBL objectives as well as finding  
41 interdependent relationship among TBL objectives; instead the study suggested to find  
42 potential impact on all elements of the TBL. In line with the views of Lederwasch &  
43 Mukheibir (2013), we review the impact of operational, environmental and social  
44 improvement initiatives on elements of the TBL.  
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48 Overall, the impact assessment of operational improvement practices in the mining industry  
49 is scant. Typically the studies measuring efficiency and productivity of coal mines have been  
50 exploratory in nature and do not follow standardised practices and procedures. A few studies  
51 employed data environmental analysis (DEA) to analyse the performance of  
52 both opencast and underground coal mines (Kulshreshtha & Parikh, 2002). The studies show  
53 that efficiency of opencast mines has improved due to the technological advancement  
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56 <sup>4</sup> In the literature the initiatives are broadly referred to as sustainable development practices or activities.  
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3 in opencast mining compared to underground mining. In addition, coal firms all over the  
4 world are exploring best practices to improve their performance and their overall efficiency.  
5 Comparative research using a DEA approach shows that coal firms in China have low  
6 efficiency compared to the coal firms in the USA (Fang, Wu, & Zeng, 2009). Assessing  
7 production planning and control such as work load control to accomplish operational  
8 improvement and eco-efficiency has been discussed by de Oliveira Neto & Lucato (2016).  
9 Moreover, a study explored the usage of lean thinking to reduce inefficiencies and  
10 distribution distance by 32 percent in road transportation with respect to coal firms in Mexico  
11 (Villareal, Garza-Reyes, & Kumar, 2016).  
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14 A related, but slightly different concept of customising Eco-Efficiency (EE) framework for  
15 the mining sector in Australia was introduced by Van Berkel (2007). The framework relates  
16 five preventive practices: process design; input substitution; plant improvement; good  
17 housekeeping; and reuse, recycling and recovery. The study identified the feasibility of the  
18 framework as per technical and operational aspects. A study by Prashar (2016) integrated  
19 different statistical tools such as design-of-experiments, Taguchi methods and Shainin  
20 methods to achieve process improvement in complex industries. Hilson & Nayee (2002)  
21 discussed the contribution of cleaner production to wider technical and economic benefits to  
22 the company. It is evident that these studies focus on operational improvement practices and  
23 do not explicitly consider impact on environmental performance or social welfare.  
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26 However, a few studies do review the impact on environmental performance of the mining  
27 industry. For example, cleaner production and its impact on the environmental performance  
28 has been studied by Basu & van Zyl (2006). The authors focused on minimising  
29 environmental impact such as waste minimisation, greater recycling, pollution control and  
30 waste disposal. The study is similar to that by Hilson & Nayee (2002), but with an added  
31 focus on environmental performance. Goodland (2012) proposed responsible mining by  
32 discussing how it can help to achieve both environmental sustainability and improved profits  
33 by encouraging the use of best practice that can reduce waste, inefficiency and conflicts.  
34 Most of the other studies on environmental performance improvements are in terms of offset  
35 activities to compensate for the damaging environmental impacts from the mining activities  
36 by funding projects external to their mining operations (Virah-Sawmy et al., 2014). Some  
37 studies talk of broader sustainability practices. For example, Ranangen & Lindman (2017)  
38 develop general sustainability practices guidelines for Nordic mining industry. The guidelines  
39 focus on corporate governance, fair operation practices, economic aspects, human rights,  
40 labour practices, society and the environment.  
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44 Some studies focus on the social welfare aspects of the coal mining industry. For example,  
45 Narula et al. (2017) document social challenges in the coal mining sector from the Indian  
46 context and suggest a framework to uplift the livelihood of local communities through  
47 capacity building activities. A study by Tiainen (2016) analysed social component of  
48 sustainability and emphasised that the importance towards social welfare aspects is low.  
49 There is a need to be proactive in establishing an internationally ambitious governance  
50 framework for social sustainability in mining with the encouragement of local community to  
51 participate. The review of the literature reveals a gap in existing studies in terms of impact of  
52 operational, environmental and social improvement initiatives in the coal mining sector on  
53 the elements of the TBL – an objective of the paper is to address this gap.  
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### 3. Methodology

We adopt a two-stage methodological approach to develop a framework that helps us to understand how the choice between process and offset-based environmental improvements in coal mining may affect TBL performance. Although the focus is on coal-mining activities but group-wide investments that could affect coal mining activities are also included. The first stage examines three case studies of large multinational coal mining firms to understand the types of environmental improvement initiatives they have been undertaking, the balance between process and offset-based improvement initiatives and the potential impacts of these initiatives upon the TBL.

