Environmental and other effects of mining and transport

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Preface

This report has been produced by IEA Clean Coal Centre and is based on a survey and analysis of published literature, and on information gathered in discussions with interested organisations and individuals. Their assistance is gratefully acknowledged. It should be understood that the views expressed in this report are our own, and are not necessarily shared by those who supplied the information, nor by our member countries.

IEA Clean Coal Centre is an organisation set up under the auspices of the International Energy Agency (IEA) which was itself founded in 1974 by member countries of the Organisation for Economic Co-operation and Development (OECD). The purpose of the IEA is to explore means by which countries interested in minimising their dependence on imported oil can co-operate. In the field of Research, Development and Demonstration over fifty individual projects have been established in partnership between member countries of the IEA.

IEA Clean Coal Centre began in 1975 and has contracting parties and sponsors from: Australia, China, the European Commission, Germany, India, Italy, Japan, Poland, Russia, South Africa, Thailand, the UAE, the UK and the USA. The Service provides information and assessments on all aspects of coal from supply and transport, through markets and end-use technologies, to environmental issues and waste utilisation.

Abstract

Historically coal mining is associated with damage to natural landscapes and the rise and fall of the mining communities which grow up around mine sites. But the sector has grown and most mining companies now act with forward planning and responsibility to minimise potential negative effects on mining land and, in some cases, to leave behind a positive legacy. This study addresses the environmental effects of coal mining and related transport, reviewing the potential environmental impacts arising at all stages of the coal chain. The report summarises the relevant issues in the major coal producing nations. Whilst for some regions the main concern is environmental, social and political issues dominate in others. Potential environmental impacts from emissions of dust, water, and local land use are reviewed, highlighting emerging techniques to limit and reduce negative effects. Automation and remote control of larger, more dangerous equipment reduce risk for mine workers. Many of the major coal mining companies use corporate and social responsibility not only to improve the working conditions of miners on site, but also to reach out into the local population to improve the lives of all those involved in the wider communities which grow and establish around mine sites. Examples of best practice for mine operation, transport logistics and dust control are included to demonstrate the potential for improved performance and environmental sustainability in mining practices. Socio-economic impacts, as well as regional employment and community engagement, are also covered. Permit bonding is required in most regions to ensure that the cost of reclamation is included in the mine plans. However, problems remain at abandoned mine sites in some less developed regions, and funding may be required to complete the reclamation process.

By nature, coal mining involves significant, but temporary, intrusion into the land above and around the coal seams, and along the delivery chain. However, with appropriate environmental impact assessment and responsible working practices, this intrusion is minimised and ameliorated.

Acronyms and abbreviations

BEE	black economic empowerment
CAS	collision avoidance system
CBM	coal bed methane
CCC	Clean Coal Centre
CMM	coal mine methane
CSR	Corporate and Social Responsibility
Db	decibel
DFF	depletion of fossil fuels
EC	European Commission
EGR	exhaust gas recycling
EIA	environmental impact assessment
EITI	Extractive Industries Transparency Initiative, Kazakhstan
EP	Equator Principles
GHG	greenhouse gas emissions
ICMM	International Council of Mining and Metals
IEA	International Energy Agency
LTIFR	lost time injury frequency rate
MPRDA	Mineral, Petroleum and Resources Development Act, South Africa
MRPP	mining risk prevention plan
MSHA	Mine Safety and Health Administration, USA
Mtoe	mega tonnes oil equivalent
NEMA	National Environment Management Act, South Africa
NGO	non-governmental organisation
NMA	National Mining Association, USA
NSW	New South Wales, Australia
OB	overburden
OPC	optical particle counters
OSH	occupational health and safety
PCEPG	Panjiang Coal and Electric Power Group, China
PM	particulate matter
PM_{10}	particulate matter <10 microns
PPP	public-private partnership
PRB	Powder River Basin
PWCS	Port Waratah Coal Services, Australia
SCADA	supervising control and data acquisition system
SCR	selective catalytic reduction
SMCRA	Surface Mine Control and Reclamation Act, USA
SSO	Smith School of Enterprise and the Environment, University of Oxford
UAV	unmanned aerial vehicle
UCG	underground coal gasification
UN	United Nations
UNECE	United Nations Economic Commission for Europe
UNEP	United Nations Environment Programme
US EPA	US Environmental Protection Agency
VIS	vehicle intervention system
WEC	World Energy Council
WRI	World Resources Institute

Contents

List of Figures

List of Tables

1 Introduction

Coal mining is an industry which has employed millions of people worldwide over centuries and has played a significant role in poverty alleviation, industrialisation and economic growth. However, during this time it has also become associated with images of damage to landscapes, noise and air pollution, accidents, and displacement of communities.

Many countries are looking towards using less coal, preferring to focus less on fossil fuels and more on renewable sources. This is having a significant effect on mining activities. Non-governmental organisations (NGOs) and action groups are gaining strength in their opposition to operational and proposed coal mines. For example, Appalachian Voices was one of several local community groups who worked together to sue Frasure Creek Mining for water quality violations at several surface mines in eastern Kentucky, USA. The settlement in 2016 required Frasure to pay US$500,000 to the state. However, if this remained unpaid, US$6 million would be required. Over and above this, neither Frasure nor its parent company, Trinity Coal Corp, are allowed new mining permits unless at least US$2.75 million is paid (Coal Age, 2016). This is, of course, an example of when mining is not carried out within the legal requirements and problems such as this can lead to bad press for the industry. Stories such as this in the news, increase interest in the environmental effect of coal, not just during combustion in power plants, but along the complete fuel chain, from mining through to delivery to the plant. This includes consideration of the state of land prior to mining activity and the question of how this land can be returned to either its original state or to a condition which makes it useful for agricultural, commercial, industrial or social use. Consideration of the whole coal chain must include wider environmental effects of mining activities and must expand beyond the mine itself to reflect regional issues such as employment and social impacts as well as including the effects of transporting the coal via trucks, wagons, trains and ships to its final place of use. NGOs and action groups often raise concerns about the lack of consideration of the whole supply chain in coal production plans. For example, coalaction.org.uk questions the social and environmental implications of coal imported from places such as Russia or South America where environmental laws and human rights may be less stringent than those of the countries which will eventually use the coal.

The United Nations (UN) Economic Commission for Europe (ECE) Committee on Sustainable Development recently noted that "*until recently, social and environmental factors have rarely been considered in the classification of natural resources. Their importance has grown considerably in the last few years. Many projects have been delayed or cancelled because they failed to meet social or environmental expectations, even though they met all other requirements*," (UN ECE, 2017).

Figure 1 summarises the coal chain, along the bottom, from mining through transport to the destination and ultimate use of the coal. At the top of the figure, the organisations involved in these activities are listed. And so, to consider the environmental effect of the coal chain, every activity from mining through to delivery to the plant must be included. The operational practice and the environmental and social responsibility of each of the organisations involved in the chain will play a significant role in determining the overall environmental impact of the complete chain.

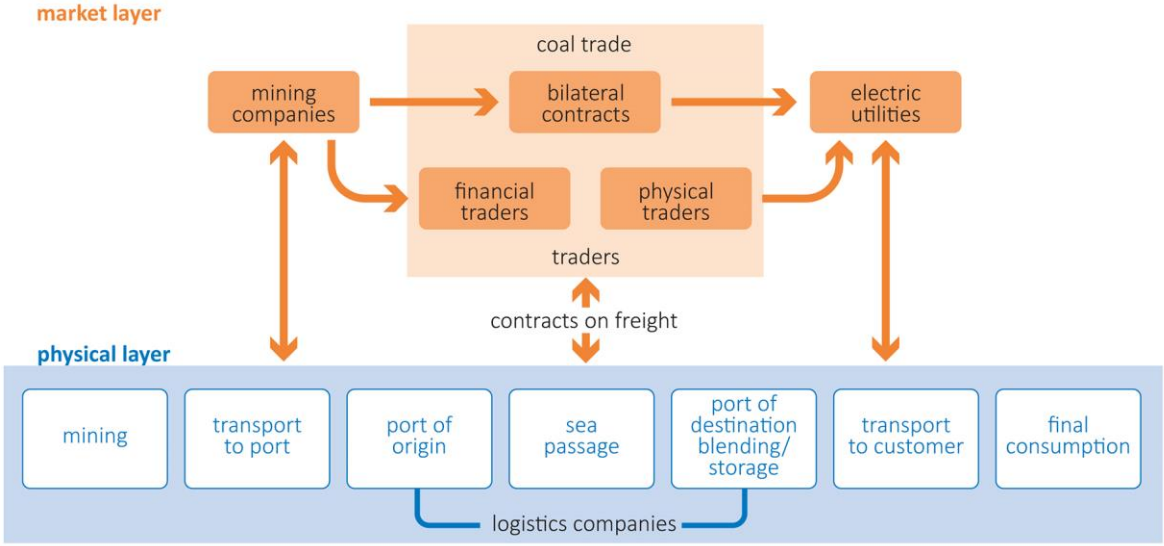

Figure 1 The coal supply chain (Better Coal, 2017)

Figure 2 shows the upstream emissions of greenhouse gas (GHG) emissions from all fossil fuels globally demonstrating that somewhere between 5% and 37% of global emissions from fossil fuel use are from processes prior to combustion. These emissions are from mining and extraction as well as transport and processing. Whilst these data include emissions from oil and gas as well as coal, the contribution from coal is likely to be a significant proportion of the total. The World Resources Institute (WRI, 2017) notes that only around half of the world's largest companies report these emissions or disclose stranded asset or other risk issues to their stakeholders. More forward-thinking companies are working to standardise the estimation and disclosure of this kind of information to demonstrate their commitment to climate issues (Russell, 2017). However, for the moment, there are few data relating to the overall impact of coal mining on emissions globally or even regionally.

