ASSESSING CLIMATE CHANGE RISKS AND OPPORTUNITIES FOR INVESTORS

Mining and Minerals Processing Sector

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Introduction

The mining and minerals processing sector already is financially vulnerable to the consequences of extreme weather events such as drought, bushfires, high temperatures and flooding. Climate change is forecast to increase the exposure of this sector to climate, energy and carbon price risks. Many adaptation measures and opportunities to mitigate energy cost and carbon risks are open to mining and minerals processing companies.

Purpose

This guide provides information to help investors assess and integrate climate risk and opportunity in the mining and minerals processing sector into investment analysis.

How to use this guide

Identify the risk factors: Recognise key climate change, energy and carbon risks faced now by investors in the mining and minerals processing sector in Australia. (Table 1 and Table 2 provide a checklist of issues for investors)

Indentify how risks will increase: Unmitigated climate change will increase risks related to weather, energy cost and carbon. Increasing risks are explained.

Identify the adaptation strategies and mitigation measures: The most cost effective measures companies can take to mitigate energy costs and carbon risks (reduce exposure) and adapt to physical risks (to build resilience for climate changes which can no longer be avoided) are then described based on observations of leading practices.

Assess materiality: Not all climate change risks affect all sectors equally. Tables identifying risks, adaptation strategies and mitigation measures in this guide include the most significant issues for the mining and minerals processing sector.

Integrate the information into investment processes: The diagram below indicates how investors can integrate the information in this guide into investment practices.

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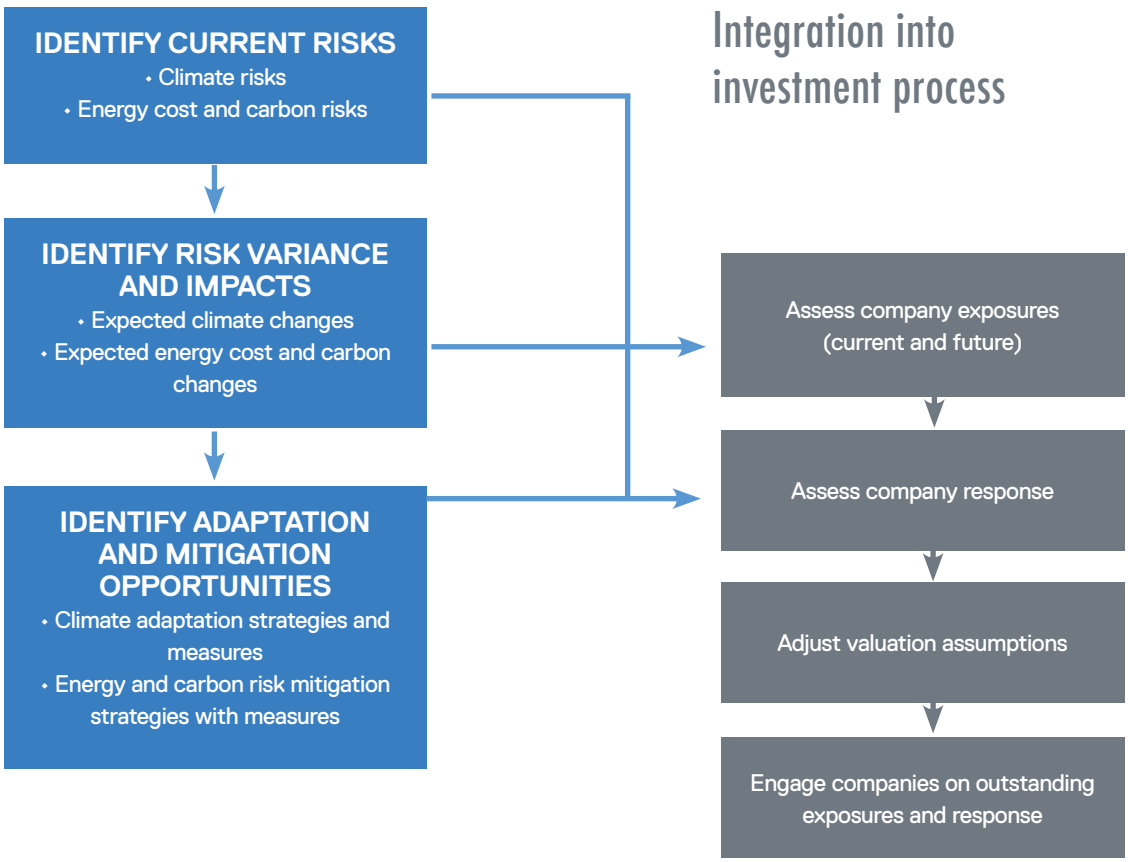

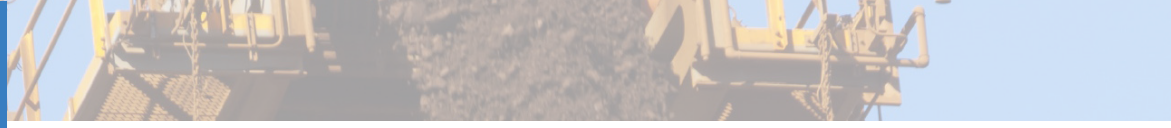

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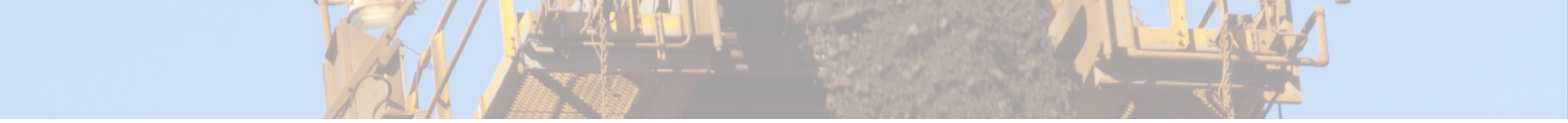


SUMMARY OF CLIMATE RISK AND OPPORTUNITY IN THE MINING AND MINERALS PROCESSING SECTOR

Climate related risks

The mining and minerals processing sector is a capital intensive sector with many long life fixed assets, long supply chains and significant water requirements to enable operations. The mining sector in Australia and globally has always been vulnerable to extreme weather with flooding events and changes to water availability through drought.[2] Examples of existing vulnerabilities include:

Cyclones and flooding	2011's cyclone Yasi and the ensuing flood shut down 85% of all coal mines in Queensland, costing $2.5 billion. Unable to meet their contracts related to these mines, BHP Billiton, Rio Tinto, Anglo American, Xstrata, Peabody Energy, Macarthur Coal, Aquila Resources, Vale, Cockatoo Coal and Wesfarmers all had to declare *force majeure.*[3]
Intense rainfall events causing overflow of tailings dams effecting significant down-stream pollution	Extreme rainfall and flooding events can cause tailings dams to fail, potentially leading to significant pollution which exposes mining companies and institutional investors to significant legal and compensation costs. This is well illustrated by BHP Billiton's Ok Tedi tailings dam failure in PNG in 1999.
Droughts and lack of water availability	In the 1950s, Broken Hill mining almost shut down due to lack of water from an 8 year drought. More recently in 2007, Newcrest Mining's large gold mine in Cadia Valley faced closure within a year due to the decline of the Belubula River, its main water source.
Bushfires causing coal mines to catch alight	Coal mines can and have caught alight when natural bushfires come into contact with them. In 2006, a bushfire started a coal fire at International Power's open cut brown coal mine at Hazelwood, near Morwel. Stretching to more than two kilometres along the coalface it took weeks to control and led to losses in time, equipment, assets and production.[4]
Heat waves causing chronic heat fatigue	Heat stress in the mining industry has been a formally recognized issue of concern for over one hundred years. It reduces productivity, increases poor decision making and risks of accidents, and heat related strokes.[5] Once temperatures and humidity levels pass a threshold, the core heat of our bodies can quickly rise to dangerous temperatures. High temperatures are already experienced in regions of Australia where mining occurs. For instance, in February 2004, temperatures reached 48.5°C in western NSW. In February 1998, parts of the Western Australia's Pilbara reached 49°C. As far back as 1960, Oodnadatta in South Australia reached 50.7°C. In January 2013, extreme temperature records were broken all over Australia as part of an unprecedented heat wave. The heat wave lasted twice as long as any previous heat wave in many parts of Australia. Unmitigated climate change is forecast to increase the likelihood of more days per annum with higher extreme temperatures and the chances of longer lasting heat waves. [6]

Climate change risks, forecast change, potential impacts and adaptation strategies

The latest climate science shows how, over the last century, the average intensity (and in some cases frequency) of these extreme weather events has increased due to climate change [7] and, if current greenhouse gas emission trends continue, will continue to increase over the coming decades. Given this, it is reasonable for investors to expect companies to plan for such scenarios now including implementing cost effective adaptation strategies open to mining companies summarised in Table 1 and described in further detail below in Table 4.

Table 1 Climate change risks, forecast change, potential impacts and adaptation strategies

MORE INTENSE CYCLONES

FORECAST CHANGE

Cyclone intensity

+60% by 2030
+140% by 2070

IMPACTS

- Damage to infrastructure
- Operations disrupted
- Supply chains disrupted

ADAPTION STRATEGIES*

- Increase design and construction standards
- Flood defence measures
- Pumping equipment and backup generators
- Engage with government
- Multiple transport routes
- Insurance

EXTREME RAINFALL EVENTS AND FLOODING

FORECAST CHANGE

Despite overall decreases in rainfall (see below), rainfall events will become more intense creating a greater risk of flooding.