We conduct content analysis of Annual Reports, Sustainability Development Reports (SDRs) and CDP (formerly the Carbon Disclosure Project) reports for three major mining companies: Anglo-American, BHP Billiton and Rio Tinto. All data and information in the following sections is sourced from these reports for the period 2011-2016. The three companies were chosen as they represent three of the most significant players in the global mining industry, representing over US\$120 billion in revenue with mining activities across 114 different sites. The three companies together account for almost 20 percent of the revenue of the Top 40 largest global mining companies (PwC, 2016); they also emitted over 100MT CO<sub>2</sub> in 2014.<sup>5</sup>

In the second stage, the relevant results from the content analysis were used to develop a small-scale survey which was undertaken with representatives of large mining firms and experts in the mining industry. The main aim of the survey was to test the validity of the dichotomous split between types of environmental improvement initiatives, obtain further detail on the types of process and offset-based environmental improvement initiative that mining companies have been implementing, and the potential and perceived impact on the TBL. The survey consisted of six [open-ended](#) questions and took place in April and May of 2017. Invitations were sent to representatives of large mining firms involved in environmental management and corporate social responsibility, individuals at mining associations and academic experts working in the field of mining ~~were also contacted to take part.~~ [Initial invitations were sent to individuals at mining companies and mining associations known to the corresponding author, and continued via snowball sampling. Responses were received from eight representatives of large-scale multinational mining firms, two representatives of mining associations and four academic experts. The responses were from individuals based in the UK, North America and South America, though responses from individuals of multinational firms represented operations across a broad spectrum of countries. Although this is a small sample, but it is not a limitation as the aim was to collect indicative information rather than statistically significant data.](#) Additional interviews were conducted with two participants to clarify information provided. As information collected was confidential for commercial reasons, the broad results of the survey, rather than any individual responses, were used along with information from the three case studies to develop an over-arching framework for the impact of different types of environmental improvement initiatives on the TBL.

### 4. Case studies

#### 4.1 Case Study 1: Anglo-American

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<sup>5</sup> Estimated by the authors from data from the SDRs of the three coal mining companies.

Anglo-American (AA) is a multinational company, headquartered in the UK and South Africa. It has operations across all continents, and is the world's largest producer of platinum. It also produces copper, diamonds, coal, iron ore and nickel. It has over 100,000 employees. It currently has 46 active operations with the majority in Southern Africa. It had total revenue of over US\$23 billion in 2016 and made a profit before tax of over US\$2.5 billion.

#### 4.1.1 Operational improvement initiatives

AA has undertaken a number of initiatives specifically targeting improvements in operational efficiency, especially as it relates to the extraction and use of coal power plants that also bring environmental benefit. The company has invested in vast capacity, which will remain in service until 2050. The company is also investing in coal technology for the zero-emission coal-fired power plant. They are using high-efficiency, low emission coal combustion technologies, simultaneously reducing emissions and improving efficiency. Future technology development program at AA focuses on equipment automation projects in opencast and underground mining and safety of people proximity intervention system. AA link their operational performance to different factors, e.g. safety, environment, production and cost.

#### 4.1.2 Environmental initiatives

AA have reduced their GHGs from 20 MT CO<sub>2</sub>e to 18MTCO<sub>2</sub>e between 2010 and 2015. The company set a GHGs reduction target for 2015 of a 19 percent reduction from the base year of 2011. This has been extended to a 22 percent reduction for 2020 from the 2015 base. Both targets are based on a projected consumption pattern (CDP Report 2016). In order to achieve this target Anglo-American have adopted a four-step approach to reducing their GHGs:

- *'reduce our carbon footprint as part of our voluntary commitment to mitigate our impacts and reduce our exposure to emerging climate change regulation'*
- *'manage our climate risks and opportunities associated with our products and investments'*
- *'improve our ability to influence the development of effective climate policy'*
- *'drive greater resilience to the physical effects of climate change within our business and host communities'*.

Examining this approach highlights that mitigation of GHGs in fact forms only a small part of AA's overall climate change strategy. Climate change is the responsibility of a Sustainability Committee chaired by a non-executive director. Incentives are provided for the achievement of targets relating to climate change to the corporate executive team and energy and environment/sustainability managers.

The key overarching initiative to reduce GHGs is AA's ECO2MAN energy efficiency programme. Launched in 2011 this operational energy and carbon-management programme works to analyse the activities of the company and identify opportunities to reduce energy consumption and therefore GHGs. The programme works to integrate energy and emissions management into business processes. The model includes a number of different elements such as 'analyse and improve' and 'service strategy'. ECO2MAN is AA's key overall framework for controlling GHGs and is a clear example of a process-based production-based investment. Such process-based initiatives has helped AA identify and operationalise a large