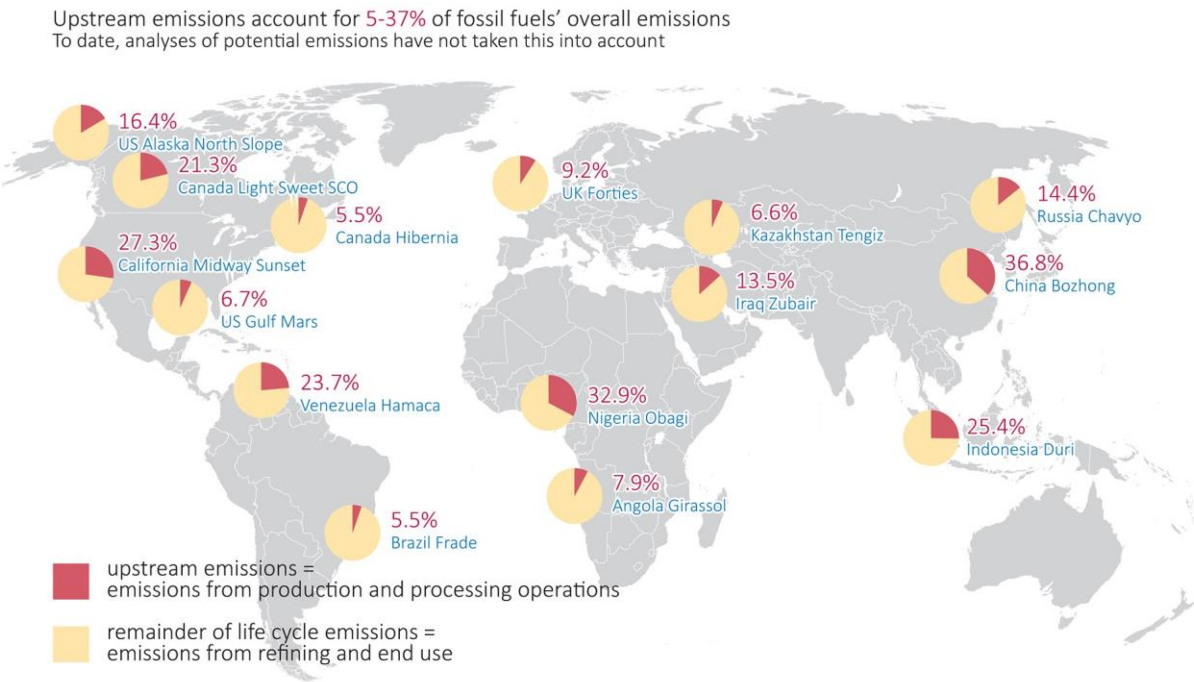

Figure 2 Upstream GHG emissions from fossil fuels (WRI, 2017)

There are few reports which cover the environmental effects of the complete coal chain. There are, however, plenty of data on individual sections of this chain or on individual issues. This report brings together information to consider the complete coal chain from mining to delivery of the coal to the combustion plant. However, the issues that are considered important with respect to mining activities and their effect vary from region to region and therefore Chapter 2 considers the mining activities in the major coal producing nations of the world, highlighting the focus of concern in each. Chapter 3 then looks at the international regulations and guidelines which promote best practice and environmental sustainability in coal mining. Coal mine land conditions before and after mining, including impact assessments and remediation requirements, are summarised in Chapter 4. Emissions and control of dust from the coal mine, through all transport options, to final storage and use is the focus of Chapter 5. Chapter 6 then considers the other potential effects of coal mining, including health issues, noise, economics and socio-economic impacts. Finally, Chapter 7 reviews the requirements for coal companies to step up, demonstrate corporate and social responsibility, and to engage and work with the local community.

2 Overview of major coal exporting countries

In 2016, of the top ten mining companies in the world, five were coal producers – BHP Billiton, Rio Tinto, China Shenhua Energy, Coal India, and Glencore, and, by 2017, Anglo American had also moved up into the list (Els, 2016, 2017). In a study of potential stranded assets, the Smith School of Enterprise and the Environment, University of Oxford (SSO, 2016) listed the top 20 coal mining companies for which coal provided more than 30% of the company's revenue. The information is summarised in Table 1.

Table 1 Summary of top 20 thermal coal miners with more than 30% of revenue from thermal coal (SSO, 2016)

Number	Parent owner	Country	2014 thermal coal revenue, US$ million	Number of mines	Production, Mt (No)	Diversification, % revenue from coal	Projected Capex/EBITDA	Debt/equity, %	Current ratio	EBITDA-Capex/interest	LR-M1 (proximity to populations and protected areas (Rank)	LRH-M2 (water stress) Rank	Asset base, %	NRH-ALL, ** %
1	China Shenua Energy Company	China	14,006	23	305 (23)	35	45	28	1.30 x	7.66 x	9	6	CH-100	31
2	Sasol	S Africa	11,050	6	41 (6)	58	75	22	2.58 x	7.10 x	14	14	SA-100	44
3	Coal India Ltd	India	10,251	13	494 (8)	89	46	1	3.15 x	1728.94 x	2	17	IN-100	31
4	China Coal Energy Company	China	5,966	11	107 (6)	52	201	113	1.36 x	–	6	1	CH-100	31
5	Adani Enterprises Ltd	India	5,068	6	8 (2)	55	28	142	1.08 x	2.71 x	12	15	**Note 1**	38
6	Peabody Energy Corporation	USA	4,890	28	232 (28)	72	31	481	1.02 x	0.23 x	16	13	AU-39 US-61	49
7	Inner Mongolia Yitai Coal Co Ltd	China	3,397	13	51 (13)	85	282	109	1.63 x	-6.26 x	10	5	CH-100	31
8	Yanzhou Coal Mining Co Ltd	China	3,045	23	73 (19)	31	150	119	1.21 x	-1.34 x	8	7	AU-43 CH-57	42
9	PT Adaro Energy TBK	Indonesia	2,909	4	56 (4)	91	23	49	2.10 x	5.34 x	13	19	ID-100	44
10	Alpha Natural Resources	USA	2,837	3	84 (3)	66	163	141	0.40 x	-0.28 x	19	9	US-100	44
11	PT United Tractors	Indonesia	2,826	1	6 (1)	66	39	7	1.90 x	105.39 x	20	20	ID-100	44
12	Banpu Public Company Ltd	Thailand	2,638	10	39 (9)	85	69	156	1.23 x	1.38 x	7	10	ID-70 CH-30	40
13	Arch Coal	USA	2,350	12	264 (11)	80	32	-849*	2.66 x	0.59 x	18	8	US-100	44
14	Yang Quan Coal Industry (Group) Company Ltd	China	2,337	25	13 (4)	70	113	–	–	–	5	1	CH-25	31

Table 1 – continued

15	Pingdingshan Tianan Coal Mining Company	China	2,324	10	6 (1)	45	–	114	0.85 x	-0.34 x	21	26	CH-100	31
16	Shanxi Lu'an Environmental Energy Development	China	2,301	5	30 (5)	90	162	69	0.89 x	-2.66 x	3	1	CH-5	31
17	Alliance Resource Partners	USA	1,861	13	41 (11)	100	29	92	1.01 x	18.26 x	17	18	US-13	44
18	The TATA Power Company	India	1,741	3	27 (1)	31	19	95	0.69 x	2.40 x	1	11	ID-3	44
19	Indo Tambangraya Megah TBK Pt	Indonesia	1,600	6	29 (6)	94	39	0	1.88 x	121.77 x	4	12	ID-6	44
20	Consol Energy Incorporated	USA	1,356	5	32 (5)	46	67	76	0.52 x	-1.11 x	15	16	US-5	44

Note 1: ID-17%, AU-17%, IN-66%;

* companies are ranked by exposure with 1 being the most at risk

** NRHs (national risk hypothesis) have been aggregated to a single outlook percentage based on the sum of high risk (+2) and medium risk (+1) evaluations relative to the maximum possible and weighted by asset locations.

The companies listed in Table 1 are not necessarily the largest coal mining companies but rather the companies with the greatest reliance on coal production for their revenue. The largest coal mining companies, although based in a home country, often have mining activities over several continents. Three of the world's largest coal mines are in the USA, two are in China and two are in Australia. The largest ones are (Mining Technology, 2013):

- North Antelope Rochelle, Powder River Basin, USA – this Peabody mine has reserves estimated at 2.3 billion tonnes. It consists of two mines, North Antelope and Rochelle, which have been combined since 1999. The mine is alleged to produce the cleanest coal in the USA (the coal quality averaging 8,800 British thermal units per pound (Btu/lb; 20,500 kJ/kg) and sulphur content as low as 0.2%);
- Haerwusu, China – a Shenhua (state-run company) opencast mine with 1.5 billion tonnes of reserves;
- Hei Dai Gou, China – another opencast mine owned by Shenhua with reserves of 1.5 billion tonnes of low sulphur coal;
- Moatize, Mozambique – the opencast mine, owned by Vale (Brazilian mining company) with estimated recoverable reserves of just under 1.5 billion tonnes;
- Black Thunder, Powder River Basin, USA – a surface mine with 1.47 billion tonnes of reserves run by Arch Coal;
- Peak Downs, Australia – 1 billion tonnes of reserves in an open-cut mine run by BHP Billiton;
- Mt Arthur, Australia – another BHP Billiton open-cut mine with 1 billion tonnes of reserves;
- Caballo, Powder River Basin, USA – 800 million tonnes (Mt) of surface mined coal owned by Peabody Energy;
- Raspadskaya, Russia – 782 Mt of underground coal run by Raspadskaya; and
- Cerrejón, Colombia – 754 Mt of open-pit coal owned in joint venture by Anglo American, BHP Billiton and Glencore Xstrata.

The list emphasises the fact that many coal mines are owned by companies from other nationalities – for example, the US ownership of mines in South America, the South American ownership of mines in Africa, and, not included above, Australian mines owned by Indian and Chinese companies. This adds to the complexity of how each mine is run. When a mine is proposed, it must respect the laws and regulations of the local and national authorities. However, there will also be a layer of company practice that will reflect the company itself and how it regulates its own performance, much of which may be based on national issues pertinent to the country where the company has its headquarters. Company health and safety practices are often developed over time and may well show some regional differences. It is perhaps not surprising, then, that strategies for environmental issues and sustainable development will vary from company to company, from region to region, and even from mine to mine.

2.1 Coal production and export by country

Figure 3 shows the coal production per country as collated by the WEC in 2015. Recently, China has been by far the largest producer of coal. However, as discussed later, the country's attitude to coal and coal mining is changing dramatically (WEC, 2017).

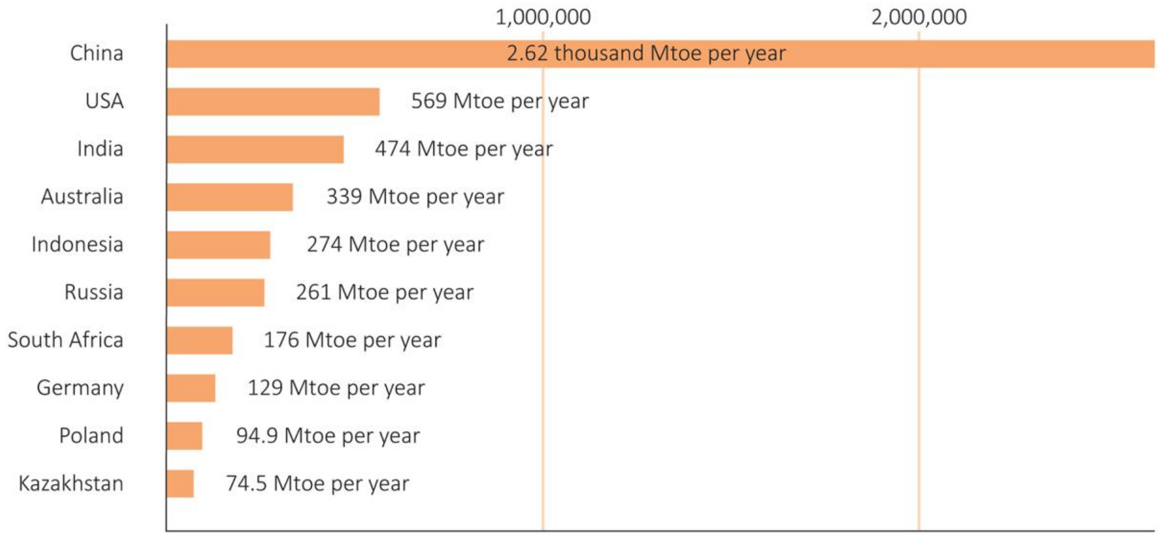

Figure 3 Top coal producing countries (WEC, 2017)

The data in Figure 3 relate to the total production of coal. This includes coal used domestically as well as coal exported. Below, in Table 2, are the 15 countries that exported the highest dollar value worth of coal during 2015 (Workman, 2017).