IMPACTS

- Damage to infrastructure
- Operations disrupted
- Supply chains disrupted

ADAPTION STRATEGIES*

- Increase design and construction standards
- Flood defence measures
- Pumping equipment and backup generators
- Engage with government
- Multiple transport routes
- Insurance

REDUCED WATER AVAILABILITY

FORECAST CHANGE

(%)	2030	2050	2070
North:	-10 to +5	-20 to +10	-30 to +20
South:	-10 to 0	-20 to 0	-30 to +5

Number of months in drought by 2070
South Western Australia : +80%
Eastern Australia : +40%

IMPACTS

- Water supply cost increase
- Greater competition for water

ADAPTION STRATEGIES*

- Improved efficiency of water storage
- Develop alternative water supplies
- Improve recycling of 'worked' water
- Desalination
- Work with communities and government

AVERAGE HIGHER TEMPERATURES

FORECAST CHANGE

0.1 to 1.5°C by 2020
0.3 to 4.0°C by 2030
0.4 to 8.0°C by 2080

IMPACTS

- Chronic heat fatigue
- Spread of dengue fever
- Higher energy costs (e.g. air conditioning)
- Higher risk of coal mining spoil piles self-combustion

ADAPTION STRATEGIES*

- Heat stress prevention plan[8]
- Improve underground cooling systems
- OH&S disease exposure prevention plan
- Energy efficient air-conditioning
- Coal mining spoil self-combustion prevention strategies

MORE DAYS OVER 35°C (northern Australia)

FORECAST CHANGE

7 to11 days per annum in 2000
69 days per annum by 2030
308 days per annum by 2070

IMPACTS

- Chronic heat fatigue
- Spread of dengue fever
- Higher energy costs (air conditioning)
- Higher risk of coal mining spoil piles self-combustion

ADAPTION STRATEGIES*

- Heat stress prevention plan
- Improve underground cooling systems
- OH&S disease exposure prevention plan
- Energy efficient air-conditioning
- Coal mining spoil self-combustion prevention strategies

HIGHER RISK OF BUSHFIRES

FORECAST CHANGE

Days with very high and extreme Forest Fire Danger Index (FFDI) ratings: [9]
4 to 25% by 2020
15 to 70% by 2050

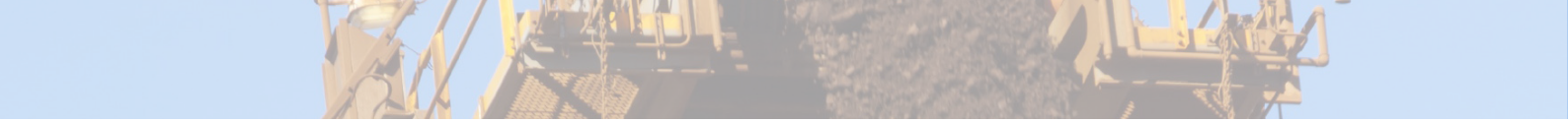
IMPACTS

- Higher risk of coal mine fires

ADAPTION STRATEGIES*

- Improve bushfire management plan
- Build appropriate fire breaks
- Reduce bushfire fuel loads
- Coal mining spoil fire prevention
- Work with Rural Fire Service

*Adaptation strategies listed in this table are a sample of risk management measures available to companies.



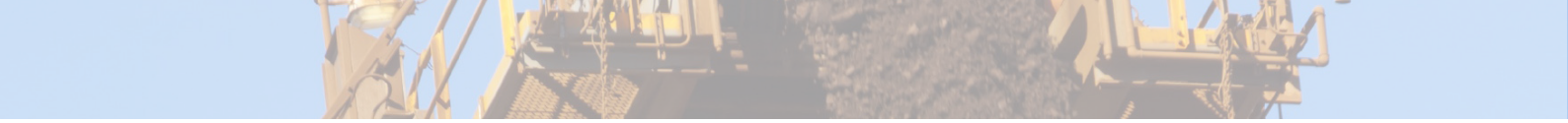
Energy costs and carbon risks and mitigation opportunities

Declining ore grade concentrations	Mining companies constantly assess ore grades. Energy cost is an important input to assessing mine feasibility. While current operational energy costs make up around 7-12% of total mining costs for different mining sub-sectors in Australia, within 10 years, energy costs could be as high as 20-30% of total operational mining costs. Energy intensive gold and copper mines are most exposed if cost effective investments are not made in more energy efficient comminution (crushing and grinding) technologies. Over the last 30 years, the average grade of mined Australian ore bodies has halved[10] leading to a 70% increase in energy consumption across mining operations.[11] This is rising at around 6% annually.[12] Once grades fall below 1%, energy requirements rise exponentially to grind ores to obtain the valuable mineral.
Short term focused capital expenditure	Energy savings of up to 50% per tonne below business as usual energy usage trends are practically feasible in the design of new Greenfield metal ore mining and minerals processing operations through implementing an integrated mine-to-mill energy efficiency strategy.[13] Few mining companies are realising such long term operational energy cost savings due to investors and industries focusing on minimising upfront capex costs in establishing mine site operations as quickly as possible. This may leave some mines exposed to reduced competitiveness (over the longer term) if energy costs rise while at the same time mineral prices fall.
Diesel fuel price exposure	The mining sector in Australia relies on diesel fuel to run generators and mining haul trucks. The price of diesel fuel is pegged to the oil price which the International Energy Agency (IEA) forecasts to rise significantly once the global economy returns to historic growth trends.
Reliance on diesel fuel subsidies	The Australian mining sector currently receives tax deductions for the use of diesel fuel. The G20 has committed to phasing out fossil fuel subsidies and the OECD continues to highlight Australia's subsidies for fossil fuels.
Price on carbon	Over 50 national or sub-national carbon price schemes are in place around the world. Many of the remaining nations have some form of climate change regulation or policy which creates a shadow carbon price on energy prices. Mining is energy intensive thus, if carbon mitigation steps are not taken, the price on carbon increases energy costs.

Energy price and carbon risks are summarised in Table 2 with relevant mitigation strategies for investors to discuss with companies.

Table 2 Energy cost risks, forecast change, potential impacts and mitigation strategies

DECLINING ORE GRADE CONCENTRATIONS 	FORECAST CHANGE 2010 - Energy costs 7 - 12% of total costs 2030 - Energy costs 20 - 30% of total costs IMPACTS Higher energy costs	SAMPLE MITIGATION STRATEGIES · Mine-to-mill energy efficiency strategy · Geometallurgical analysis of ore body · Ore body sorting and concentration upgrade · Energy efficient comminution equipment · Energy efficient mineral separation
SHORT TERM FOCUSED CAPITAL EXPENDITURE 	FORECAST CHANGE In new mines, BAU locks in up to 50% higher energy costs long term compared to investing in advanced energy efficient mine-to-mill circuits. IMPACTS Higher energy costs	· Mine-to-mill energy efficiency strategy · Geometallurgical analysis of ore body · Ore body sorting and concentration upgrade · Energy efficient comminution equipment · Energy efficient mineral separation
DIESEL FUEL PRICE VOLATILITY 	FORECAST CHANGE IEA predicts a long term oil price of around $200 per barrel once traditional growth rates resume. IMPACTS Higher energy costs	· Energy efficient materials movement strategy · Energy efficient overburden removal · Energy efficient mine haul trucks · In-pit crushers and conveyors · Low carbon energy sources
REDUCTIONS IN DIESEL FUEL SUBSIDIES 	FORECAST CHANGE $2 billion diesel fuel rebate IMPACTS Higher energy costs	· Energy efficient materials movement strategy · Energy efficient overburden removal · Energy efficient mine haul trucks · In-pit crushers and conveyors · Low carbon energy sources
PRICE ON CARBON 	FORECAST CHANGE 2012 - 2015: $23 per tonne 2015 onwards: global market price, likely to be between $10 - $20 per tonne IMPACTS Higher energy costs	· Integrated whole of mine energy efficiency · Low carbon energy sources · Reducing fugitive emissions · Carbon offsets · Enabling third party emission reductions



Analysis of the climate change risks

The mining sector in Australia and globally has always been vulnerable to extreme weather events such as cyclones, flooding events and changes to water availability through drought.[14] As this guide illustrates, such extreme weather events have already negatively impacted on mining companies' cash flows. The latest climate science shows how, over the last century, the average intensity (and in some cases frequency) of these extreme weather events has increased due to climate change[15] and, if current greenhouse gas emission trends continue, will continue to increase over coming decades. It is critical that investors understand the scale and speed of these likely changes to factor them into their investment decisions. All the following extreme weather events pose significant risks to investments in the mining sector's infrastructure, operations and/or supply chain.

Extreme weather events are forecast to become more intense. Climate change modeling predicts an increase in the intensity of cyclones of 60 per cent by 2030 and 140 per cent by 2070.[16] This is forecast to produce more extreme flooding events associated with such intense cyclones. Projections also indicate tropical cyclones are moving southward as sea surface temperatures increase.

Rainfall events are forecast to become more intense and unpredictable. The wetter conditions experienced in Australia in the last two years are consistent with scientists' knowledge and understanding of how the climate is changing due to human induced climate change. Australia's climate is significantly affected by the La Niña/ El Niño oscillation in the Pacific Ocean. The El Niño oscillation brings drier drought conditions to Australia whilst La Niña brings higher rainfall events. The oscillation between these two cycles underpins why Australia has always been the land "of droughts and flooding rains."