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3 number of GHG reduction opportunities, and we would propose that such a programme could  
4 bring large operational efficiency benefits to the company.  
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6 In addition to such process-based initiatives, AA has also embarked on a number of end-of-  
7 pipe production-based initiatives. For example, at its New Denmark Colliery in South Africa  
8 the company have introduced mobile methane flaring units to reduce intermittent methane  
9 that is drained from boreholes drilled into underground workings. The project has been  
10 estimated to have reduced methane emissions at the colliery by 15 percent.<sup>6</sup> This end-of-pipe  
11 technology has only small operational efficiency benefits, although, as it is funded through  
12 the United Nations Framework Convention on Climate Change (UNFCCC) Clean  
13 Development Mechanism, it is anticipated that the company will recover all costs of its  
14 implementation. The project could potentially have spin-off benefits as it could encourage  
15 AA to introduce mobile methane flaring units at its coal mining operations at other sites  
16 around the world.  
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19 AA has also made offset-based initiatives, both internally and externally, in order to reduce  
20 its overall GHGs. Internally, it has installed solar panels at a number of its Thermal Coal  
21 operations in South Africa, including 90KWp at its colliery at Greenside, 553KWp at its  
22 colliery at Goedehoop and 240KWp at its Kriel colliery. The latter is also connected to South  
23 Africa's grid thus potentially providing capacity to South Africa as a whole. The 2013 SDR  
24 of AA highlights that these investments are as much to do with long-term potential for cost-  
25 savings as for reduction of GHG emissions:  
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28 *'Thermal Coal carefully manages its energy use and CO<sub>2</sub> emissions, not only because of their*  
29 *contribution to climate change, but as a results of the need to address energy security and the*  
30 *rising cost of electricity'* (Anglo American , 2013).  
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32 There may also be social benefits, especially from the grid-connected systems, but given the  
33 small scale of the current scope of initiatives in solar PV (AA's Thermal Coal's total PV  
34 capacity was only around 1MW in 2013) this is likely to be small.  
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36 Larger social benefits are likely to come through AA's external based offset-initiatives  
37 through its Zimele Green Fund. The Fund, established in 2011 forms part of AA's wider  
38 Zimele Enterprise fund that was established in 1989 to serve as a catalyst to emerging black  
39 businesses in South Africa. The Green component was set-up to support businesses that  
40 mitigate GHGs, reduce energy and water consumption and improve waste and emissions  
41 management. Projects can receive up to SAR10 million under the Fund via a blend of debt  
42 and equity or a pure loan. The wider Zimele programme has spawned spin-off programmes in  
43 other countries that AA operate such as Chile and Botswana. Such a green fund is designed to  
44 have a strong social development component but also works to reduce GHGs overall in the  
45 world, if not directly reducing AA's own footprint. Although it is unlikely to have much  
46 impact on operational efficiency of the business, the learning-by-doing benefits of such  
47 schemes for improving the overall social impact of the mining business can be seen by AA's  
48 roll-out of similar programmes in other jurisdictions.  
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53 <sup>6</sup> Although the flaring of methane creates a large amount of carbon dioxide, and in some instances can be a  
54 source of significant GHGs that may not otherwise have been created, for no material gain (for example gas  
55 flaring in the oil fields of Nigeria (Anomohanran, 2012), the flaring of fugitive methane that would otherwise  
56 have escaped due to industrial activity can actually reduce GHGs due to the lower global warming potential of  
57 carbon dioxide as compared to methane (Karacan, Ruiz, Cote, & Phipps, 2011).  
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### 4.1.3 Social initiatives

Reporting on social development is the least consistent of the three TBL elements. AA's key reported metrics include those related to expenditure on Corporate Social Initiatives (CSI) and jobs created/sustained through their enterprise development initiatives. The former is the only common metric between the three case study companies so we concentrate on this metric – even though it represents an input into the social development process rather than an outcome. Key to AA's social development initiatives is its Zimele Fund in South Africa and related initiatives in other countries. AA's expenditure on CSI peaked in absolute terms in 2012 at US\$145.7 million and declined to US\$124.1 million in 2015. The decrease in 2015 is explained by fall in profits rather than a lack of AA's commitment to CSI. This is evident from the fact that when expressed as a share of pre-tax profit it actually peaked in 2015 as CSI expenditure levels declined marginally whilst profits declined substantially in line with fall in commodity prices (Anglo American, 2015).<sup>7</sup> In terms of job creation 2015 actually represented a fall from previous years with less than 14,000 created compared to over 20,000 in the previous year.

## 4.2 Case Study 2: Rio Tinto

Rio Tinto is a British-Australian company with headquarters in London and Melbourne. It is one of the world's major producers of aluminium, iron ore, copper, uranium, coal and diamonds. It is also involved in refining of bauxite and iron ore. It has over 50 operations worldwide with over 50,000 employees in 2016. It has revenue of over US\$30 billion in 2016 with profits of almost US\$5 billion.