Table 2 Coal exports by country in 2015 (Workman, 2017)

Country	Value of export, $ billion	Per cent of world total
Australia	28.4	36
Indonesia	16.4	20.8
Russia	9.3	7.2
USA	5.7	7.2
South Africa	4.3	5.4
Colombia	4.3	5.4
Netherlands	3	3.8
Canada	2.7	3.4
North Korea	1.1	1.4
Poland	0.732	0.9
Mongolia	0.542	0.7
China	0.498	0.6
Czech Republic	0.328	0.4
Vietnam	0.265	0.3
Belgium	0.232	0.3

Currently Australia is the largest exporter of coal, producing 36% of the world's coal import requirements. Indonesia produces over 20% and the remainder is made up from countries such as Russia, the USA and South Africa. The sections to follow look at the challenges of coal production in each of the top ten coal producing regions in more detail.

2.2 Challenges in the top ten coal producing/exporting regions

Mining activity changes the landscape and the environment around it. It is also a source of significant revenue and a major employer. Coal provides energy security and cost-effective power for many economies. However, the economic and energy security benefits of coal production can be offset to varying extents by environmental and social costs. According to Frantal (2016), the coal industry has been frequently associated with the 'resource curse' whereby regions where development has been heavily dependent on extraction of minerals and fossil fuels are characterised by economic vulnerability, demographic instability, negative health and socio-economic impacts, increasing geographic isolation, imbalances of scale and power with respect to extractive industries and the absence of realistic alternatives for diversified development. Impacts on the environment and local communities are particularly evident in developing countries where public property and procedural rights are limited. Although this is mostly reported for regions such as Africa or Asia, Frantal stresses that displacement and resettlement issues are also continuing in some regions of eastern Europe.

The following sections summarise coal mining activities in the major coal producing nations around the world and, where possible, include details of regional issues as well as relevant legislation and actions taken to minimise the impacts. The countries are covered in order of scale of coal production, as shown in Figure 3. Direct comparison of mining activities and issues in each region is not possible since each country is unique and the focus of 'concerns' around the mining industry vary. Whilst some countries are forward thinking with respect to land use and reclamation, others focus more on employment, or water issues, or on socio-economic concerns. The following sections demonstrate these variations and reflect the information in the published literature relevant to mining in each region.

2.2.1 China

During the 1980s, small-scale coal mining operations in China proliferated and left a problem of local pollution and environmental legislation enforcement challenges. The Chinese government has reduced small-scale mine operations and closed 1725 mines during 2014 alone. The government would prefer coal mining to be consolidated into large scale and remote 'coal bases' than scattered over small sites. At the end of 2015, the Chinese government issued a moratorium on all new coal mines and, between 2016 and 2018, there will be no new mines approved. Over and above this, a further 1000 mines were to close by the end of 2016. China's Xianjiang region had closed 112 coal mines by the end of October 2017, representing 98% of the northwest region's target for the year (Reuters, 2017c). The new actions to reduce water stress in the country may have further effects on any existing and new coal mining activities (SSO, 2016).

Laws relating to mining in China are extensive. A summary, provided by China Mining (China Mining, 2017) lists legislation relevant to work safety, tax, environmental protection, waste management, land use and mineral resources and the interested reader is referred to the China Mining website for further information www.chinamining.org/policies.The Chinese government has tightened legislation in all areas of the energy sector. In 2011, the '12th Five-year development plan for the coal industry' and 'Opinions of energy conservation and emissions reduction work in the coal industry' were published. These two directives prescribe emission standards for all medium- and large-sized coal enterprises. Energy savings goals in the mining industry concentrate on: organisation, system, management, technology, talent, and capital, and attempt to incorporate ideals of a 'circular economy' where waste is minimised and recycling promoted.

Yu and others (2017) introduce the ways in which Chinese coal companies comply with the 12th Five-Year Plan (FYP) in terms of improving efficiency and performance while reducing emissions. The study focused on options for improving mining efficiency in Chinese coal mines, considering investment in state-of-the-art equipment and techniques. This can be achieved in such a way as to reduce energy consumption and pollutant emissions but also increase profit if a multi-objective decision-making approach is taken. Yu and others (2017) created a mathematical model aiming to maximise mining profits with the lowest possible levels of energy consumption and emissions. The complex model included:

- use of emissions as raw materials in the production of auxiliary products to improve efficiency (such as use of coalbed methane or waste coal for energy production as well as the more efficient use of diesel and oil on the mine site);
- modification of techniques or equipment;
- enhanced construction of environmental facilities dealing with waste streams; and
- enhanced management and monitoring of energy consumption and pollutants.

The model was used to assess the situation at the Chaohua coal mine in Henan Province. By considering the approaches proposed in the mathematical model, the mine, with an annual production rate of 2 Mt, could achieve significant improvements in energy efficiency whilst simultaneously reducing emissions. For example, gasoline use per unit of coal produced (for transport) could be reduced by 42% and diesel use (for on-site machinery) could be reduced by 32%. At the same time, SO_2 emissions could be reduced by 36%, mine water production reduced by 82%, and coal waste reduced by 87%. All this could be achieved whilst improving profitability at the mine. Although few data were included on the status of the case study mine and how possible it would be to use the algorithm in practice is open to debate, modelling has the potential to improve production and reduce emissions from mining activities.

Many regions in China have been severely damaged by historical mining activities and some companies are acting to remediate the issue. The Beipan River in Western China has been the site of many mines, not just coal, and has been heavily polluted since the 1990s. The region has been working towards sustainable development since 2000. The Panjiang Coal and Electric Power Group (PCEPG) has become the largest coal mining group in China since the 1970s with over 50,000 employees. Many of its mines, together producing over 30 Mt/y, feed into tributaries of the Beipan River. By 2012, PCEPG had established 54 pollution control projects and built 40 more pollution treatment facilities. Water quality has improved such that the river, which used to run black with contaminants, is now clear with thriving fish populations. Coal wastes, which were previously left in huge discarded piles, are now treated and used to generate electricity, offsetting coal use and clearing unsightly areas. PCEPG has built 3 full-scale power plants to turn the waste material into power (90 MW total capacity). Sludge from the coal mines is used in an on-site brick factory saving on shale rock and other natural materials. Coal mine methane from the PCEPG mines is fired at 15 coalbed methane plants, reducing CO_2 emissions by up to 1.2 Mt/y. PCEPG has also invested in projects related to anti-poverty, school education, village development and dealing with natural disasters (Yu, 2017).

Yu (2017) suggests that China's central government has undergone a transformation towards ecologically sustainable development from the late 1990s onwards, reflected in the huge numbers of laws and policies which have been established since then. New mining standards are more rigid and any mining companies not in compliance will be forced to close. Corporate social responsibility (CSR) and public outreach are reported to have played a major role in educating the public and raising awareness of environmental issues, as exemplified in the case of PCEPG discussed above. Public pressure to improve the environment is growing. However, Yu (2017) suggests there are still problems to be addressed in the move towards more sustainable mining in China:

- lack of post-decommission management, poor pollution control and poor waste management at many older mines. The Chinese government does not charge fees for mine closure and many mines are abandoned with no consideration of remaining waste and water issues;
- recycling of coal mine wastes is minimal and many mines are too small to consider re-use or recycling as economically viable;

- mine backfill is incomplete due to a lack of suitable technologies. This leaves a major problem with subsidence at old, closed mines. Coalbed methane leakage from abandoned mines remains a problem; and
- socio-economic and environmental pressures are growing which cause a reduction in the market for coal. This has led to slower production at some mines and closure of others, often with a lack of investment in remediation.

The Chinese government has recently decided to cut its coal capacity by 500 Mt by 2020. This could leave 1.3 million coal mining industry workers unemployed and, according to Yu (2017), could lead to new social and economic issues in some communities.

With respect to safety, China has a poor past record, with Chinese mines claimed to be the most dangerous in the world. Illegal mining activities were a large part of the problem. There are over 5.8 million coal miners in China compared to around 80,000 in the USA. But standards and practices have been improving and the measured deaths per 100,000 coal miners in China was 16 in 2013, similar to the value of 20 for the USA in the same year (Economist, 2015). The new Chinese plan for the closure of smaller mines, discussed above, is expected to improve safety by coordinating activities in larger, more efficient, mines. Between 2010 and 2015 the death toll from coal mining incidents dropped by 75% to 598/y. The plan is expected to reduce fatal accidents in mines by >15% by 2020 (Reuters, 2017d). Fines have been introduced to enforce coal mine safety and almost 4,000 penalties (amounting to the equivalent of $50 million) were imposed in 2017, up by over 93% from 2016 (Xinhuanet, 2016).

2.2.2 USA

Underground coal mining is giving way to surface mining in the USA with many coal companies also diversifying into oil and gas (SSO, 2016). The USA is home to some of the largest in the world – 10% of all US coal production comes from the Powder River Basin (PRB). The PRB area has the largest, most accessible mines in the world producing some of the most economical coal. The Clean Air Act Amendments of 1990 required the use of low sulphur coal at many plants and the coal from the PRB was perfect for this growing market.

The local community has raised concerns over the effect of mining in the region, including issues with displacement of native herds of bison along with the grazing lands used by cattle (Braasch, 2013). Trucks carry 200 t of coal each, transferring the coal to trains up to 150 carts long with up to 100 trains loaded daily and claims have been made over elevated dust concentrations (Braasch, 2013). New techniques used to reduce dust at this site are discussed in Chapters 5 and 7. In April 2013, twenty-one environmental groups asked for an immediate moratorium on new coal leasing in the PRB. New regulations in 2014 require better water management and monitoring. Interestingly, renewable energy has also received local objections and a wind farm nearby was fined US$1 million for bird kills at two wind turbine arrays (Braasch, 2013).

The mining industry is required to reclaim land after mining activities, but this activity is state controlled. And so, although the SMCRA (Surface Mine Control and Reclamation Act) requires coal companies to self-bond to cover the cost of remediation, individual states may disallow this practice. (A 'self-bond' is a legally-binding promise without separate guarantee or collateral and which is therefore only permitted to companies which pass certain financial tests). The self-bonded miners are a liability in many states where the local government is obliged to remediate damage if the company goes bankrupt (SSO, 2016). The National Mining Association (NMA) has urged the US Congress to step in to change current practice on reclamation and the associated funding. Of the US$11 billion paid into the Abandoned Mine Lands fund since it began in 1977, only US$2.8 billion of the US$8.5 billion spent to date has resulted in the reclamation of mine sites. The problem is reported to be due to issues with the programme structure and the diversion of 'substantial sums to non-core activities' (CoalAge, 2017a).