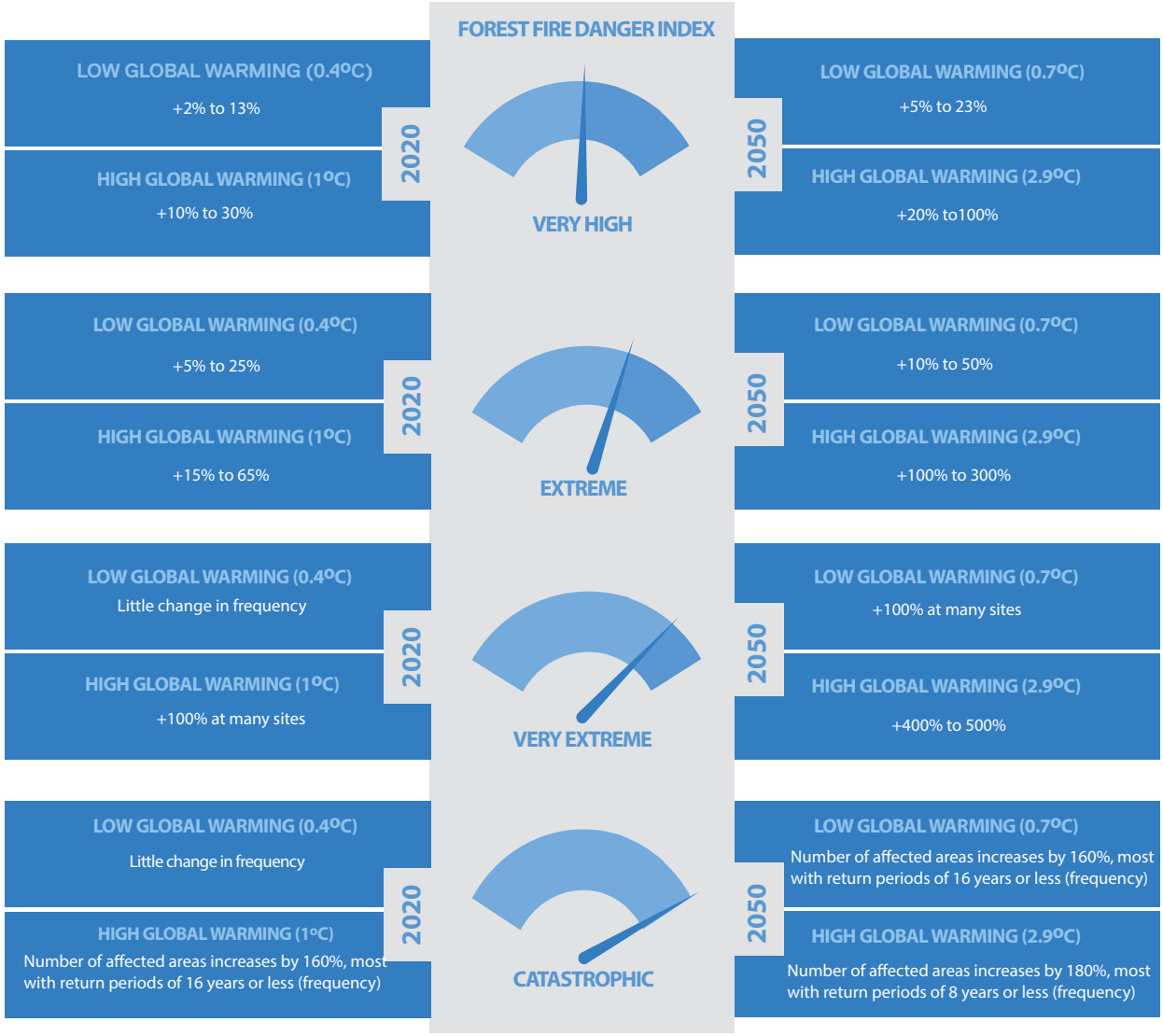
The latest climate science suggests it is highly likely this oscillation between drought and flood will become more extreme and intense. This means that when a long, dry period of a El Niño cycle transitions into a La Niña cycle, the rain is more likely to fall as heavy downpours than as extended drizzle. Warmer climates also enable more intense rainfall events as warmer atmospheres can hold more water vapour. That the 1 in 100 year 2001-2009 drought was broken by 1 in 100 year flooding events in early 2011, is consistent with what climate models predict as being more likely to occur this century.

Water availability. Average annual rainfall is expected to decrease in southern, western coast and subtropical Australia by up to 10 per cent by 2020, up to 20 per cent by 2050 and up to 30 per cent by 2070.[17] There is likely to be changes to water availability in northern Australia as well. For instance, the majority of water used in mining and minerals processing in the Pilbara is sourced from groundwater, the recharge of which depends on cyclonic rainfall events occurring between November and March each year. Whilst the intensity of cyclones is forecast to increase, the frequency of cyclones is forecast to decrease in northern Australia due to climate change. This makes it much harder to predict whether mining companies' groundwater supplies will be adequately recharged or not over the long term. It would be prudent for investors to consider assets' geographical locations in their analysis.

Temperature rises. Where most mining companies operate in Australia, the temperatures in summer can already get very high. For instance, during the Eastern Australian heat wave in February 2004, temperatures reached 48.5°C in western New South Wales. Climate change will increase the likelihood of these extreme temperatures rising. In northern Australia, where a significant percentage of mining occurs, the number of days over 35°C is highly likely to increase from 7-11 per year currently experienced to up to 69 days per year by 2030 and up to 308 days per year by 2070 without global action to reduce emissions. Coupled with the extremely high humidity in northern Australia, higher temperatures risk causing heat related illness and poor decision making leading to risks of accidents and fatalities. Risk management strategies can provide insight for investors into a company's preparedness for these eventualities.

Bushfires. Coal mines can combust if either natural bushfires come into contact with them or if self-heating of coal mining spoil piles leads to spontaneous combustion.[18] Globally, there have been hundreds of reported fires at coal mines caused by nature, either lightning or natural bushfires, or combustion of coal mining spoil piles over the last 100 years.[19] Coal fires are estimated to contribute around 0.3% of global greenhouse gas emissions. If a coal mine combusts and is not extinguished quickly, it can burn through the coal seams underground for a long time and even re-start bushfires a significant distance away from the initial fire where coal seams potentially surface. These pose financial risks to coal mining companies from increased carbon emission costs, loss of resource assets as well as the potential for litigation if parties, external to the mines, are adversely affected by bushfires caused by coal fires. Due principally to forecast changes to temperature and decreases to average rainfall in western and south-eastern Australia due to climate change, the number of days with extreme Forest Fire Danger Index (FFDI) ratings will increase by 5-25 per cent by 2020 and 15-65 per cent by 2050.[20] (Table 3)

Table 3: Per cent changes in the number of days with 'very high', 'extreme', 'very extreme', and 'catastrophic' fire days due to weather in 2020 and 2050, compared to 1990. [21]



It is reasonable for investors to expect large mining companies and regional mining communities to have undertaken site specific climate change risk assessment by now. To help Australian mining and mineral resource companies undertake climate change risk assessment, CSIRO has developed climate change scenarios for 11 of Australia's major mining regions.[22] CSIRO's work has already translated global climate models into likely localised impacts to analyse climate change risks in these 11 mining regions. For instance, this work models useful short-term trends such as likely changes to water availability out to 2030; important information relevant for the current lifespan of many existing and all new mines.[23]

CSIRO has undertaken additional work with some of the major Australian mining companies to help them assess potential negative impacts from unmitigated climate change, assess optimal adaptation strategies and start to develop regional climate change adaptation plans. This is part of a formal CSIRO research program to explore how the mining sector can best adapt to climate change (see Key Resources). This is highly relevant and timely work, as having understood the likely risks from climate change, the next steps are to assess the potential negative impact on mining companies as profitable long-term investments, and whether or not mining companies are adopting optimal adaptation strategies to minimise the risk of these negative impacts on cash flow.

Having understood the likely risks from climate change, the next step is to assess the potential impacts on mining company activities. Table 4 provides an overview of in-house risk analysis by many leading mining companies as reported through the Carbon Disclosure Project (CDP). Table 4 also incorporates CSIRO's findings on the potential impacts of climate change risks for the Australian mining sector (see Key Resources). Investors can use this overview as an analytical checklist to help enable a rapid assessment of the risk exposure for a particular mining company's assets and benchmark the company's awareness of its climate change related risks.

While some of these risks, like sea level rise, are long-term in nature, given mining and mining related infrastructure, such as ports, have long design lives, risks from sea level rises still need to be factored into their design and maintenance.

Climate change impacts

Table 4: Analysis of climate change risks and potential impacts

MORE INTENSE EXTREME WEATHER EVENTS  **COMPANIES REPORTING RISK*** Alumina , Anglo American, Barrick, BHP Billiton, Rio Tinto Group, Xstrata	**DAMAGE TO MINE INFRASTRUCTURE AND DISRUPTION OF OPERATIONS** More intense natural disasters may damage mine, transportation, energy infrastructure, equipment and staff accomodation which, in turn, can disrupt operations.
MORE INTENSE EXTREME WEATHER EVENTS  **COMPANIES REPORTING RISK*** Exxaro, Gold Fields, Goldcorp, Kumba Iron Ore, Sesa Goa, Implats, Xstrata, Vale	**DISRUPTIONS TO SUPPLY CHAINS** More intense rainfall and extreme weather events risk disrupting supply chains and transportation services of critical materials, personnel, energy fuels and movement of ore to mineral processing comminution plants and to ports for export.
MORE INTENSE EXTREME WEATHER EVENTS  **COMPANIES REPORTING RISK*** Exxaro, Rio Tinto Group	**HIGHER INSURANCE PREMIUMS** Greater intensity and damage from extreme weather events has led to an exponential increase in weather related insurance and re-insurance costs over the last 50 years. Unmitigated climate change is forecast to contribute to continuing this trend leading to ongoing increases in insurance costs.
MORE INTENSE EXTREME WEATHER EVENTS  **COMPANIES REPORTING RISK*** Anglo Platinum, Anglo Gold - Ashanti	**COMMUNITY RELATIONS AND CORPORATE SOCIAL RESPONSIBILITY** Internationally, there may be increased requests for financial and employee support in response to natural disasters in host communities.
HIGHER TEMPERATURES  **COMPANIES REPORTING RISK*** Anglo Platinum, Exxaro, Gold Fields, Iluka Resources	**HEALTH AND SAFETY** Higher risks of more days with temperatures over 35ºC coupled with high levels of humidity lead to an increased risk of illnesses related to heat which can inhibit decision-making and affect productivity as a result of more accidents, injuries and fatalities.
MORE INTENSE FLOODING  **COMPANIES REPORTING RISK*** Northam Platinum, Yamana Gold	**HEALTH AND SAFETY** Higher risk of more intense rainfall events and flooding may affect employee safety on-site and on roads. Extreme flooding events also pose another risk; the longer flood waters remain in the mine pit the more time they have to collect natural salts. Moreover, as rivers subside they become more sensitive to the discharge as the discharge represents a greater proportion of the river's volume.
SEA LEVEL RISE  **COMPANIES REPORTING RISK*** Anglo American, BHP Billiton, Exxaro, Rio Tinto Group, Sterlite Gold, Vale	**DISRUPTION TO PORTS** Sea level rise and more intense extreme weather events may negatively affect port availability as well as interrupting and delaying operations. Costs for transport may rise in such circumstances.