### 4.2.1 Operational improvement initiatives

Rio Tinto has adopted a different approach to improving operational efficiency than AA, with potentially different results on emissions. It is focused more on rationalising its portfolio and focusing on few operations with suitable (economically efficient) scale. Rio Tinto is divesting selected operations and has recently sold a major stake from their Australian and South African holdings as a long-term strategy to focus on cost control, productivity gains and cash generation. Rio Tinto is also investing in technologies to increase coal production and tailor better product for its customers. Rio Tinto has launched a new phase of its 'Mine of the Future' technology and innovation program, which is driving value by optimising the performance of key international coal operations. This latter component may bring with it environmental management improvements as a by-product, but its overall focus is on efficiency improvements.

### 4.2.2 Environmental initiatives

Rio Tinto has larger GHGs than AA. It emitted 31.3 MT CO<sub>2</sub>e in 2015, a substantial decline compared to 2011 when it emitted 43 MT CO<sub>2</sub>e. Rio Tinto is aiming for the substantial decarbonisation of its business by 2050. It has a short-term target to reduce the GHGs intensity of its production by 24 percent from a 2008 baseline by 2020. The progress towards achieving this target is reported to the company's Executive and Sustainability Committees.

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<sup>7</sup> For example gold prices fell from a high of almost US\$1900 in September 2011, before falling to under US\$1100 in December 2015 (Kitco, 2017). Coal prices fell from approximately US\$70 per short ton in 2012 to just over US\$40 per short ton in July 2015 (Kitco, 2017).

Rio Tinto does not identify a business wide process-based production-based investment such as AA's ECO2MAN programme. It does however report some smaller process-based initiatives that have improved small components of the businesses emissions performance. For example, an engine replacement programme is being rolled out in Australia for the company's haul trucks via the Dhanna Yurubaya project. Through software engineering changes efficiencies of 5-7 percent have been achieved in reducing energy consumption and GHGs. At Richards Bay Minerals, a titanium mine in Australia, an Energy Leadership Programme has been initiated leading to an identification of 24 projects that reduce energy consumption and therefore GHGs, predominantly through shifting electricity load around in the day to reduce energy waste. Further projects have been implemented to improve energy efficiency in shipping and minimising electrical losses at aluminium facilities.

Rio Tinto has also implemented a number of internal offset-based initiatives. For example, at its Diavik Diamond Mine in North-Western Canada Rio Tinto has installed a 9.2MW wind farm, integrated into the mine's main diesel-powered system. This has saved the company US\$5-6 million a year in fuel costs, paying back the initial US\$33 million cost in only a few years, and reducing the mine's GHGs by around 6 percent. With the mine planned for closure in 2023 the company is investigating whether the wind turbines can be donated to the local community.<sup>8</sup> This highlights the potential for these offset-based initiatives, even internal ones, to have social development benefits as well as improving operational efficiency.

#### *4.2.3 Social initiatives*

Rio Tinto, in a similar manner to AA, also report on total community contributions. Like AA its absolute level of contributions have declined from a peak of US\$332 million in 2013 to US\$184 million in 2015. Contributions have followed commodity prices (profitability), showing substantial increases from US\$119 million in 2009 until 2013 and then decreasing until 2015. Given Rio Tinto's larger profits than AA, these figures represent a relatively smaller overall contribution. Unlike AA's Zimele Fund, Rio Tinto have no reported uniform fund for community development. However, in 2015 they supported over 1,800 different socio-economic programmes. A note of caution may be in order; it may be wrong to conclude that Rio Tinto's community contributions is lower than that of AA as some of its dispersed activities may not be recorded in its reports.

### **4.3 Case Study 3: BHP Billiton**

BHP Billiton is a British-Australian company headquartered in Melbourne. It is the world's largest mining company, and at times has been Australia's largest by revenue. It is a major producer of coal, copper, iron ore, petroleum and potash. It has 18 major operating sites producing minerals worldwide. It has revenues of over US\$30 billion in 2015 with a workforce of approximately 65,000. It made an underlying attributable profit of US\$6.5 billion in 2015.

#### *4.3.1. Operational improvement initiatives*

BHP Billiton has made strides towards improving operational improvement by focusing on reducing cycle time through having the right technology, right data and right process. By

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<sup>8</sup> <https://canwea.ca/wp-content/uploads/2013/12/canwea-casestudy-DiavikMine-e-web2.pdf>

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2  
3 reducing cycle time, BHP Billiton has focused more on improving integration of technical  
4 work, enhancing strategic planning and value creation. They have increased the  
5 truck utilisation across all mines which helps them to offset the adverse weather conditions.  
6 Technology is playing a vital role in improving their operational efficiency. They have  
7 invested in predictive maintenance software to predict machinery faults and investing in  
8 mobile technology and designed a mobile application to allow real-time access to relevant  
9 information to employees. In a similar vein to the investments at Rio Tinto these operational  
10 efficiency improvements are only likely to affect GHGs in a small manner.  
11

#### 12 4.3.2 Environmental initiatives

13  
14 BHP Billiton experienced an overall increase in GHGs between 2011 and 2014, rising from  
15 40.8 MTCO<sub>2</sub>e to 45 MTCO<sub>2</sub>e.<sup>9</sup> BHP Billiton have adopted an integrated approach to climate  
16 change with four major areas of activity: mitigation, adaptation, low-emissions technology  
17 and portfolio evaluation. Specifically the company will:  
18