The current focus on mining in the USA centres on President Trump's aim to create employment for coal miners. During the Obama administration, the amount of electricity produced from coal in the USA fell from 52% of the total to 30%, 411 coal-fired power plants closed and more than 50 coal mining companies went bankrupt. The coal mining sector employed 98,505 people in the USA in 2015, significantly fewer than at the beginning of Obama's presidency (127,745). Although President Trump aims to restore many of those jobs, Murray Energy, the largest privately-held coal mining company in the USA, believes that much of the employment was lost to technology rather than legislation. Competition from cheaper natural gas and renewables is also an important factor. It is unclear if there will be a resurgence in coal mining soon (Rusche, 2017).

2.2.3 India

India is preparing to open its large coal reserves to foreign mining companies. This is part of the programme to bring access to electricity to an additional 300–400 million people within the next five years (Goldemberg, 2014). Coal is currently the cheapest source of electricity in India and will remain so for at least two decades. Imported coal is twice as expensive as indigenous coal. Most coal in India is surface mined (Garg, 2017).

In February 2015, the Indian Minister of Finance proposed to double the coal levy to 200 INR/t (3.10 US$/t) to increase the National Clean Energy Fund. Privatisation of coal mining met with labour resistance in 2015 (SSO, 2016). Coal mining activity in the country is still expanding – Coal India plans to increase coal production to 1 billion tonnes per year by 2020. However, to achieve this growth, the environment ministry has exempted mining companies from engaging in public hearings. For this to be acceptable in terms of due diligence, there must have been a previous public hearing for the lease area and provision that the mining plan, including the closure plan, forest clearance work, and other operational requirements are approved by the Central Ground Water Authority. The exemption eases pressure on mining companies and speeds up the approval process; NGOs are concerned that it will lead to further environmental issues (Aggarwal, 2017).

Coal India plans to close around 100 non-profitable mines over the next 2–3 years, as well as some high-risk ones (Sengupta, 2017). An annual safety audit of all mines is required which will grade them into high, moderate- and low-risk categories. Safety standards are reportedly tightening following an opencast mine collapse in 2016 which claimed 18 lives in the eastern coalfields of Lalmatia (IT, 2017).

Adani, an Indian coal mining company, plans to expand operations in the Hasdeo-Arend region of Chattisgarh which could mean the removal of five villages to make way for the new mines. Although the lands of the 'Adivasis', the Indian tribal people, are protected under the Indian constitution, these rights are in conflict with coal expansion plans. Although the land was previously protected, and the Indian Environment Ministry had declared the region a 'no-go' area for mining, this decision appears to have been overridden in 2011 with the approval of the PEKB mine. The argument appeared to be the 'overriding economic interest' in the expansion of coal production and use. However, in 2014 the National Green Tribunal overturned the permission for the PEKB mine and priority was given to the preservation of the habitat of elephants in the region. Adani is currently appealing the decision in India's Supreme Court (Morton, 2016).

Goswami (2013) studied the effects of coal mining on the local environment at two coalfields: – the Raniganj coalfield in West Bengal, in the Damodar valley near the Asansol industrial belt; and the Jharia coalfield in the Dhanbad, 260 km from New Delhi. It is estimated that mining activities in the Damodar area alone have led to the loss of over 5.5 million hectares (ha) of farmland. Subsidence around the mines in the Jharia and other coalfields have led to irreparable damage to houses, railway lines, roads, paddy fields and surface water sources. The number of farmers in the Safgram area has decreased from 4103 in 1971 to 1753 in 2004, largely due to the reduction in agricultural land. The Jharia coalfield is reported to have significant problems due to the failure of pillars and underground fires leading to the subsidence of 4000 ha of land prior to 1988. This is expected to remain an issue for years to come. There is reportedly no specific legislation in India relating to subsidence and its control.

Goswami (2013) states that the dust pollution in the coalfield regions is by far the greatest health issue and, although the miners receive health support, residents do not. In the Jharia coalfield, around 47% of the particle load in the atmosphere comes from the movement of vehicles in the area with only 6% or less coming from the mine itself. This dust issue could be largely resolved using the techniques and technologies discussed in Chapter 5. Goswami also suggests that local wildlife is reduced around Indian coal mines due to hunting by mine workers, disturbance of local habitats, noise menace and urbanisation, as well as loss of forest cover.

Over 27% of coal-bearing areas in India are under forest and, of this, around 123 ha of forest land provides 1 Mt of coal. Coal is mined in 14 states within India including Chhattisgarh (21%), Jharkhand (20%) and Odisha (19%). Most of the mines are in areas of tropical dry deciduous forests (70%) and tropical moist deciduous forests (24%). Coal mining companies are required to replace trees and create plantations upon completion of mining activities. However, loss of forest land is expected to increase from 75,934 ha in 2013-14 to 191,881 ha by 2032. Coal companies may reforest some of these areas, improving tree density, as well as creating plantations over further land areas surrounding mined land. Figure 4 shows the impact of coal mining on forests in India, assuming the coal mining companies continue to replant trees. Although land converted to coal mines, in blue, will increase, it is also suggested that afforestation could occur over both mined and degraded forest land but also in non-forest lands, leading to increased forest coverage. This could require significant stakeholder engagement as well as community involvement in maintaining these new forest lands (Garg, 2017).

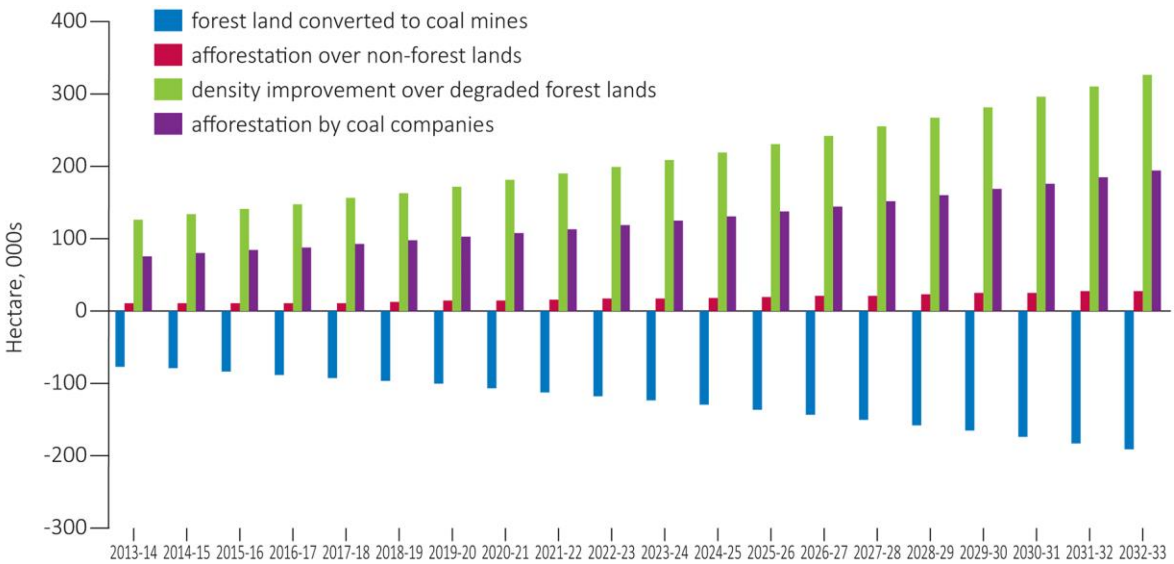

Figure 4 Potential impact of coal mining on forests in India (Garg, 2017)

Protests against mining activities in India are increasing in frequency with 'many' opencast projects delayed due to community resistance, especially in West Bengal (Goswami, 2013).

2.2.4 Australia

Australia's 2015 Energy White Paper states that the country plans to be a 'global energy superpower' and export coal for decades to come. In 2013-14, 88% (375 Mt) of the country's coal was exported. Three quarters of this production is by the major transnational corporations – Peabody, BHP Billiton, Rio Tinto, Glencore, Anglo America and Mitsubishi (Connor, 2016). Peabody has three mines in Australia with the world's second largest reserves of coal. The company has ramped up production by 37% since 2000, although this has been made possible through government support (Goldemberg, 2014).

This promotion of coal production has led to significant disagreements between land owners and mining companies with issues of health, employment, state revenue, economic growth and sustainable development all heavily contested. According to Connor (2016), policies and legislation relating to mining have become more centralised at the state government level and less at the local level. The Environmental Planning and Assessment Act has been amended many times since its publication in 1979. The original Act prioritised economic growth and social welfare through environmentally responsible development of natural and manmade resources and allowed for community participation in proposed developments. However, over the years there has been a loss of local and stakeholder control over resources. Recent amendments to the Act have limited the influence of public submissions, reduced the scope of objections, and limited the basis for appeals and civil enforcement procedures. Overall the movement seems to be towards more ministerial control. Despite this, public action, demonstrations and conflicts continue to grow with blockades at proposed coal mines becoming more frequent.

In March 2016, Adani Enterprises (an Indian company) were held responsible for a coal spill during a cyclone which caused wetlands near the Abbot Point port in Queensland, Australia, to turn black. Adani was about to make a final investment decision on the development of the AUS$16.5 billion Carmichael coal mine which would supply Australian coal to India, shipped via Abbot Point. Some blame was pointed at the regulators who could arguably have set tighter rules in the flood-prone area. But activists have been fighting the development of the Carmichael mine for over six years and the decision on this project is regarded as an important indicator of the future of the global coal industry and the effectiveness of divestments. If active campaigning and withdrawal of funding is successful in convincing the government to block the mine or Adani to cancel their plans, then it could provide impetus for further anti-mining activities elsewhere (Smyth, 2017). Protests were ongoing in the first half of 2017 but Adani hopes to have financing secured by the end of 2017 (FT, 2017). Deutsche Bank has refused to fund the project, claiming that there was no consensus over the environmental impact of the port development and associated dredging (CoalAge, 2014). Much of the concern focuses on the shipping route which crosses the Great Barrier Reef. Public protests continue and a reported three million Australians have expressed concern over the project (Passmore, 2017). Mining People International, a human resources organisation, has summarised the major issues around the proposed new mine (MPI, 2017):

- The mine will comprise both opencast and underground mines, covering around 30,000 ha, produce around 25 Mt/y and cost around AUS$16.5 billion to establish and operate.
- Adani has been accused by protestors of historical 'destruction, corruption, and criminal activity' but, in India, it is regarded as one of the most trusted brands.
- There is disagreement as to how many jobs will be created, with numbers varying from 1500 to 10,000.
- Aside from the large and vocal protests against the mine, Adani has had issues with securing bank funding. The Australian government has offered to provide a loan for the construction of a railway between the mine and the port but further funds are necessary to proceed with the mine.
- Protesters suggest the new port and shipping route threatens Australia's Great Barrier Reef, but it has received Australian Environment Ministry approval and survived a High Court Challenge on these issues.
- Many argue that the mine is vital for India, in terms of coal supply for the country's growth, and will bring significant royalties for the Queensland government.