HIGHER TEMPERATURES AND DROUGHT

COMPANIES REPORTING RISK*

BHP Billiton, Rio Tinto Group, Xstrata

HIGHER BUSHFIRE RISK

Bushfires risk damaging life and mining infrastructure and assets. Hence most mining companies have bushfire prevention protocols. Another serious risk arises from coal seam fires. [24] These can occur naturally from bushfires or from the spontaneous combustion due to self heating from coal mine spoil piles.

COMBINED EFFECTS

COMPANIES REPORTING RISK*

Lonmin, Newmont Mining

MINE CLOSURE - HIGHER DECOMMISSIONING COSTS

Water scarcity and hotter temperatures will make it more difficult to re-establish vegetative cover and will put stress on other environmental mitigation measures in some regions.
Increasing flood risks will result in enhanced risks to decomissioned sites requiring higher and more costly levels of flood protection. Rising groundwater levels may create new source-pathway-receptor relationships increasing risks associated with contaminated land.

WATER SCARCITY

COMPANIES REPORTING RISK*

Rio Tinto, BHP Billiton, Barrick, Xstrata, Anglo Platinum

COMMUNITY RELATIONS

Changes to water availability may lead to increased competition over water resources which risks affecting community relations.

CHANGES TO WATER AVAILABILITY

COMPANIES REPORTING RISK*

Anglo Platinum, Rio Tinto Group, BHP Billiton, Barrick, Xstrata

WATER SCARCITY

In many parts of Australia, there will be reduced amounts of water available for mining, processing, and refining activities from changes to water availability due to climate change.

SPREAD OF TROPICAL DISEASES

COMPANIES REPORTING RISK*

Anglo Gold - Ashanti, Cameco, Harmony Gold Mining

HEALTH AND SAFETY

Higher temperatures are likely to increase the incidence, prevalence and geographic reach of tropical diseases such as dengue fever, with consequences for workplace health and productivity.

MORE INTENSE DROUGHT

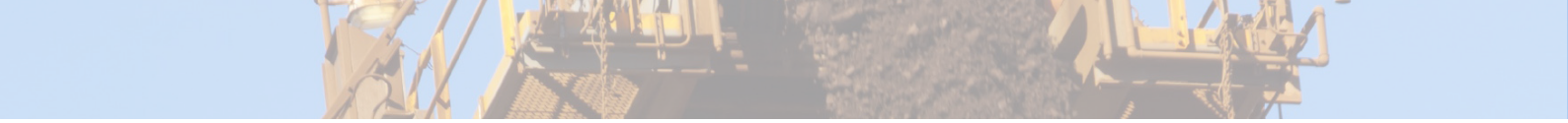
COMPANIES REPORTING RISK*

Anglo American, Barrick, Gold Fields, Kumba Iron Ore

NATIONAL SECURITY AND FOOD SECURITY

Internationally, climate change related disasters and extreme weather events may decrease food security, worsen poverty, induce migration, contribute to civil unrest, and increase conflict over natural resources.

*Companies listed are a sample of those reporting through the CDP their recognition of these risks.
(Source: Adapted and Updated from Nelson, (2009) [25]



ANALYSIS OF CLIMATE CHANGE ADAPTATION OPPORTUNITIES

Increasingly leading mining companies are going beyond compliance to adequately protect their assets, operations and supply chains from the material risks of extreme weather, floods, drought, and bushfire. There is a growing recognition that current regulatory frameworks and government standards are not sufficient to protect company assets and operations from more intense extreme weather events. This is demonstrated by Carbon Disclosure Project responses which report

- 51% of mining companies suffered damage from extreme weather events in recent years[26]
- 81% of mining companies' physical assets would be compromised by extreme weather events[27]
- 53% of mining companies are exposed to potential risks from water stress and restrictions.[28]

As mentioned above, mining companies' risks exposure will only increase over time due to climate change. So many mining companies are proactively adapting to reduce the chances of such events affecting their cash flow and production forecasts. Consider the examples of how mining companies are going beyond compliance to prevent costly damage from flooding and improve water management to ensure long term water security.

Examples of mining companies exceeding compliance to reduce risk exposure

Preventing flooding. SafeWork Australia publishes codes of practice for open cut mines, which require mining companies to "design surface water drainage paths through and around the mine. To reduce the potential risk of loss of life or injury to personnel, the surface drainage paths design should at least take into account 1 in 100 year 72 hour rainfall/flood event." Recent flood events in Australia have demonstrated how going beyond compliance obligations and investing in more purposeful flood prevention measures may be necessary for many parts of Australia. For instance, in 2008, the Ensham coal mine in central Queensland was flooded with more than 100,000 megalitres of water. It took four months to pump it out and recover a submerged dragline. The total cost was estimated at $300 million. Having invested in flood prevention measures and levees to protect these mines from a 1 in a 1000 year flood, this mine completely avoided being flooded in the next major flooding event in 2010.

Smart water efficient practices to ensure water security. All major mining companies in Australia publically recognise the need to better manage water as one of their top priority climate change adaptation strategies. Some companies have, at certain mine sites, gone well beyond compliance to achieve water security in a changing climate such as

- Fortesque Metals Group, which has invested in managed aquifer capture, storage and recharge
- Newcrest Mining, at their large gold mine in Cadia Valley, has made significant investments in sophisticated rainwater and stormwater harvesting and water treatment and recycling strategies in surrounding areas to meet its water needs.[29]

Until recently, the mining industry has not had a standard water mass balance accounting system to easily measure and monitor its water usage, which means historically, this industry has not been as efficient as it could have been with water. There are profitable opportunities for going beyond compliance in the area of better water management in the mining sector, as is shown by the latest research from the University of Queensland Centre for Water in Mining. For instance, a recent study into water use in Bowen Basin coal mines in central Queensland, found there is potential to reduce freshwater usage by up to 70 per cent and "worked water" by as much as 20 per cent on average.[30]

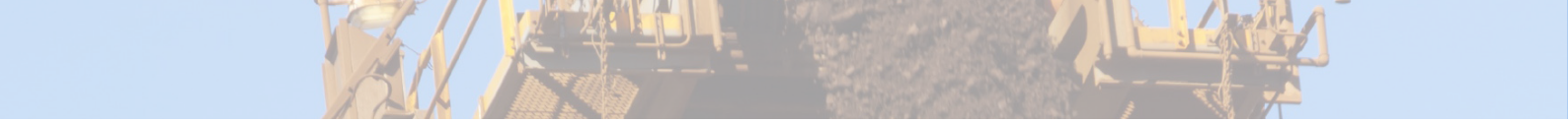
These examples of mining companies financially benefiting from implementing climate change adaptation strategies illustrate there are numerous "win-win" options to better manage and reduce climate change related risks (see Table 5). Yet although most major mining companies have begun to implement adaptation strategies for those most immediate risks such as the risks of water scarcity or flooding, none has yet acknowledged all of the risks listed in Table 4 and committed publically to addressing most of these risks. Investors should look to see if mining companies are disclosing climate change related risks (Table 4) and their adaptation strategies (Table 5) to demonstrate that they understand their risk exposures and how to confidently manage them.

Addressing water and weather related risks (i.e. cyclones, flooding, drought, high temperatures and bushfires) should already form part of an effective risk management strategy for any mining company. Climate change increases the probability and severity of these risks (Table 4) and may adversely impact companies' cash flows and assets value. Numerous examples show mining companies can benefit from going beyond current compliance obligations to more adequately address these risks. Through the Carbon Disclosure Project, the majority of mining companies report their exposure to significant risks from extreme weather events and water scarcity. Additionally, a majority have suffered damage to assets from extreme weather events in the last few years.