- 19 - *'Continue to take actions to reduce our emissions*
- 20 - *Build the resilience of our operations, investments, communities and ecosystems to*  
21 *the impacts of climate change*
- 22 - *Recognising their role as policymakers, seek to enhance the global response by*  
23 *engaging with governments*
- 24 - *Work in partnership with resource sector peers to improve sectoral performance and*  
25 *increase industry's influence in policy development to deliver effective long-term*  
26 *regulatory responses*
- 27 - *Contribute to the reduction of greenhouse gas emissions from the use of fossil fuels*  
28 *through material investments in low-emission technologies' (BHP CDP Report 2016)*  
29  
30  
31

32 BHP Billiton has set a target of keeping their absolute level of emissions for 2017 below that  
33 of the base year of 2006. A process has been established across the business to identify,  
34 evaluate and implement suitable projects to achieve this target. GHGs has become a Key  
35 Performance Indicator (KPI) for the company and in 2015 reductions of 676,000 tCO<sub>2</sub>e was  
36 directly attributed to projects identified through this process.  
37

38  
39 BHP Billiton has introduced a strong set of internal incentives to incentivise this process.  
40 Monetary rewards are given to the CEO, the corporate executive team, business unit  
41 managers, environment and sustainability managers and all employees via a short-term  
42 incentive pool that is based on a number of target measures including GHGs reduction  
43 projects.  
44

45 This structure is a good example of the type of process-based production-based investments  
46 that we propose could achieve environmental improvements and operational efficiency gains.  
47 BHP Billiton has also implemented end-of-pipe production-based initiatives. At its North  
48 American shale gas operations the company has worked to reduce fugitive emissions by  
49 capturing and selling natural gas that otherwise would have been vented or flared and  
50 produced substantial GHGs. Such actions could potentially improve operational aspects of  
51 the business as a whole by reducing, and in fact monetising, an otherwise waste product.  
52  
53

54  
55 <sup>9</sup> We only examine BHP Billiton up until 2014 due to the demerger of South32 from BHP Billiton in 2015 that  
56 removed a substantial share of GHG emissions from the company. BHP's emissions in 2016 consequently fell  
57 to 18 MTCO<sub>2</sub>e.  
58

Along with these production-based initiatives BHP Billiton has undertaken a series of other offset-based initiatives, predominantly internal. For example, in 2011 it constructed a new Combined Cycle Gas Turbine (CCGT) power station for its Western Australian Iron Ore mining operations. The station included heat recovery steam generators which capture waste heat and generates additional power, reducing GHGs and minimising gas usage. This sort of investment has the potential to reduce GHGs (though not as much as renewable generation) and also improve operating efficiency by reducing waste. Such initiatives however offer little wider social development gains.

There are no clearly identified external climate-related offset-based initiatives. They have however engaged in partnerships in other environmental related areas. For example in 2015 BHP Billiton entered into a US\$7 million partnership with the Great Barrier Reef Foundation to support critical marine research and rehabilitation works on the reef. Such investments bring clear social development benefits, but are unlikely to affect BHP Billiton's operations in any substantial manner.

#### 4.3.3 Social initiatives

BHP Billiton have an annual target to invest 1 percent of pre-tax profits in community programmes, calculated on the average of the previous three years' profits. This is a lower level than either AA or Rio Tinto but the target has ensured that its contributions have been relatively more stable. For example, contributions in 2012 were US\$214 million, but had actually risen by 2015 to US\$225 million, unlike either AA or Rio Tinto. A large share of BHP's social development occurs through two corporate charities: BHP Billiton Sustainable Communities (based in the UK) and the BHP Billiton Foundation (based in the US). Both of these organisations provide grants to organisations to create social projects that create sustainable outcomes across all operations of the group.

#### 4.4. Comparison

We compare the performance of the three companies and examine whether there is any evidence that implementation of different types of environmental improvement initiatives has led to different effect on the TBL. We summarise examples of the different types of environmental improvement initiatives in Table 1.

Table 1: Summary of Initiatives at AA, Rio Tinto and BHP Billiton

Company	Operational improvement initiatives		Other initiatives	
	End-of-pipe	Process-based	Internal	External
Anglo-American	Flaring methane in New Denmark colliery in South Africa	ECO2MAN carbon management programme	Solar farm at Greenside colliery in South Africa	Zimele Green Fund
Rio Tinto		Energy Leadership Programme at Richards	Wind-diesel system at Dievik Diamond	



		Bat Minerals	Mine	
BHP Billiton	Capture of natural gas in North American shale operations	Requirement for all business to identify, evaluate and implement GHG reduction projects	Use of combined-cycle gas turbines at Yarnima Power Station in Australia	Partnership with Great Barrier Reef Foundation  BHP Billiton Sustainable Communities

Examining the trend in overall GHGs for the three companies (Figure 1), we can see that there are contrasting patterns. AA has experienced a small decline, before a small rise. Rio Tinto however has experienced a sharp decline, whilst BHP experienced a substantial rise, before a small fall. It is hard however to draw strong comparisons because over the time-period all three firms undertook a number of major initiatives and divestments that changed the overall scope of their business and thus their GHGs.