Although Adani seems convinced that the project will be successful, at the time of writing this report (Dec 2017) two further Chinese banks had refused to invest in the project leaving Adani with no financial support, despite the project having been approved by federal and Queensland state governments (Economic Times, 2017).

Despite the increased protests against new mines, some of the existing mines in Australia have state-of-the-art environmental controls in place and continue to improve performance to meet tightening requirements. In 2015 the Australian Minister for the Environment called for an independent review of rail coal dust emissions and management practices in the New South Wales (NSW) coal chain. This was in response to public concern over dust concentrations in the Hunter regions from coal trains connecting NSW coal mines to the Port of Newcastle. The expert review on the subject concluded that, although a 'substantial set of activities' had been undertaken to measure emissions and reduce dust, the information gathered was sporadic and partial. Thus, it was recommended that a network of dedicated monitors be established in the area to provide real-time monitoring to demonstrate background levels as well as to identify areas of concern. In addition, dedicated monitors along the rail corridor and near known sources of emissions were also recommended. It was also advised that all data should be made available to the public (O'Kane, 2016). Dust issues are considered in more detail in Chapter 5, with case studies of best practice from the NSW project.

2.2.5 Indonesia

Indonesia is the world's largest exporter of coal, most of which is shipped to China. Between 2012 and 2015 the coal and mining industry was subject to a series of reforms. Foreign ownership is limited and progressive divestment is required throughout the mine's operational life. There is an export ban on raw materials so processing must occur within the country. It is hoped that this will stimulate economic development in Indonesia. A cap on total coal exports has also been imposed (SSO, 2016).

Unlike many other regions, the Indonesian coal mining sector has the backing of the government and therefore faces fewer challengers and objections to its expansion (Floyd, 2017).

The coal mining industry in Indonesia is fragmented with only a few big producers and many small mining companies working mainly in Sumatra and Kalimantan. The sector is profitable since reserves are abundant and the emerging markets of China and India are relatively nearby. The Indonesian government requires coal producers to reserve some of their production for domestic consumption and can adjust the export tax to discourage exports when required. Coalbed methane has received interest recently (II, 2017).

Mongabay, an environmental action group, suggest that 2522 mining permits do not fulfil what are known as 'clean and clear' standards for mining in the country. Further, it is estimated that 74 Mt of coal were extracted illegally from small mining operations in 2013 (Mongabay, 2017). Although Indonesian mining regulations require the reclamation of mining land as part of the mining licence, many companies simply abandon closed mine sites with little or no remediation or safety treatment. Of the 856 licence holders in East Kalimantan in 2015, only 338 had reclamation guarantee funds in place and only 96 had deposited these funds in advance. East Kalimantan has hundreds of abandoned open-pit coal mines, filled with acidic water, which are neither closed-off nor have any associated remediation plans. Between 2011 and 2016, 27 people were killed in abandoned mine pits in the region (Apriando, 2017).

Figure 5 Untreated lake in a former coal mine pit (Apriando, 2017)

Figure 5 is an example of a site where a coal mine has been closed and abandoned by the mine owners, leaving the area to flood. Although the locals see this as a potential fishing ground, the land may still be unstable and the effect of leaching from abandoned coal, waste and topsoil material on water quality and potential toxicity to the fish stocks has not been evaluated.

2.2.6 Russia

The Russian coal industry employs around 151,000 people with 500,000 more in energy related industries. There are 32 industry-based towns with a total population of 1.5 million. There are 169 coal mining companies, 107 performing open-pit mining and the remainder have deep mines. Efficient production has become the focus of most of these companies to keep costs down and sales competitive (Uzhakhov, 2016).

According to Slivyak and Podosenova (2013) mining 'cities' such as Vortuka, and Novokuznetsk suffer from extreme dust pollution from blasting and other mining activities. Rivers in the Kemerovo region are described as 'polluted' and 'very polluted'. Up to 6 ha of land are disturbed per tonne of coal produced, with some regions such as Kemerovo showing ten times the national average for total land disturbance.

As is the case in China, coal mining has historically not had a good safety record. According to Kazanin and Rudakov (2016), "occupation safety level in the Russian coal mining industry still causes great anxiety". During 2014 there were eight incidents at Russian mines, two of which involved multiple casualties, making a total of 26 fatalities in the year. However, in the same year (2014), fatalities in the coal mining industry in Russia fell to 0.07 per 1 Mt of coal produced, similar to rates reported in the EU, and these two statistics presented together suggest that Russia has previously had an above-average history of mining casualties. Improved occupational health and safety (OHS) measures have been implemented throughout the Russian mining industry with a Zero Accident Vision corporate programme. The programme also concentrates on Lost Time Injury Frequency Rate (LTIFR) and includes improved mining strategies as well as training programmes for mine workers. The joint coal company Yuzhkuzbassugol and Evraz have a zero fatalities and severe injuries initiative and, during the 2005 to 2014 period, accidents fell from 27 to 8/y and fatalities from 107 to 26/y. However, a series of methane explosions in Vorkuta in February 2016 claimed 36 lives and negated the improved safety record (Heyman, 2016). Coal mine safety records and action plans for different countries are discussed in more detail in Chapter 6.

2.2.7 South Africa

Coal is the primary source of energy in South Africa and it is also an important source of liquid fuels. Coal mining and production stagnated somewhat between 2004 and 2014 but is expected to increase significantly, with the opening of up to 43 new mines by 2018 (Mathu, 2014).

The mines are largely owned by BHP Billiton, Anglo Coal, Glencore, Sasol and Exxaro as well as the black economic empowerment (BEE) companies or junior miners. The five leading companies produce over 80% of the coal and the remainder is from the junior miners. The Chamber of Mines liaises between the mining companies, the labour unions and the government. Mathu (2014) proposed that a public-private partnership (PPP) model would enhance collaboration and integration of these major players, focussing on:

- improved communication;
- faster interpretation and implementation of policy;
- streamlined coal transportation and logistics; and
- enhanced sustainability.

President Zuma has called for radical economic transformation within the country and has established a charter to ensure the fair sharing of the benefits of the South African economy among the black population. Within this there is the requirement for at least 30% of the mining industry to be owned by black investors by mid-2018. However, there has been an industry backlash, including the threat of legal action, by mining companies who feel this may lead to divestment across the industry. Another proposed requirement that mining companies must buy 70% of their equipment from black-owned companies within the country could reduce profit margins in companies already struggling to remain in profit (Hume and Cotterill, 2017).

The South African coal mining business model has three main stages: source (coal mining and beneficiation), transportation and customers or consumers. Mathu (2014) carried out interviews with employees in all areas of the coal business in South Africa and produced four major policy recommendations:

1. The coal mining industry needs to move from internal focus to cross-enterprise collaborations.
2. An integrated strategy is required to facilitate communication between the major industry players.

3. Long-term plans are needed for skills development and to identify and reduce potential skills deficiencies.
4. There should be a shift from road to rail transport to reduce environmental degradation by trucks (rail transport tends to be more efficient and removes coal transport from more populated areas).

Eskom consumes around 50% of the coal produced in the country for power production. The power crisis in the country between 2007 and 2008 resulted in coal stockpiles at power stations. The coal then deteriorated due to ageing and weathering. Coal transport by road had to be increased to resolve this issue which reportedly affected the environment (in terms of dust and noise) in the Mpumalanga area where most of the coal plants are located. Around 70% of the coal transported within the country travels by conveyor belt, 24% by road and 6% by rail. The current aim of Eskom is to reduce the transport by road and increase that by rail since it is considered more economic, safe and sustainable. Issues with inadequate rail wagons were reported prior to 2014 but these issues may have been resolved. Originally plants such as Majuba and Tutuka were supposed to receive their coal from nearby coal mines by conveyor. However, issues with coal quality and availability have meant that much of the coal is now delivered by road and rail. Road freight has a competitive advantage in South Africa since the Government is legally required to maintain the roads. The railway is owned by a state-owned corporation (TRASNET)) so rail maintenance depends on its financial capabilities. The Richard's Bay Coal terminal is the largest single coal export terminal in the world, exporting over 73 Mt in 2016 (Reuters, 2017b). According to Mathu (2014), additional rail lines could reduce the environmental issues of noise and air pollution caused by delivering coal by trucks.

Leonard (2016) alleges that mining activities in the Highveld coalfields around Mpumalanga have led to heavily contaminated groundwater and discharges into streams. Several civil society groups have complained that coal mining companies do not participate in discussions with local land owners and occupiers. The area of Dullstroom is of concern as it has significant local wildlife and tourism. Leonard (2016) argues that the consultation on new mining in this region was incomplete. There appears to be some disparity between the governance and implementation of overlapping legislation on mining from the National Environmental Management Act (NEMA) and the Mineral, Petroleum and Resources Development Act (MPRDA). Environmental impact assessments fall under both these acts and the MPRDA are less stringent. Although legislation in the country is tight, there is doubt over whether it is being applied in practice – between September 2012 and November 2013, a total of 46 mines operated without water use licences.

According to Leonard (2016), there are several issues which need to be resolved within the mining industry in South Africa, including:

- a lack of human resources within the government to ensure effective enforcement of environmental policies;

- political pressure is used to promote mining (for social and economic advantages) without effective associated governance to ensure it is carried out in a sustainable and environmentally appropriate manner;
- some ineffective governance; and
- some participation by industry and government appears to be without genuine engagement.

2.2.8 Germany

Coal use in Germany rose in 2016 for the third year in a row, even as the country met its ambitious targets to transition to wind and solar power. The challenges of phasing out coal whilst maintaining baseload capacity is discussed in more detail in a separate CCC report (Sloss, 2016). Capacity reserves have been created for the country's lignite assets which may protect the jobs of lignite workers (SSO, 2016). Lignite is still produced from four regions and, although mining is to be scaled down in many regions, at least one mine, Garzweiler, will continue to 2030 and possibly beyond. Subsidies for hard coal production are to be phased out by 2018 and only two deep mines are still operational. Employment in mining is in decline and this may affect the German economy – it has been estimated that, for each job in the lignite industry, another 2.5 are created in support industries (Euracoal, 2017). According to Morton (2016b), the number employed in the coal industry in eastern Germany has reduced from 100,000 to 17,000 since reunification (1990) and, across the whole of the country there are now only 50,000 workers in the industry, compared to more than 400,000 working in renewable energies. Protests against the Garzweiler mine by over 1500 people closed the mine for a day in 2006, which was the largest ever public protest against mining in the country (Marx, 2016).

Schmidt (2014) reviews the legal principles of mining in Germany. There are mining inspectorates in each region and the Federal Government has a state committee for mining. Legislation is stringent. Although there is a unified federal law for the whole country, mining supervision falls under individual federal state authorities. These federal mining authorities are responsible for health and safety as well as for mineral rights and relevant environmental regulations. It is believed that concentrating all the responsibilities for mining activities in one authority increases efficiency, is public-oriented, and promotes efficient administrative procedures; the federal authority acts as co-ordinator for mining health and safety issues in their region and also as the main point of contact between the public and the industry to deal with any local concerns.