Table 5: Climate change adaptation strategies

MORE INTENSE EXTREME WEATHER EVENTS  COMPANIES ADAPTING* BHP Billiton, Rio Tinto, Xstrata	**REDUCE RISKS OF AND COSTS OF DISRUPTIONS TO SUPPLY CHAINS** · Diversify supplier base to ensure the resilience of infrastructure, work with government and transport providers to explore private investment in transport where routes or locations may be vulnerable. · Ensure multiple transport options/routes to get ore from mine to port to minimise risks of delays due to flooding. · Increase storage capacity for essential materials, fuel and products used · Review and increase insurance policies covering extreme weather events, business continuity and business disruption.	**MORE INTENSE EXTREME WEATHER EVENTS**  COMPANIES ADAPTING* BHP Billiton, Rio Tinto Group, Xstrata	**REDUCE RISKS OF REDUCED ASSET OPERATION AND PERFORMANCE** · Consider geographic diversification as a strategy to manage potentially severe regional climate impacts · Consider provision of emergency power and water supplies, pumping and wastewater treatment · Ensure multiple transport options/routes to get ore from mine to port to minimise risks of delays due to flooding · Develop robust climate-proof business continuity plans · Use insurance mechanisms to cover risks
MORE INTENSE BUSHFIRES  COMPANIES ADAPTING* Rio Tinto, Rio Tinto Argyle Diamond Mine, Xstrata, BHP Billiton, Ango Coal Australia, Centennial Coal, Felix Resources Limited all have bushfire management plans	**REDUCE RISKS OF BUSHFIRES CAUSING COAL IN COAL MINES TO CATCH ALIGHT** General prevention strategies include: · Review mine's Bushfire Management Plan in light of risk of more intense bushfires · Review proximity of mine to fire prone vegetation to ensure vegetation is set far enough back from the mine · Build appropriate fire breaks and perimeter trails and review fuel reduction programs · Provide adequate fire protection works on site, including the availability of trained personnel, water tankers and fire fighting equipment and annual hazard reduction measures with particular attention to boundaries of adjoining landholdings · Make available to the Rural Fire Service and emergency services when required, water carts and trucks in cases of bushfire incidents on the mine site		
MORE INTENSE FLOODING  COMPANIES ADAPTING* Anglo American, BHP Billiton, Rio Tinto Group	**REDUCE RISKS AND COSTS FROM DAMAGE TO ASSETS AND INFRASTRUCTURE** · Flood defence measures · Improve drainage systems to increase capacity to cope with greater rainfall intensity and assist water soaking into the ground, reducing rapid runoff · Ensure pumping equipment can cope with worst case scenario flooding events. · Work with local water catchment authorities and local and state governments to encourage regional flood management and mitigation planning. Encourage regional investment in identification of managed aquifer water storage and recovery opportunities. · Ensure multiple transport options/routes to get ore from mine to port to minimise risks of delays due to flooding. · Insurance policies covering flood damage, business continuity and business disruption		
SEA LEVEL RISES  COMPANIES ADAPTING* Anglo American, BHP Billiton, Rio Tinto Group, Xstrata	**REDUCE RISKS OF AND COSTS OF DISRUPTIONS TO SUPPLY CHAINS** The IPCC recommends the following strategies to reduce the risks of damage from sea level rises -[31] · Protect: Protect mine property and infrastructure from sea level rises so that existing land occupation can be maintained by constructing hard structures (such as seawalls) and using soft measures (such as wetlands to protect from storm surges) · Accommodate: The land is still occupied but some modifications are made · Retreat: Ensure all new mine construction is sufficiently inland to avoid risks from storm surges[32]	**SPREAD OF TROPICAL DISEASES**  COMPANIES ADAPTING* Anglo American, BHP Billiton, Rio Tinto Group	**REDUCE WORKFORCE HEALTH AND SAFETY RISKS** · Assess the health and safety risks from changing climate and their impact on assets and operational processes · Review management protocols concerning increased vector borne disease exposure including the immunisation of staff and offering them additional immunisation where appropriate · Review emergency procedures and develop contingency plans including disaster management plans and measures to address the risk associated with extreme natural events and pandemics
CHANGES TO WATER AVAILABILITY - LONG TERM WATER SECURITY  COMPANIES ADAPTING* BHP Billiton, Rio Tinto Group, Xstrata	**REDUCE RISK OF LOSS OF PRODUCTION AND GREATER COMPETITION FOR LOCAL WATER ASSETS** · If water resources are inadequate, explore and develop alternative water supplies including, where appropriate, harvesting of stormwater and flood waters, more efficient use of water and water treatment and recycling · Work with communities that use the same water resources to avoid competition for those resources	**MORE INTENSE-EXTREME WEATHER EVENTS**  COMPANIES ADAPTING* Anglo American, Barrick, BHP Billiton, Rio Tinto Group, Xstrata	**REDUCE RISK AND COSTS FROM DAMAGE TO ASSETS AND INFRASTRUCTURE** More robust design and construction standards of mining related infrastructure, buildings and staff accommodation to meet or exceed cyclone related Building Codes of Australia requirements in northern Australia

(Source: Adapted and updated from Acclimatise [2009][33])
*Companies listed are a sample of those reporting through the CDP their implementation of mitigation measures.



ANALYSIS OF CLIMATE CHANGE MITIGATION OPPORTUNITIES TO ADDRESS ENERGY COST AND CARBON RISKS

In addition to extreme weather related risks, there are also energy and carbon risks to mining companies. These mainly relate to the risks of declines in ore grade concentration (see Table 2), diesel fuel prices and market based carbon pricing. Energy price rises already constitute a significant operational cost for most major mining companies at around 7-12% of total costs but this is rising at 6% per annum. This is not new. Energy costs have risen by 70% over the last 30 years due to declining ore body concentration and are forecast to keep rising. Also, the sector is highly exposed to both regulated and market driven diesel costs for its onsite electricity generation in remote areas and for operating haul trucks. Thus the sector remains vulnerable to any future spikes in oil and diesel prices.

The final section of this guide describes climate change mitigation strategies available to companies such as using energy efficiency to insulate against rising energy costs and a legislated carbon price. Investors can reasonably expect companies to consider or implement the following strategies to manage these risks:

Declining ore grade concentrations. Investing in an integrated approach to energy efficiency can reduce energy costs by 10–30% below business as usual (BAU) trends in most existing mining and minerals processing circuits.[34] Energy savings of up to 50% per tonne, below business as usual energy usage trends, are practically feasible in the design of new Greenfield mining and minerals processing operations (in the metal ore sub-sector) using the latest and best ore sorting and comminution technologies and strategies. [35]

Inadequate capital expenditure locking in higher energy costs. Short-term 'saving' on capital investment succeeds in locking in inefficient ways of moving or processing ore. So in both areas of materials movement (removal of overburden and transport of mineral ores) and crushing and grinding, choices of technology and equipment locks in whether or not you can have an energy efficient process or not. Figures 1 ,2 and 3 below show how materials movement currently has huge potential to improve energy efficiency.

Diesel fuel price exposure. The mining sector in Australia is dependent on diesel to run generators and to fuel haul trucks. Cost curves (Figure 2 and 3) show the most profitable energy efficiency measure for mining companies, in the short term, is improving the fuel efficiency of materials movement through the use of in-pit crushers and conveyors (IPCC), conveyors, and electrifying haul trucks with "trolley assist".

Reliance on diesel fuel subsidies. In addition to the above measures which also combat price volatility, using alternative renewable energy fuels, or biodiesel, would remove altogether the tax burden excised on fossil fuels.

Price on carbon. Energy efficiency strategies are the most cost effective means of reducing greenhouse gas emissions. In addition, mining companies can reduce their exposure to the carbon price through understanding the main sources of greenhouse gas emissions and systematically reducing those emissions. Whilst every mine is different, it is generally found that the majority of greenhouse gas emissions arise from the following sources.

- **Onsite fossil fuel energy usage.** For most mining operations, energy use represents almost all greenhouse gas emissions associated with the operation. The Australian mining industry currently uses mainly fossil fuel based diesel to operate core mining and minerals processing operations and mining haul trucks. Most energy is used for comminution, materials movement, mineral ore separation/froth flotation and ventilation of underground mines. Smaller overall amounts of energy are used for blasting, drilling, dewatering and operating mine site buildings and staff accommodation.
- **Fugitive methane emissions.** Fugitive methane emissions represent around 7% of total greenhouse gas emissions for the mining sector, with the majority emanating from coal seams. It is important to note these emissions are limited to a relatively small number of coal mines and it would be prudent for investors to question what mitigation measures are in practice at each.
- **Transport.** Transport related greenhouse gas emissions from a fly-in fly-out workforce and distributing mineral ore to markets around the world are also significant.

The Australian Government, formally through the Australian Greenhouse Office[36], has recommended the following strategies - investing in energy efficiency, renewable energy, carbon offsets and reducing fugitive methane emissions - to reduce greenhouse gas emissions.

Energy Efficiency

According to the Australian Government "*Energy and fuel efficiency strategies (for comminution, materials movement, minerals separation, ventilation and onsite buildings and accommodation) are the most cost-effective method of reducing greenhouse gas emissions. Increased energy efficiency can often be achieved within a payback period consistent with other process improvement projects.*"[37]

By investing in profitable energy efficiency opportunities, mining companies can reduce energy costs by 10–20% below business as usual trends in most existing mining and minerals processing circuits.[38] For new metal ore mines, companies can achieve up to a 50% reduction in energy intensity compared to business as usual. Investing in advanced energy efficient comminution strategies and technologies may insulate mining companies from forecast increases in energy demand and costs from declining ore grade concentrations.

There are many energy efficiency opportunities, as shown at the Australian Government's Energy Efficiency Exchange's mining report http://eex.gov. au/industry-sectors/mining/opportunities/ and at ClimateWorks Australia's (for the Australian Government) Industrial Energy Efficiency Data Analysis – Mining Sector report, http://www.climateworksaustralia.com/publications.html, available from April 2013. ClimateWorks Australia's report on energy efficiency opportunities in the mining sector provides detailed analysis of each mining sub-sector's total energy efficiency potential and return on investment for each energy efficiency measure. ClimateWorks Australia also, for the first time, has produced detailed cost curve analysis for all major Australian mining sub-sectors, examples of which are provided below (Figures 2 and 3). The Energy Efficiency Exchange's mining report provides further detailed explanation to better inform efforts to identify and implement each energy efficiency opportunity.