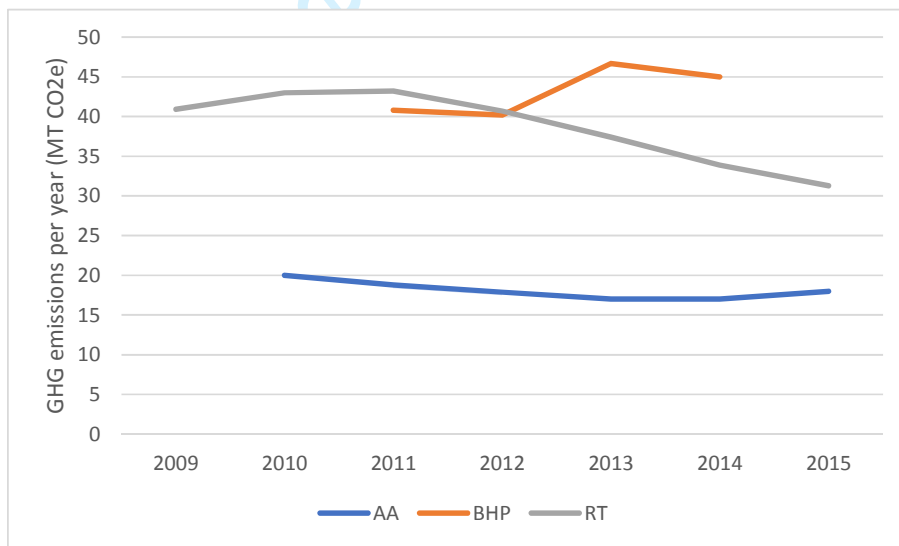


Figure 1: GHG emissions at AA, BHP Billiton and Rio Tinto

(Source: Company Sustainable Development Reports 2011-2016)

We now examine potentially more comparable metrics that could inform us about both operational improvement initiatives and environmental management initiatives. Figure 2 shows the GHGs per unit of revenue for each of the three firms. Rio Tinto were the most GHGs intensive of the three firms, with AA generating the least GHGs for each unit of revenue. AA and Rio Tinto show a general downward trend until 2014 before spiking sharply to levels comparable or even higher than five years previously. The metric follows closely movements in commodity prices, falling when the price of minerals has reduced indicating little evidence of strong improvements in operational processes. Instead the fall in commodity



prices would have impacted revenue, but left environmental performance largely unchanged.<sup>10</sup>

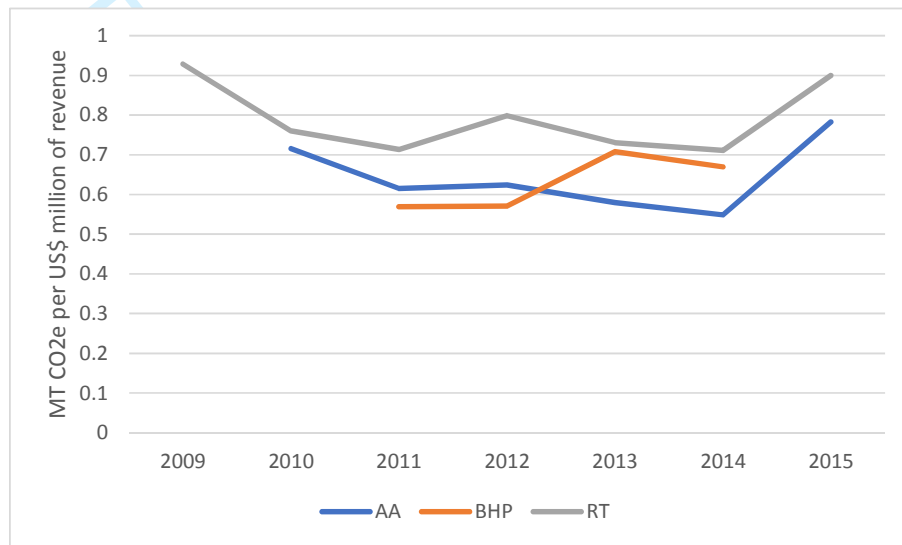


Figure 2: GHGs per unit of revenue

(Source: Company annual reports and Sustainable Development Reports 2011-2016)

Table 2: Summary of key TBL indicators

(Source: Company annual reports and Sustainable Development Reports 2011-2016; data for AA and Rio Tinto is for 2015 and BHP is for 2014)

Parameters/company	AA	Rio Tinto	BHP
Revenue	US\$23 billion	US\$34.8 billion	US\$67 billion
Pre-tax profits	US\$2.5 billion	US\$5 billion	US\$6.5 billion
GHGs	18 MT CO <sub>2</sub> e	31.3 MT CO <sub>2</sub> e	45 MT CO <sub>2</sub> e
GHGs (MT CO <sub>2</sub> e) per US\$ million revenue	0.783	0.899	0.670
Community contributions	US\$124.1 million	US\$184 million	US\$225 million

<sup>10</sup> The scale of the impact of falling commodity prices in the industry is discussed by amongst others by Colgan, (2015) and The Telegraph, (2015).