Closed mine reclamation and remediation, often to areas of enhanced agricultural value and recreational use, has been the norm in Germany for over a hundred years (Euracoal, 2017).

2.2.9 Poland

Poland promotes its coal as an alternative to Russian natural gas (Goldemberg, 2014). The country has both hard coal and lignite resources ensuring energy stability whilst having one of the lowest rates of energy dependency in the European Union (EU). However, the cost of extraction and increasing imports (mainly from Russia) means coal production is decreasing. Coal exports have dropped from over 23 Mt/y in 2000 to 10.8 Mt/y in 2013. Imports have increased from 1.4 Mt/y to 10.5 Mt/y during the same period (Manowksa and others, 2017).

In 2014 the Ministry of Economy proposed a plan for energy policy in Poland to 2050. The main objective was 'to create conditions for a steady and sustainable development of the energy sector while ensuring energy security in Poland'. The aims of the plan, which were distributed for social debate, are shown in Table 3. The plan concentrates on restructuring to improve performance and decrease emissions in the industry. There is a concerted move towards increasing energy efficiency and cogeneration and renewables. However, coal is expected to remain a major contributor to the country's energy system for many years.

Polish coal mines began the process of privatisation in 2009 when Poland joined the EU. Reportedly most mines are not profitable and the wages and pensions of the miners are heavily subsidised by the government. Although Poland has a high coal demand, cheap imports are causing Polish production rates to drop. Poland is a post-communist state where the government is relatively resistant to some environmental policies which may be detrimental to the country's economy in the longer term (SSO, 2016).

Coal is mainly extracted from the Upper-Silesian and Lubelskie coal basins. And, although Poland is the biggest producer of coal in the EU, mining companies struggle to be profitable. Redundancies are being considered as part of cost-cutting strategies but are known to have wider impacts on social decline and local communities. The number of coal miners employed in Poland is expected to drop from over 62,000 in 2015 to around 54,000 by 2020, through natural means, which are retirement and a lower intake. However, the efficiency of the miners is expected to increase during this period due to investment and advances in new technologies. Manowska and others (2017) recommend that Polish companies avoid costly and disruptive redundancies in favour of this more natural flow of miners from the sector and suggest that overall costs will be lower with such a strategy.

Table 3 The objectives of energy policy in Poland to 2050 (Manowska and others, 2017)

Operational aims	Ensuring energy security in the country	Increasing energy competitiveness and effectiveness of Poland	Reducing the impact of energy industry on the environment
Intervention areas	Safety and diversification of sources and supply directions or primary energy carriers	Rationalisation of primary energy costs	Reducing greenhouse gases emission
	Ensuring an appropriate level of productive capacity and diversification of the production structure of the final energy	Development of competitive markets of electrical energy and natural gas as well as contribution to the internal energy market in the EU	Reducing greenhouse gases emission into air, water and soil
	Maintaining and developing transmission and distribution capabilities as well as security of critical infrastructure	Improving energy efficiency	Increasing the consumption of renewable energy resources, among other biofuels
Energy policy trends	Trends in restructuring and property/ownership transformations	Trends in science and research	Trends in international cooperation
Priority intervention trends	Efficient management of domestic solid fuels resources: renewable power industry; intelligent energy networks	Energy efficiency, including cogeneration: pro-consumer power industry; development of trans-border connections	Energy efficiency, including: cogeneration; pro-consumer power industry; development of trans-border connections

Frantal (2016) reports that in Poland, with a heavy (80%) reliance on coal for primary energy demand, around 80% of the local population are in favour of mining activities, according to some sources. However, there is doubt over this high acceptance value since many communities still oppose coal mining activity. Frantal suggests that the acceptance of mining activities in Poland depends upon the socio-economic parameters characterising the local communities.

2.2.10 Kazakhstan

Kazakhstan produces over 74 Mtoe (million tonnes of oil equivalent) of coal per year and has reserves of around 23,500 Mtoe (World Energy, 2017). Coal production is expected to grow and the government has set an ambitious coal production capacity target of 151 Mt/y by 2020. The coal is amongst the cheapest in the world to produce but has a high moisture content and low heating value, as well as high ash and sulphur. This limits its potential for export, other than to neighbouring Russia or China. Most coal produced is used domestically to provide over 60% of the country's primary energy consumption. The opening of the mining sector to privatisation in 1998 allowed foreign investment and upgrading of technology, although initial investment after this period was slow. However, India and China could be new markets in the future – India has shown interest in investing in Kazakh mines and China has signed agreements of around US$1.5 billion which will include several industries including energy, transport and chemical industries (Rowland, 2016).

Kazakhstan's coal mines are gassier than most mines making drainage an important safety issue. There is significant potential for coal bed methane (CBM, extracted before mining) and coal mine methane (CMM, extracted during mining) power projects at many mines as well as the prospect for larger gas production projects feeding into a gas pipeline network (Kazenergy, 2015). The US EPA have carried out several pilot studies to determine the feasibility for coal mine methane production in the Karaganda coal basin. Although methane capture and usage would improve mine safety whilst bringing in potential revenue, an economic analysis suggested that the quality of captured methane was too low to be suitable to sell to the current gas market. However, power generation using reciprocating engines could offset energy use at the mine sites and could be combined to create several distributed power plants around the mine area (US EPA, 2013). Following a mining accident in 2004 which killed 30 people (AK, 2017), the European Bank for Reconstruction and Development provided a loan for health and safety improvements in Kazakh coal mines (BW, 2017).

The Extractive Industries Transparency Initiative (EITI) has been implemented in Kazakhstan since 2005 to focus on political and anti-corruption issues and to improve the transparency of company and government revenues in the extractive sector, including coal mining. The funding for this initiative comes from international and domestic organisations and from development institutions such as the World Bank (Kazenergy, 2017).

One of the world's largest opencast coal mines, Bogatyr, is in the northeast of the country and produces around 30% of the country's total output. Coal from the Bogatyr site is delivered to 'most' of the coal-fired power plants in the country by rail (Rowland, 2016). The Bogatyr mine operators have upgraded the transport technology at the mine site to use hydraulic excavators and large trucks and are working with Turkish, German and Australian companies to streamline the movement and processing of the coal through the stockyard to the transport hub. There has been an investment of €390 million in the overall modernisation of coal processing at the site. The mine operators have also initiated several social responsibility projects including employment programmes, youth support and technical scholarships. Funds are invested in redevelopment projects, leisure facilities and landscaping of local towns. Sheltered housing for over 2500 people and a health centre supporting over 1300 children has been built. Samruk Energy, the main power company in Kazakhstan, owns both mines and power plants and has a corporate and social responsibility approach which concentrates on employee stability and development, focussing on resolving disputes and protests. Samruk also has a sustainable development plan which includes guidelines based on those defined by the ICMM (*see* Chapter 3). In 2015, 1035 billion tenge (around US$3 million) was invested in environmental protection by the company. The plan includes the intention to move towards 'clean coal' options. Loans are being sought for the development of UCG (underground coal gasification) and CMM projects, as discussed above. Other projects include health and safety, CO_2 emissions reduction, and social responsibility initiatives (Samruk, 2017).

2.2.11 Other regions

The **EU** has approved a plan for **Spain** to spend €2.13 billion in aid funds to close 26 coal mines by 2018. The money will help with severance and support pay for the miners, who have protested about the closure of the mines (Coal Age, 2017b).

In the **UK,** there are currently only 13 working surface mines. A new opencast mine has been proposed by Bank's Group for a site at Highthorn, England, close to a nature reserve. Opposition from Friends of the Earth, the Northumberland Wildlife Trust and residents based on concerns over GHG emissions and effects on water and wildlife could stop the project and, could 'mark the beginning of a definite end to the industry in the UK' (Coal International, 2016a).

Conversely, the UK has announced a possible new deep mine to start production of coking coal in 2020. The West Cumbrian Mining project would produce coal for the steel and iron-making industry and not for power production. Planning consent is underway and the mine proposes to employ over 510 skilled workers (Lodge, 2016).

Ukraine requires coal imports but is currently trying to source it from places other than Russia. However, in 2016, this required the purchase of coal from rebel-held mines to avoid an energy crisis. According to Vorotnikov (2016), coal production from the deeper mines in Poland, Ukraine and the Czech Republic will end soon leaving issues of unemployment and environmental clean-up. Subsidies for the coal mining industry in the Ukraine have been cut drastically and production has dropped to the point where the country is now a net importer. Those mines which remain in operation will largely be privatised. Armed conflict continues in some regions and demand requires that the government buy coal from these mines (up to 4 Mt), although this is seen as a 'social' move as the government does not want to be held responsible for miners suffering extreme hardship. Polish company, Polska Grupa Gornika, will take over 11 Ukrainian mines, although at least five of these may be closed due to being uneconomic.

The **Czech Republic** is exploring for new deposits along the Czech-Polish border where mining restrictions may be lifted to allow a fresh source of affordable lignite into the region. The Czech Coal Group hopes to open two mines at one of the largest high-quality brown coal reserves in the country but environmental policy currently prohibits mining in the region (Vorotnikov, 2016). Coal mining companies pay only 1.5% of their profits from brown coal and 0.5% from black coal to the regions and municipalities affected by mining. In 2012 the Mining Act was amended to allow greater input from local communities to the negotiations on financial compensation from mining activities. In some regions, there is a public backlash against mining activities. For example, in Horní Jiŕetín, around 57% of the residents are opposed to coal mining. Further issues are predicted as the current brown coal mining activity in the Northern Bohemian Basin will reach its current legal territorial limits by 2018. Social responses to current and proposed mining in the region are discussed more in Chapter 6.

In 2015 the Samarco iron ore tailings dam in Brazil failed, flooding two villages and contaminating the local river. Now new mining projects in the country face significantly more scrutiny by local populations and action groups. According to Gibbs (2016), governments throughout **South America** are following the case against Samarco and insurance for new mining activities are coming under greater scrutiny. Although the Samarco incident was at an iron ore mine, all mining activities are raising more public interest and it is expected that Brazil will react by introducing a range of legal and regulatory reforms which will be copied throughout other countries.

Coal mining is a lucrative business in **Colombia** where it creates employment and foreign investment. However, despite the government making royalties from the mining, there was a reported lack of investment in mining municipalities where there are high levels of poverty and low standards of living (Calco and Perez, 2016).