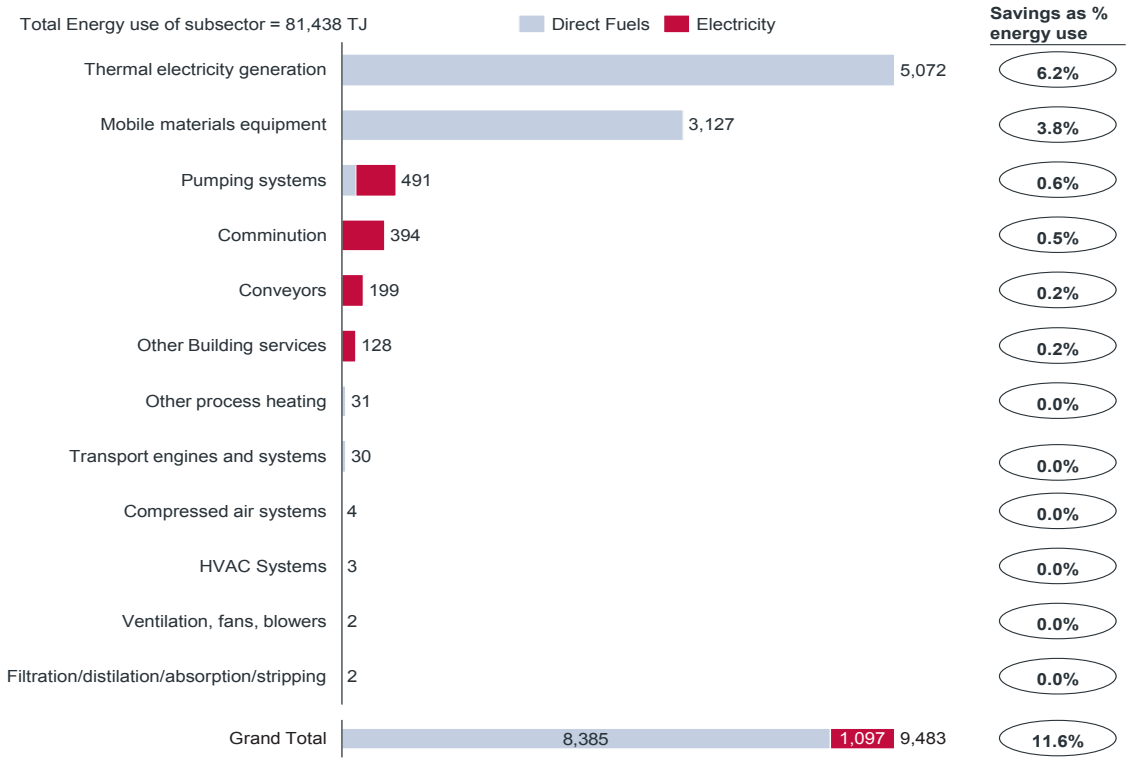


Figure 1: Energy efficiency opportunity potential (PJ) – metal ore mining sector (Source: ClimateWorks Australia for Department of Resources, Energy and Tourism [RET] – IEEDA, 2013[39])

Figure 1 above and the following cost curve, Figure 2, are designed to help inform investors, respectively by

- indicating the quantum of energy reductions available to the open cut metal ore mining subsector in Australia using known technologies (reflecting Table 2)
- indicating the range and cost-saving energy efficiency" projects available to companies in the open cut metal ore sub-sector. (reflecting Table 2)

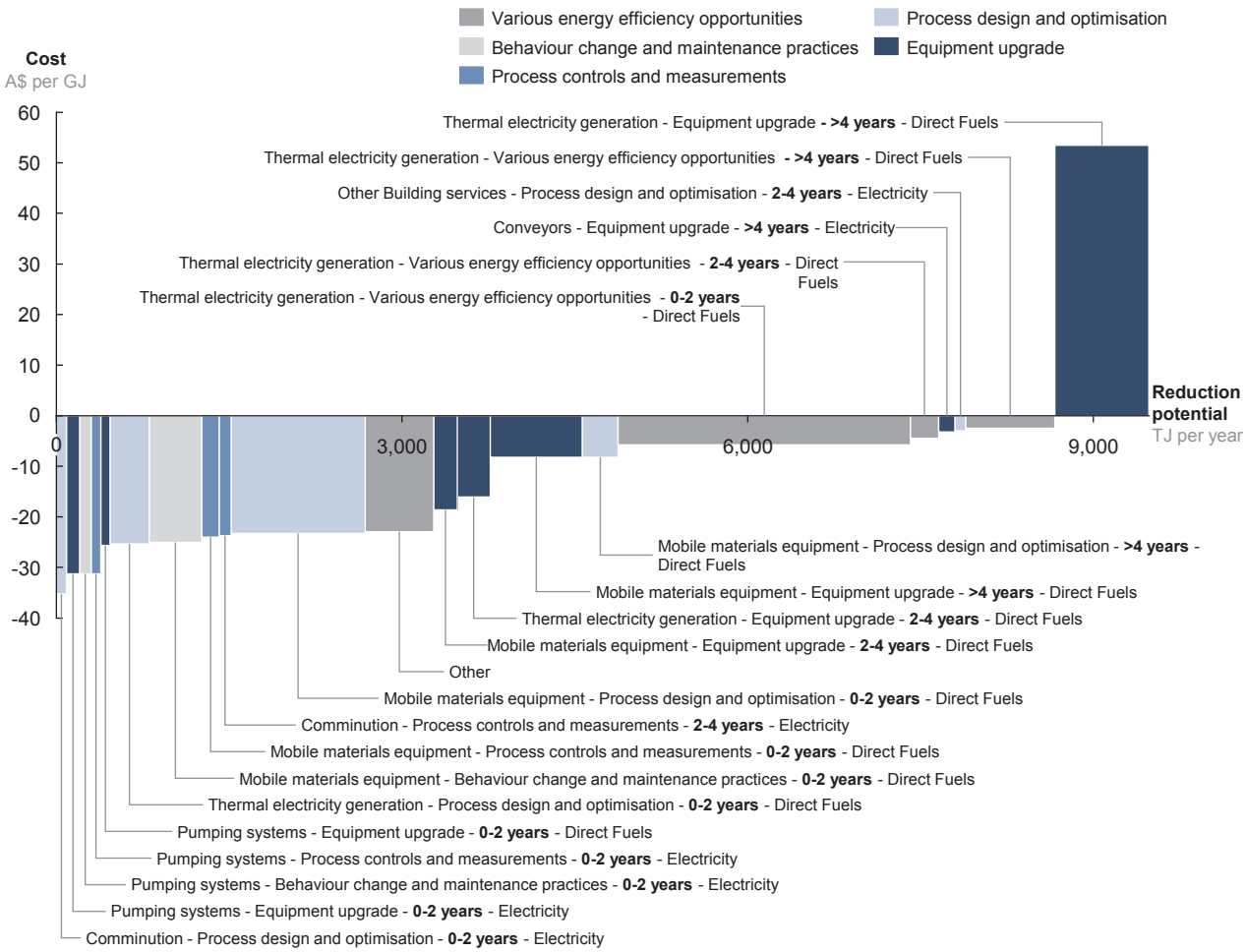


Figure 2: Energy efficiency opportunity cost curve – metal ore – open cut mining sector (Source: ClimateWorks Australia for RET, IEEDA, 2013[40])

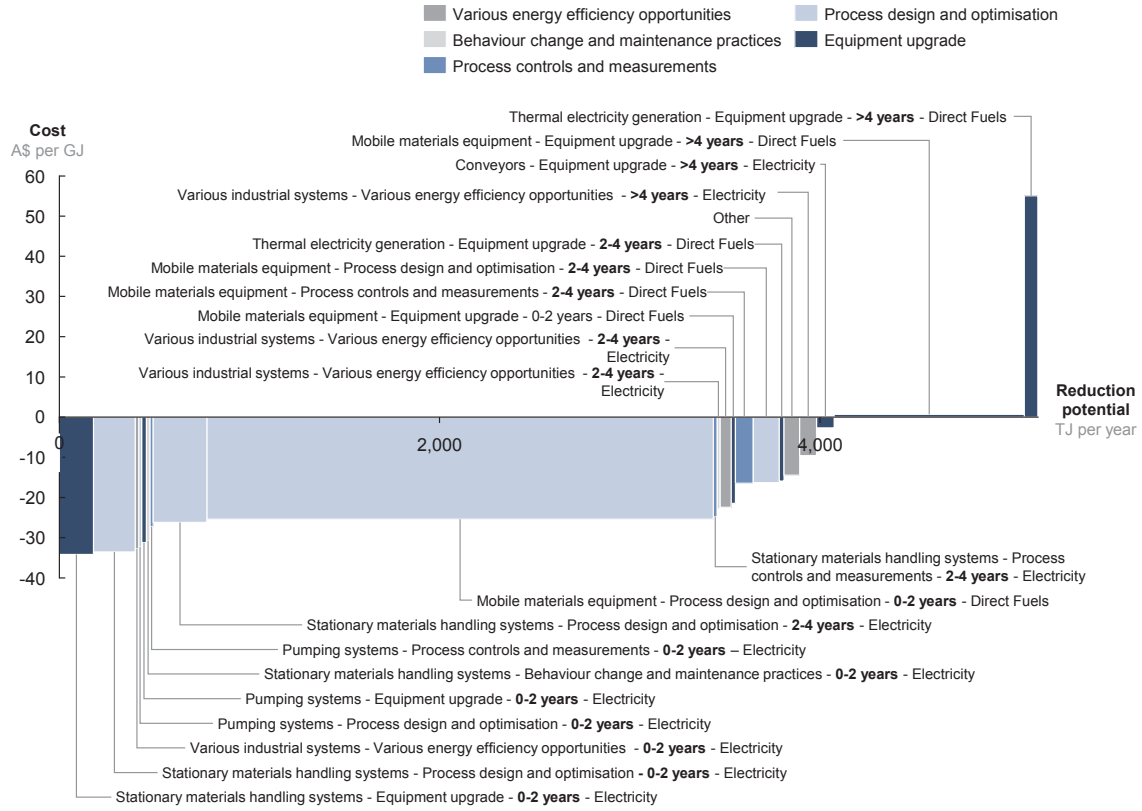


Figure 3: Energy efficiency opportunity cost curve - coal mining – open cut mining subsector. (Source: ClimateWorks Australia for the RET, IEEDA, 2013)

ClimateWorks Australia's and the Australian Government's analysis shows how the most cost effective and most significant energy efficiency opportunities differ for each mining sub-sector. For instance, open cut coal mining requires little energy for comminution compared to the metal ores sub-sector, so while process design and optimisation of comminution is the most profitable energy efficiency opportunity for the metal ores sector, it is not mentioned in the open cut coal mining cost curve above (Figure 3).