Community contributions per US\$ million revenue	US\$5.39	US\$5.29	US\$3.35
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## 5. TBL initiatives framework

As discussed in the introduction section we develop a framework that categorises the environmental improvement initiatives into two different types. The first type we refer to as ‘production-based initiatives’. These are initiatives into projects or programmes that change the nature of the coal mining process or key production techniques within the process. The second type we refer to as ‘offset-based initiatives’. These are initiatives that either offset the emissions involved in the coal mining process, for example replacing fossil fuel energy generation with renewable generation or involve reducing the emissions of actors outside the mining process (for example, funding projects that avoid emissions in local communities or the surrounding area). We examine the potential impacts on operational improvement of these two different types of initiatives.

### 5.1 Production-based initiatives

Coal mining companies have undertaken initiatives that have made substantive changes to their operational processes in order to reduce their GHGs. For example, improving ventilation systems to reduce energy consumption, flaring waste gases (such as methane) that are potent greenhouse gases and implementing environmental management systems that allows for GHGs to be managed and reduced. We divide production-based initiatives into two categories: end-of-pipe initiatives and process-driven initiatives. End-of-pipe initiatives are those that reduce GHGs at the point of their release, for example flaring of methane gas that is emitted during coal mining substantially reduces the GHGs by reducing the global warming potential of the emitted gas. Process-driven initiatives are those that change fundamentally the mining process in a way that reduces GHGs. For example, improving the efficiency of mine ventilation systems large energy savings can be made, which in turn can reduce the GHGs of the coal mining operations.

We propose that these two different types of production-based initiatives have different effects on operational improvements. We propose that end-of-pipe initiatives have only minimal effects on operational improvement – this is because they do not change the overall operational environment of the mining operations – but they could improve revenue streams through offering potential to earn revenue from monetising waste products. These initiatives have only a minimal impact on social welfare as they do not offer any direct benefit to the local communities other than by potentially reducing local air pollutants.

In contrast we propose that process-driven technologies have the potential to have strong positive impacts on operational improvement. These technologies try to identify and improve the efficiency of various processes in mining operations in order to reduce GHGs through actions such as reducing energy consumption. In doing so these actions should lead to improved production efficiency and cost reductions. To the extent the process reduces local pollutants it can potentially improve social development outcomes.

### 5.2 Offset-based initiatives

Coal mining companies also reduce the GHGs by taking up offset-based initiatives such as substituting fossil-fuel generation for renewable energy and by funding projects external to their mining operations, in local communities. Although these projects help reduce the GHGs, but they have no clear impacts on operational improvements. They may however have stronger impacts on social development outcomes.

We divide these initiatives into two categories: internal and external. Internal refers to initiatives that produce the same end-product, i.e. energy, but uses alternative technologies that reduce overall GHGs. The most common of these are the adoption of renewable technologies for energy generation. These technologies have the potential to make large reductions in the GHGs of the coal mining industry. Their role in promoting operational improvement is however limited. We propose that there may be minimal or even negative effects on operational improvement due to the potential difficulties in the integration of different technologies into the operational processes. These technologies however may have medium-scale benefits for social development as these technologies potentially offer electricity to local communities while reducing local air pollutants that may arise from traditional fossil-fuel generation. External offset initiatives include those in which coal mining firms compensate for environmental damage caused by their operations by funding projects external to their mining operations. These projects have potential to achieve substantial social development benefits, and are often directly targeted to benefit local communities along with providing environmental benefits (such as funding renewable energy generation in local communities or funding forestry development or waste recycling). These projects offer limited opportunities to improve operational efficiency as they mostly operate outside the day-to-day operations of the mining companies.

Table 3 summarises the TBL framework. It should be noted that some initiatives may cross-cut these categories.