Investment in Colombian coals increased drastically after 2005 and nearly 9000 mining licences were granted between 2006 and 2010. However, after 2012 the government tightened environmental regulations, introduced penalties and fines and, in some cases, scrapped foreign investment projects where the local population had raised objections. This resulted in the stalling of around US$7.3 million of investment in the sector. Significant investment was needed for ongoing projects to comply with stricter regulations without which significant fines would have been incurred. Mining activities in the 'Paramos' (high altitude moorlands) from where 70% of the country's water supply originates, have been banned completely as of February 2016, revoking 347 mining licences. A government decree of 2012, allowing mining in the eastern plains, Pacific rainforests and the Amazon was revoked in June 2016. Much of this recent change is due to local communities and indigenous populations taking legal action to change government policy. Retained mining income in the La Guajira region alone has fallen from 70% to 25%. And so, although coal production in Colombia is expected to increase from 87 Mt to 105 Mt within the next four years (to 2021), the future is not clear as the investment sector is uncertain of the potential additional costs of new projects under stricter environmental controls (Gibbs, 2016).

Calco and Perez (2016) have carried out mathematical modelling studies on the potential for internalising the cost of investing in environmental and social issues in Colombia. Although more data are needed, the study suggested that the Colombian environmental agencies should provide an economic mechanism for the compensation, mitigation and restoration of the environmental and social effects of opencast mining in the region. This would help achieve sustainable development in the industry in the short term and would increase the welfare of future generations. Greater investment now, while profits are still relatively high, could save money in the long term by avoiding long-term damage that would be costly to remediate.

2.3 Comments

The issues which affect the coal mining industry in different countries are quite distinct. Whilst countries such as India and Australia plan to expand and invest in coal mining, they are meeting with increased public protests and investment challenges. China has been cleaning up its coal industry for at least a decade but still has illegal mines to close and dangerous, abandoned sites to remediate. New government initiatives in China aim to close smaller, less efficient mines to coordinate mining in larger basins which will have higher efficiencies and improved safety. Similar challenges are found in Indonesia where abandoned and flooded mines cause numerous deaths every year. For Russia, the challenge is more about mine safety, following several years of mining accidents with multiple fatalities. South Africa faces issues related to moves to promote black ownership of mining companies which is resulting in investment concerns and a backlash from the industry. Poland has the highest coal dependency of any country in Europe and, although the population is often reported to be in support of continued mining, there are many sections of the community who complain of continued environmental damage and devastation of local communities.

The major issues for mining operations can be quite distinct in different countries. However, there are issues and challenges which are relevant for all mines and mine operators and they are the focus of the remainder of this report.

3 Regulations and guidelines for mining projects

There are many areas of environmental protection to consider before and during mining. There are therefore a great number of rules and regulations controlling the activity, which are often not just country-specific but also state- or province-specific, reflecting national and regional concerns. These laws and regulations are replaced or amended over time as new issues become apparent. Issues such as air quality, occupational health and safety of mine workers, water quality, and transport emissions must all be respected and so the full list of legislation relating to the establishment and operation of a coal mine is extensive. Figure 6 summarises the areas of legislation relating to coal mines in Germany.

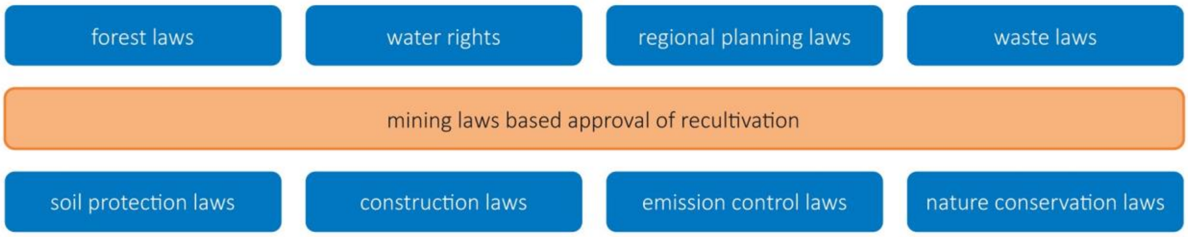

Figure 6 Legal fields associated with mining approval in Germany (Milojcic, 2011)

Mining law and legal practice must therefore encompass landscapes, forestry, soils, water, waste emissions and associated requirements for the protection of nature.

A review of national legislation for mining is therefore beyond the scope of this report. This information can be found by searching national government websites for mining directives. Often, the legislation specific to each mine is summarised on a site-by-site basis, initially within the Environmental Impact Assessment but also, in the site-specific management plan. It is therefore possible to search for information on specific mining companies and/or mine sites to find information relating to the legislation relevant in each case.

Some countries are starting coal mining activities, including several African nations. There appears to be a shift away from mining in developed economies to 'frontier markets' and 'rapidly emerging economies' or lower-middle income countries (LMIC) most of which are south of the equator. Harris and others (2015) suggest that international requirements for environmental considerations and mining best practice have not filtered down into existing regulatory systems in these countries and the capacity for this to happen will be limited without international help and finance. Environmental impact assessments and sustainable mining plans, though necessary and desirable, can be cumbersome, expensive and seen as an administrative burden. This is coupled with a lack of regulatory enforcement in some regions and could lead to avoidable environmental damage.

There are few, if any international agreements or legislative instruments which focus on aligning best practice for mining activities around the world. However, there are some voluntary programmes which provide more general guidance which are useful for governments or organisations planning to start mining as a new venture or to improve the environmental performance of existing mining activities. These are reviewed in the following sections.

3.1 United Nations

The UN has several initiatives and published guidelines relating to the best practice in coal mining. For example, the UNEP (United Nations Environment Programme) Experts Group on Coal Bed Methane (CBM) has carried out many projects relating to the capture and use of mine methane around the world. The use of CBM at the mine has several benefits – the risk of explosions is reduced whilst efficient and cost-effective power can be produced at the site, increasing the mine profitability. This is beyond the scope of this report but the interested reader is referred to the UNECE website for further details www.unece.org. Methane is covered briefly in Chapter 5.

Some of the UN initiatives which are relevant to sustainable development in coal mining and transport are reviewed below.

3.1.1 The Berlin Guidelines

In 2002, the UN published the Berlin Guidelines on mining and sustainable development. The fundamental principles of the Berlin Guidelines are as follows: governments, mining companies and the minerals industries should, as a minimum (UN, 2002):

1. Recognise environmental management as a high priority, notably during the licensing process and through the development and implementation of environmental management systems. These should include early and comprehensive environmental impact assessments, pollution control and other preventative and mitigative measures, monitoring and auditing activities, and emergency response procedures.
2. Recognise the importance of socio-economic impact assessments and social planning in mining operations. Socio-economic impacts should be considered at the earliest stages of project development. Gender issues should also be considered at a policy and project level;
3. Establish environmental accountability in industry and government at the highest management and policy-making levels.
4. Encourage employees at all levels to recognise their responsibility for environmental management and ensure that adequate resources, staff and requisite training are available to implement environmental plans.
5. Ensure the participation of and dialogue with the affected community and other directly interested parties on the environmental and social aspects of all phases of mining activities and include the full participation of women and other marginalised groups.
6. Adopt best practices to minimise environmental degradation, notably in the absence of specific environmental regulations.

7. Adopt environmentally sound technologies in all phases of mining activities and increase the emphasis on the transfer of appropriate technologies that mitigate environmental impacts, including those from small-scale mining operations.
8. Seek to provide additional funds and innovative financial arrangements to improve environmental performance of existing mining operations.
9. Adopt risk analysis and risk management in the development of regulation and in the design, operation, and decommissioning of mining activities, including the handling and disposal of hazardous mining and other wastes.
10. Reinforce the infrastructure, information systems service, training and skills in environmental management in relation to mining activities.
11. Avoid the use of such environmental regulations that act as unnecessary barriers to trade and investment.
12. Recognise the linkages between ecology, socio-cultural conditions and human health and safety, the local community and the natural environment.
13. Evaluate and adopt, wherever appropriate, economic and administrative instruments such as tax incentive policies to encourage the reduction of pollutant emissions and the introduction of innovative technology.
14. Explore the feasibility of reciprocal agreements to reduce transboundary pollution.
15. Encourage long-term mining investment by having clear environmental standards with stable and predictable environmental criteria and procedures.

It is interesting to note the eleventh item on this list, which prioritises trade and investment over environmental considerations. Whilst this means that energy security for the country is regarded as more important than reducing environmental impacts, there are ways in which the environment can be preserved in a cost-effective manner; there are numerous UNEP publications on this subject many of which are produced in the form of workshop proceedings by the Committee on Sustainable Energy and the working group on coal mine methane. A full list of publications and materials can be found at www.unded.org/energy.html . As with all UN materials, the Berlin Guidelines are entirely voluntary and, to be effective, need to be written into company policy and best practice on a case-by-case basis. The UN suggest that the guidelines are implemented through a range of instruments such as performance targets, economic instruments, negotiated or voluntary agreements and environmental management systems.

3.1.2 United Nations Environment Programme (UNEP)

The United Nations Environment Programme (UNEP) has published voluntary guidelines for activities relating to energy production. Figure 7 shows the different aspects and requirements defined by UNEP as important in the assessment of new mining activities (Skuta and others, 2017).

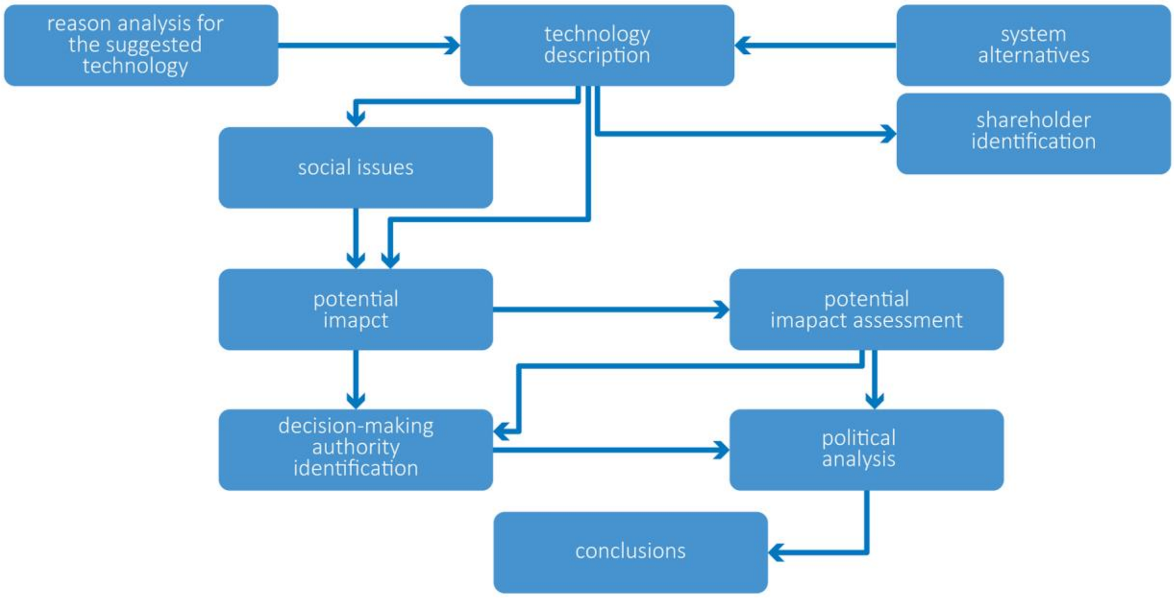

Figure 7 Factors involved in the assessment of new mining activities (Skuta and others, 2017)

The schematic shows the stages between the definition of the project and the specification of technologies involved, through consideration of social issues, potential social and environmental effects, to the decision-making process, and associated political analysis, to a conclusion of the appropriateness of the proposed plan. The guidelines are broad as they cover the mining of all materials and not just coal. The aim is to ensure that emerging economies starting mining for the first time, with no existing experience or regulations in the sector, are aware of the importance of considering all issues through the production chain and to ensure stakeholder and local engagement from early planning stages.