Australian mining companies generally have some investment in energy efficient lighting onsite or saving fuel through driver behaviour change of haul trucks, but overall they are slow to adopt more efficient practices for energy intensive components of mining such as materials movement, comminution, thermal electricity generation (co-generation) and ventilation of underground mining. As part of the capital cycle, there is significant potential to achieve a step change in energy efficiency in these areas.

- Comminution:
  - using 3D geometallurgical modeling of the ore body to enable the identification of the highest ore grades in the mine body. 3D geometallurgical models of the ore body can be used to underpin the optimal design of mine to mill circuits and the integration of energy efficiency into the measurement and accounting of energy use per unit of metal produced for any mine.
  - implementing ore sorting and gangue (waste rock) rejection to raise the average grade of ores before comminution
  - using advanced energy efficient comminution strategies and technologies.
- Materials Movement:
  - improving the fuel efficiency of haul trucks[41]
  - complementing haul trucks by investing in much more energy efficient materials movement systems such as in-pit mobile crusher and conveyor systems[42] , overburden slushers,[43] electric draglines,[44] as well as lighter and more efficient haul trucks,[45] and diesel-electric trolley haul trucks .[46] BHP Billiton recently publically suggested that these technologies may now make it possible to run virtually "truckless mines". BHP Billiton has found that technological advances in In-Pit Crushers and Conveyor technology now offer BHP Billiton the potential to achieve a step change in both labour and energy productivity whilst also reducing maintenance and carbon costs. Hence BHP Billiton recently informed UK investors of its decision to move towards truckless mines.

Improving energy efficiency in comminution and materials movement are just two ways to profitably improve mining energy efficiency and reduce energy and carbon risk exposures. Investors can ask companies simple questions about their practices in this area (See Box 1)

Once ore grade concentrations get below 1% the amount of energy needed to extract the valuable part of the mineral ore rises exponentially, exposing mining companies to escalating energy costs. (Figure 3)

Box 1: Questions for companies on energy efficiency

Questions investors can ask mining and minerals processing companies about energy efficiency practices include:

1) Has your company undertaken these steps as part of a comprehensive energy efficiency assessment of all potential energy efficiency opportunities and calculated likely ROI for your company?

2) Does your company undertake integrated mine to mill circuit design to reduce energy costs and greenhouse gas emissions?

3) Is your company using advanced mine to mill circuit design tools to optimise the design for energy and water efficiency?

4) Did you invest in the energy efficient crushing and grinding comminution circuits? Have you built in flexibility into your mining comminution circuits in case the ore body concentration changes over the mine's lifetime?

5) Does your company have programs to monitor and continuously improve the energy efficiency of the movement of overburden and also the movement of ore bodies from mine to mill? Has your company improved haul truck fuel efficiency and investigated utilising, in conjunction with haul trucks, more energy efficient earth moving equipment such as conveyors or in-pit crushers and conveyors?

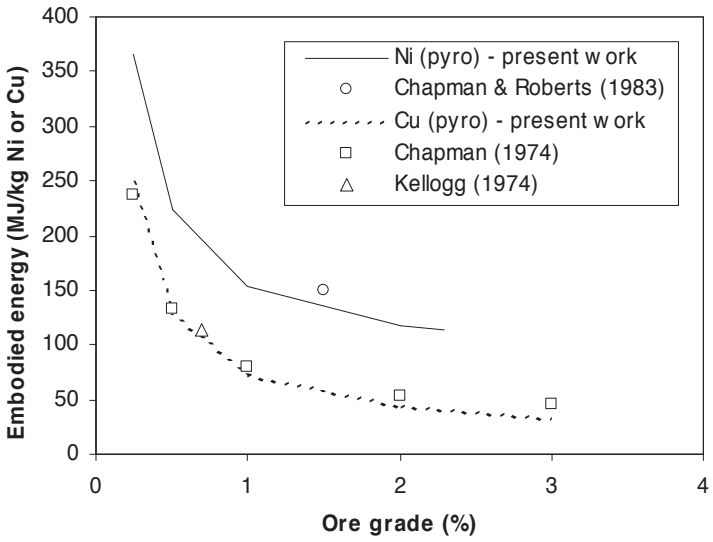


Figure 4: Effect of ore grade on total embodied energy consumption for copper and nickel production. (Source: Norgate et al, 2006[47])

Low carbon opportunities

Renewable energy alternatives. Low carbon energy supply alternatives for onsite operations further enable greenhouse gas reductions. As oil prices increase, the traditional diesel generator is becoming more expensive to run. Combined cycle gas (or liquid fuel) generators are far more efficient and many mines now have access to LNG or pipeline natural gas. Renewable energy is also becoming competitive with diesel fuel, especially where significant lengths of power line would be required to connect to the main electricity supply.[48] A government study[49] recently assessed the viability of renewable energy to contribute to meeting the mining sector's energy needs. It found wind power was already commercially competitive and solar thermal had great capacity to deliver commercially as well. The report identified a range of barriers to adoption including the perception by the industry that renewables are unreliable. The report also found significant potential for renewable energy to complement traditional energy sources for the mining sector.

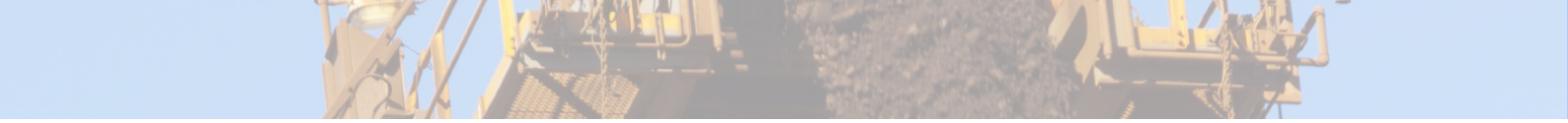
Carbon offsets. A range of major mining companies have also either begun, or are investigating the possibility of, purchasing carbon offset credits in Australia or overseas to offset their carbon emissions and thus reduce their exposure to a carbon price.

Reducing fugitive emissions. At some mines it is possible to directly capture fugitive methane emissions. For instance, during the initial stages of coal mining a highly concentrated stream of methane can be emitted. Some sites capture this methane and use it as combustion fuel. When the methane concentration drops (often to less than 1%) it is possible to use this gas stream as combustion air. Both these actions reduce the amount of methane released to atmosphere as well as offsetting a fossil fuel source.[50] Such measures offer good returns on investment. In their Carbon Disclosure Project reports, Anglo American reported "*Pre and post mining gas drainage allows methane gas to be collected for use in a gas-fired power station (or flared) which reduces fugitive gas emissions as part of the coal mining process. These actions have been taken to comply with Australia's Clean Energy Future initiative. These have a less than one year pay back period and will save annually over $50 million and reduce CO_2-e annually by 2,500,000 tonnes.*"[51]

Growth opportunities from contributing to third party reduction in greenhouse gas emissions. The mining and minerals processing sector has a critical role to play in contributing to the reduction in emissions by third parties through the mining and processing of

- High grade silicon for the production of Solar PV panels
- Iron and steel used to make wind power systems
- Rare earth metals for the production for renewable batteries which are critical to enabling low emission vehicles and for managing the variability of renewable energy systems
- "Light metals" such as aluminium and magnesium which are used to construct light-weight aircraft and other fuel efficient transportation vehicles to reduce greenhouse gas emissions
- Uranium for non-military nuclear power generation.

As such mining companies can position themselves for these growth markets.



The following table summarises many of the key energy efficiency opportunities from the start of the mining process (blasting and digging) right through the mining and minerals processing life cycle (finishing with export of mining and minerals products). For further information on each of these energy efficiency opportunities please see the Energy Efficiency Exchange Mining Sector page at http://eex.gov.au/industry-sectors/mining opportunities/

Table 6: Climate change mitigation strategies

ENERGY EFFICENCY STRATEGIES

UPGRADE THE CONCENTRATION OF THE ORE BODY (BEFORE COMMINUTION) - through resource energy efficient blasting, ore sorting and gangue rejection

It is technically possible to increase the concentration of ore bodies before comminution (crushing and grinding) through:

- Resource characterisation: Investing in understanding and characterising mineral ore bodies enables a 3D geometallurgical model to be created.[52] This 3D geometallurgical model enables the targeting of the highest concentration ore bodies for blasting and extraction and, also enables the use of software packages to optimise "mine to mill" comminution circuit design to maximise energy savings.[53]
- Implement energy efficient blasting to reduce downstream crushing and grinding energy requirements.
- Ore sorting and gangue rejection: Within any ore body there is gangue, or waste rock that can be separated from valuable mineral ore using sorting technologies.

IMPLEMENT AN INTEGRATED ENERGY EFFICIENT CRUSHING AND GRINDING (COMMINUTION) STRATEGY

There is significant potential to save energy in comminution through the following steps:

- Optimising the particle size feed for grinding mills from crushing mills
- The selection of target product size(s) at each stage of the circuit
- Using advanced and more flexible comminution circuits
- Using more efficient comminution equipment.

OTHER ENERGY EFFICIENT STRATEGIES

In addition to these, other energy efficiency strategies to consider are improving the energy efficiency of the following:

- Mineral separation processes (mixers, agitators and froth flotation cells)
- Drying and dewatering in mineral processing
- Undeground mine airconditioning and ventilation systems
- Above ground office and staff accommodation.

IMPROVE ENERGY EFFICIENCY OF MATERIALS MOVEMENT

There are numerous options to reduce the energy intensity of materials movement

- Invest and retrofit electric draglines to make them more energy efficient
- Use overburden slushers (OS) instead of traditional draglines
- Improve haul truck efficiency through lightweighting , travel minimisation, optimised driving practices, maintenance and management
- Replace diesel trucks with hybrid diesel electric trucks
- Use conveyor belts where possible instead of haul trucks
- invest in mobile"In-Pit-Crusher-Conveyor" (IPCC) systems to reduce need for haul trucks where possible

RENEWABLE ENERGY

LOWER CARBON RENEWABLE ENERGY ALTERNATIVES:

Low carbon energy supply alternatives for onsite operations further enables greenhouse gas reductions.