Table 3: Summary of TBL framework

	Example of initiative	Effects on Operational improvement	Effects on GHGs	Effects on Social Development
Production-based initiatives				
- End-of-pipe	Flaring of methane	Minimal e.g. potential to earn revenue from waste products	Medium → Strong e.g. transforms methane to less-GHGs intensive gases	Minimal e.g. potential reduction in local air pollutants that could affect local communities
- Process-driven	Carbon management programmes	Medium → Strong e.g. allows reduction of wasteful use of energy leading to cost savings	Medium → Strong e.g. identifies GHGs reduction opportunities through process	Minimal e.g. potential reduction in local air pollutants that could affect local communities

			improvements	
Offset-based initiatives				
- Internal	Switch from fossil-fuel energy generation to renewables	Negative → Minimal e.g. potential downsides in short-term from integration of new technologies	Medium → Strong e.g. avoid GHGs from burning of fossil fuels	Minimal e.g. reduction in local air pollutants that could affect local communities
- External	Funding offset initiatives in local communities	Minimal e.g. unless able to integrate an element of initiative to operations linked to mining	Medium → Strong e.g. various forms of GHGs reduction	Strong e.g. direct community support through jobs and output from initiatives

## 6. Concluding remarks

In this paper we develop a framework that provides a starting point for mining companies to develop a strategic approach to environmental improvement initiatives that can positively impact all elements of the TBL. We highlight that a typology of different abatement options are available to mining companies to reduce their GHGs and we create four distinct categories of initiatives. Each of these categories have differential effects on the elements of the TBL. Offset-based initiatives predominantly will affect the environment but may have spin-off benefits for social development, with external offset-based initiatives having more potential in this area. End-of-pipe initiatives offer clear environmental improvements but little in the area of operational efficiency. Process-driven initiatives offer both operational and environmental improvements. Hence in order to have an environmental improvements programme that also offers benefits to the other elements of the TBL, mining companies need initiatives in each of the four different types, and those companies with a diverse range of initiatives should have the strongest gains in each of the TBL elements.

In Section 3 we noted that the three coal mining companies implement a suite of environmental improvement initiatives, however with different range of focus. All three companies emphasise process-driven initiatives, with AA focusing mainly on their ECO2MAN programme that operates across the group. In their SDR's both AA and BHP highlight end-of-pipe initiatives they have implemented. Stronger focus on internal and external offset initiatives are made by AA through their investments in renewable energy and the Zimele Fund. The initiatives reported by Rio Tinto and BHP in this area are limited, although BHP's social development pledge is met through two charitable arms that provides for external offset-based initiatives.

AA as a company seems to have invested in a package of measures that best spans the four types of initiatives identified in the framework. The company had the strongest operational improvements until 2015 and had also made relatively the highest contribution to environmental and social development.

Our findings are of importance to mining companies in developing strategies and plans to reduce GHGs. They point to the importance of company-wide strategies that can implement projects across all parts of the typology. This would create advantages over approaches that allow individual divisions to decide their own projects. Although the latter allows the flexibility for middle managers to identify the most cost-effective opportunities within their own specialism, it risks the wider operational improvements and social development advantages that planning a suite of initiatives across the company can achieve. The TBL framework emphasises the need for overarching process-driven initiatives that can change operational processes resulting in operational efficiency and GHGs reduction, rather than just achieve environmental objectives such as those that can be achieved through end-of-pipe initiatives. The framework highlights the importance of looking at environmental improvement initiatives through all three lenses of the TBL; assessing these initiatives on one, or even two of the elements of TBL could under-estimate the benefits and over-estimate the costs. For example, if internal offset-based initiatives were analysed using only operational-efficiency and environmental metrics, their social development benefits could be missed out. On the other hand, if just environmental and social metrics were used, the potential operational costs reduction benefits could be missed. This highlights the need for the TBL metrics in assessing initiatives that have the potential to impact all the elements of the TBL.

The development of the framework was limited by the differential data (especially with regard to social development) that is reported by these companies through Annual Reports and SDRs – but we find evidence that those companies that have implemented a complementary suite of initiatives – especially those targeting operational processes directly, have achieved strongest environmental performance and also improvements in the other elements of the TBL. Extending this framework by analysing in the context of a wider suite of initiatives from the mining industry more generally offers a fruitful path for future research.

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For Peer Review Only

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2  
3 Thanks for the authors to make the revision, the paper is now much stronger. The method section  
4 reads ok. However, it will be important that you do provide details to the audience on how the  
5 survey was conducted, in terms of how was the respondents recruited, from which country or  
6 region, from which companies/organizations (a list of companies may be needed), are those six  
7 questions open ended?, how do we know those representatives are suitable respondents, how  
8 many respondents to the surveys etc. Overall, it is about creating transparency to the audience  
9 about the methods to allow duplicability of research.  
10

- 11  
12 - More detail has been added into the methodology section regarding how the survey was  
13 conducted including the recruitment process, the size of the sample, the countries of the  
14 respondents, the representation of the respondents, the nature of the questions and the  
15 objective of the survey. Given the confidentiality agreement offered to the representatives  
16 of mining companies and organisations when completing the survey, we have not added the  
17 names of the companies that participated.  
18  
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21 There are some presentation issues with the reference list, please see above my comments.  
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- 23 - References for ICMM and Kitco have been amended.  
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