CARBON OFFSETS

Major mining companies have also either begun, or are investigating the possibility of, purchasing carbon offset credits in Australia or overseas to offset their carbon emissions.

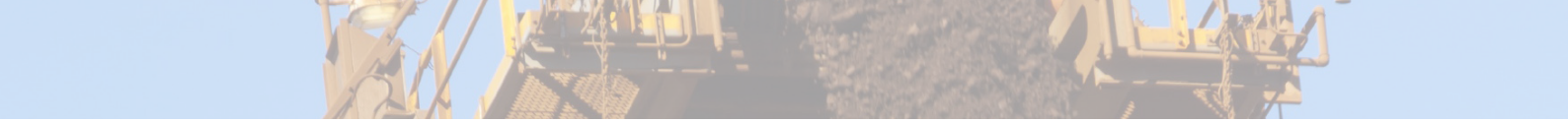
REDUCE FUGITIVE EMISSIONS

In some situations it is possible to directly capture fugitive methane greenhouse gas emissions and burn them to produce energy and reduce overall global warming potential. For instance, during the initial stages of coal mining a highly concentrated stream of methane can be emitted.

THIRD PARTY GHG REDUCTIONS

The mining and minerals processing sector has a critical role to play in contributing to the reduction in emissions by third parties through the mining and processing of high grade silicon for the producton of solar PV panels.

For further information on each of these energy efficiency opportunities please see the Energy Efficiency Exchange Mining Sector page at http://eex.gov.au/industry-sectors/mining/opportunities/



CONCLUSION

Climate change is forecast to increase the exposure of mining companies to weather, energy and carbon price risks. There are however many opportunities open to mining companies to adapt to physical climate change and cost effectively mitigate emissions.

As per the diagram in the *How to use this guide* section at the front of this report, investors can use this guide to understand the risks and opportunities faced by mining companies. The steps investors may wish to follow to incorporate climate risk and opportunity into investment processes include:

- assess company specific exposures for their severity and timeframe, current and future
- assess the company's response to these exposures and opportunities
- adjust company valuation assumptions based on materiality
- engage the company on outstanding exposures and their response.

In order to perform these steps, investors may gather information on the following issues regarding mining and minerals processing company practice:

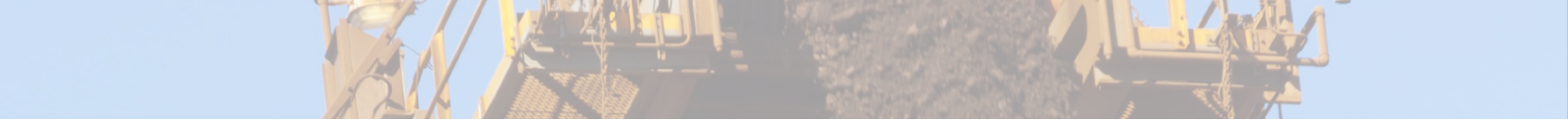
- How does the company assess the changing risk to their assets from climate change?
- Does the company consider it is exposed to the risks identified in this report?
- What level of exposure does the company consider it faces?
- What are the upstream and downstream risks to company operations from climate and energy cost risks?
- Is the company building resilience into its assets to adapt to climate risks? If so how and when?
- Does the company benchmark its energy performance? If so how?
- Which of the energy risk and carbon mitigation measures has the company already implemented?
- What management systems does the company have in place to address the risks identified?
- What does the company see as the priority energy cost and carbon mitigation opportunities for the future?
- How do the opportunities align with future capital expenditure plans?
- What is the company's preferred channel for reporting progress on these matters to investors?

A discussion with a company incorporating these questions and the analysis in this report should provide the basis for a constructive and relevant dialogue.

Investors should be mindful of existing disclosures by companies on climate risk. A similar, but generic list of questions can be found in the CDP annual questionnaire. Investors should refer to the CDP responses of companies to identify answers already provided. Many companies will have disclosed at least some climate risk and opportunity information. CDP company responses can be found at the following link, or investors can contact IGCC for assistance.

https://www.cdproject.net/en-US/Results/Pages/responses.aspx

IGCC will continue its work with members and company engagement partners to support the implementation of this analysis on the mining and minerals processing sector in investment processes. Users of this document are encouraged to provide feedback to improve the quality and relevance of the guide for investors.



KEY RESOURCES

Identifying Climate Change Risks and Cost Effective Adaptation Strategies

Nelson, J et al (2011) Adapting to Climate Change: A Guide for the Mining Industry. BSR at http://www.bsr.org/reports/BSR_Climate_Adaptation_Issue_Brief_Mining.pdf

Acclimatise (2010). 'Building Business Resilience to Inevitable Climate Change'. Carbon Disclosure Project Report. Global Mining. Oxford at http://www.commodities-now.com/component/attachments/download/97.html

Hodgkinson, J.H., Littleboy, A. Howden, M., Moffat, K. and Loechel, B. (2010). Climate adaptation in the Australian mining and exploration industries. CSIRO Climate Adaptation Flagship Working paper No. 5. http://www.csiro.au/resources/CAF-working-papers.html

In addition to this, there are more detailed guides on specific aspects of climate change adaptation such as sustainable water management and flood prevention, available for the mining sector such as listed below.

Water Management Strategies for Climate Change Adaptation

Moran, C., et al (2008) Water Management: Mining – Leading Practice Sustainable Development Program for the Mining Industry, Commonwealth of Australia, Canberra, Australia, at http://www.ret.gov.au/resources/Documents/LPSDP/LPSDP-WaterHandbook.pdf

Minerals Council of Australia (2006) Strategic Water Management: in the Minerals Sector: A Framework, Ministerial Council on Mineral and Petroleum Resources (MCMPR), www.minerals.org.au/__data/assets/pdf_file/0009/17595/Water_strategy_book.pdf

CSIRO's Mining - Climate Change Risk and Adaptation Strategy Assessment Program

CSIRO – Climate Change Adaptation and Mining Program Information - http://www.csiro.au/en/Organisation-Structure/Flagships/Climate-Adaptation-Flagship/adapting-mining-climate-change.aspx

CSIRO – Climate Change Adaptation – Mining – Full List of Reports available from http://www.csiro.au/Organisation-Structure/Flagships/Climate-Adaptation-Flagship/adapting-mining-climate-change/Reports.aspx

For a sample of CSIRO's recent work – see

Hodgkinson, J.H., Littleboy, A. Howden, M., Moffat, K. and Loechel, B. (2010). Climate adaptation in the Australian mining and exploration industries. CSIRO Climate Adaptation Flagship Working paper No. 5. http://www.csiro.au/resources/CAF-working-papers.html

Loechel, B., (2012) Mining adaptation case study report: Learning from the Fortescue Metals Group (FMG) Extreme Weather Events Risk Assessment project, CSIRO EP 126964. At http://www.csiro.au/Organisation-Structure/Flagships/Climate-Adaptation-Flagship/FMG-Extreme-Weather-Events-Risk-Assessment-report.aspx

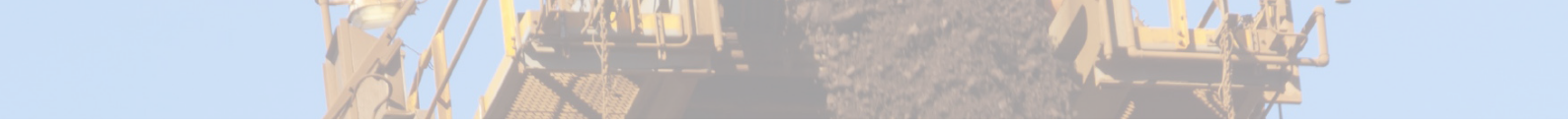
Implementing Climate Change Mitigation Strategies

RET (2012) Energy Efficiency Exchange – Mining Sector – Energy Efficiency Opportunities by Dr Michael Smith (ANU) and Adjunct Professor Alan Pears (RMIT) at http://eex.gov.au/industry-sectors/mining/

ClimateWorks Australia and DRET (2013) Industrial Energy Efficiency Data Analysis – Mining Sector. Information on the energy efficiency opportunity available to the sector, its uptake to date, and some of the barriers to implementation. ClimateWorks Australia and DRET at http://www.climateworksaustralia.com/publications.html

Australian Greenhouse Office and the Minerals Council of Australia (2002) Energy Efficiency and Greenhouse Gas Reduction Best Practice Manual - Mining. Australian Greenhouse Office and the Minerals Council of Australia at http://www.ret.gov.au/resources/documents/lpsdp/bpemenergy.pdf

Coalition for Eco-Efficient Comminution (CEEC) Web Portal – features over 70 relevant and current peer reviewed "Key Papers", "Technical" and "Conference" papers freely available at http://www.ceecthefuture.org/



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3. Commodities Now, 5 March 2013, Floods in Australia: Legal Implications for Commodity Traders

4. http://www.theage.com.au/news/National/Massive-coal-mine-blaze-still-burning/2006/10/13/1160246290407.html

5. Leveritt, S. (1999) Heat Stress in Mining

6. The Climate Commission (2013) Off the charts: Extreme Australian summer heat. The Climate Commission

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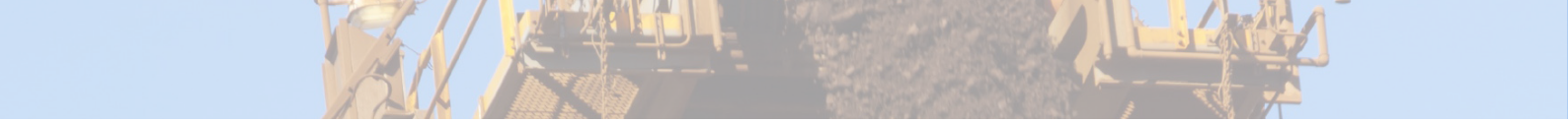

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