3.2 International Council on Mining and Metals (ICMM)

The International Council on Mining and Metals (ICMM) requires its members to implement frameworks of best practice which include respect for human rights and cultures, implementation of risk-management, pursuance of continual improvement in environmental performance and pro-active engagement in sustainable development. The website www.icmm.com details the extensive commitments listed under different areas of concern such as:

- water management, including commitments to water stewardship;
- reduction of GHG emissions;
- management of biodiversity;
- mine closure and rehabilitation;
- tailings management; and
- chemicals management.

Membership of the ICMM must be earned by demonstrating compliance with the organisation’s visions and mission. The organisation currently has 23 leading mining and metals companies (such as Anglo American, BHP Billiton, Glencore, and Rio Tinto) as members and 30 associations (such as the Chambers of Mines of South Africa and the Philippines, Euromines, and the World Coal Association).

As part of their remit, ICMM provide guidance documents on best practice in mining such as how to evaluate potential impacts prior to and during project development, as shown in Figure 8.

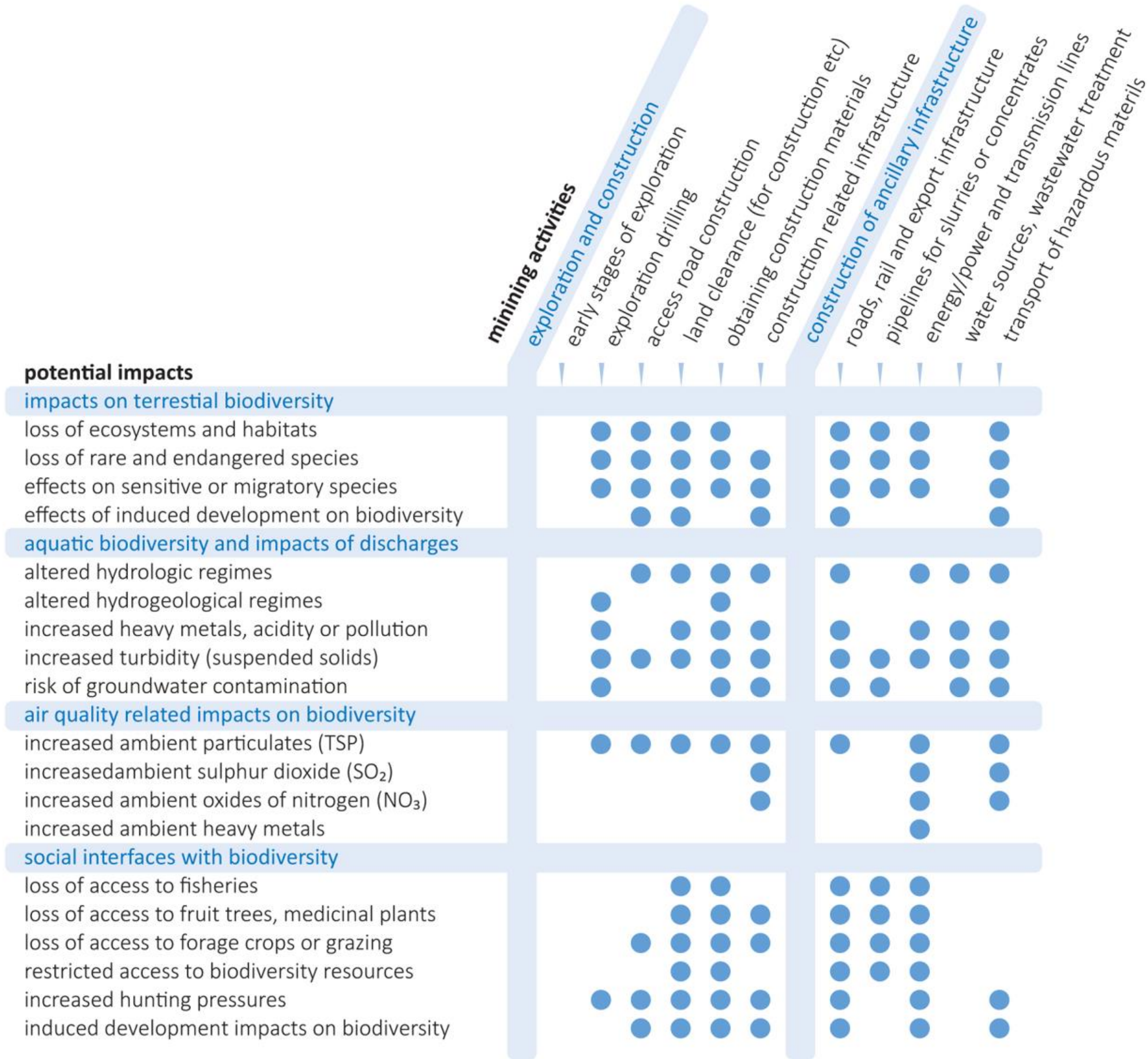

Figure 8 Environmental effects of mining projects (ICMM, 2017)

This allows project managers to determine how each part of a project may affect the local environment and, then to identify which legislation must be adhered to at each stage. For example, many stages of mining affect the concentration of ambient particles in the air. To remediate this, mining companies must evaluate the problem, using monitors or models, and ensure that any increases in particulate concentrations are below legal limits. If limits are exceeded, then remedial action will be required, either in the form of changes in mining practices or by the installation of control systems (*see* Chapter 5).

Table 4 lists the ICMM members against their performance within the best practice framework defined by the organisation, as reported for 2015.

Table 4 ICMM member performance for 2015 (ICMM, 2017)

		1	2	3	4	5	6	7	8	9	10
										Global reporting Initiative (GRI)	
Members		Alignment between members' policy framework on SD issues and ICMM's SD principles and mandatory requirements set out in ICMM's position statements		Process and outcome of identifying and prioritising materials SD risks and opportunities		Systems and approaches to manage SD risks and opportunities		Performance for the identified SD risks and opportunities		G3 application level	G4
Company	SD or integrated report for the financial year ending	Reported on	Assured	Reported on	Assured	Reported on	Assured	Reported on	Assured	Reported on and assured	Reported on
		subject matter 1		subject matter 2		subject matter 3		subject matter 4		Subject matter 5	
African Rainbow Minerals	30 June 2015	full	full	full	full	full	full	full	full		full
Anglo American	30 June 2015	full	full	full	full	full	full	full	full		full
AngloGold Ashanti	31 December 2014	full	full	full	full	full	full	full	full		full
Antofagasta Minerals	31 December 2014	none	partial	full	full	full	full	full	full		full
Areva	31 December 2014	full	full	none	full	full	full	full	full	A+	
Barrick	31 December 2014	full	full	full	full	full	full	full	full	A+	
BHP Billiton	30 June 2015	full	full	full	full	full	full	full	full		full
Codelco	31 December 2014	full	full	full	full	full	full	full	full		full
Freeport McMoRan	31 December 2014	full	full	full	full	full	full	full	full	A+	
Glencore	31 December 2014	full	full	full	full	full	full	full	full	A+	
Goldcorp	31 December 2014	full	full	full	full	full	full	full	full	A+	
Gold Fields	Integrated Annual Review 31 December 2014	full	full	full	full	full	full	full	full		full
Hydro	31 December 2014	full	full	full	full	full	full	full	full		full
JX Nippon Mining and Metals	31 March 2014	full	full	full	full	full	full	full	full		full
Lonmin	30 September 2014	full	full	full	full	full	full	full	full		full
MMG	30 September 2014	full	full	full	full	full	full	full	full	A+	
Mitsubishi Materials	31 March 2015	full	full	full	full	full	full	full	full	A+	
Newmont	31 December 2014	full	full	full	full	full	full	full	full	A+	
Polyus Gold	31 December 2014	none	partial	full	none	full	none	full	none		full
Rio Tinto	31 December 2014	full	full	full	full	full	full	full	full	A+	
South32	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Sumitomo Metal Mining	31 March 2014	full	full	full	full	full	full	full	full		full
Teck	31 December 2014	full	full	full	full	full	full	full	full		full

• full • partial • none

The companies must report annually on their sustainable development performance in line with the Global Reporting Initiative guidelines. These voluntary guidelines apply to all organisations worldwide and promote transparency and accountability in sustainability performance. The guidelines include standards for reporting economic, environmental and social performance as well as management practices. As can be seen in Table 4, all ICMM members are in full compliance with their reporting requirements. Further details on the Global Reporting Initiative can be found at www.globalreporting.org.

The ICMM has an extensive library of guidelines, surveys and projects on best practice in mining and the interested reader is referred to their website for further information www.icmm.com

3.3 Society of Mining, Metallurgy and Exploration (SME)

In the USA, the Society of Mining, Metallurgy and Exploration is also a member-based professional organisation which provides information on new technologies and provides reviews of best practices in all mining and metallurgical activities. The SME runs meetings and courses as well as awarding prizes for outstanding achievements in the minerals industry, including providing scholarships and bursaries to those who would benefit from help in this area. Output from the organisation includes guidelines for reporting results from exploration and mineral resource investigations. For more information visit www.smetnet.org

3.4 Comments

The legislation and regulations relevant to mining activities are numerous and extensive. They include legal issues relating to land ownership, land use, water conservation and protection, air quality and the health and safety of workers. A company must take these regulations and laws into account when establishing and operating a mine. As every mine is different, the owners must determine the relevant requirements and incorporate them into a mine-specific code of practice. The UN has produced a series of guidelines and programmes to help mining companies create the most appropriate mine-specific plan on a case-by-case basis. The ICMM also assists by defining best practice within the mining industry, providing case studies and guidance to new mining initiatives.

4 Minimising impacts before and after mining activity

This chapter concentrates on the effects of coal mining on the immediate terrestrial environment before, during and after extraction of the coal.

4.1 Impacts on land and landscapes

Coal mining requires the removal of a large area of topsoil, with related plants and wildlife, followed by blasting and digging to remove the materials below. Inevitably, this has local environmental impacts, including (Skuta and others, 2017):

- substantial, long-term and often spatially extensive destruction of the landscape, residences, roads and potential subsidence. Most mining activity is temporary and the land is returned to approximately its original state and contour following mine closure. However, there can be a more permanent effect on the landscape from mountain top mining or at mines in emerging economies with more relaxed approaches to reclamation;
- irreversible changes to ground and surface water, including changes in the course of rivers or streams; and
- damage and destruction to the soil profile.

The extent of these changes will depend on the intensity and type of mining, the ground morphology and geology and the structure, type and character of the local soils, plants and facilities. Skuta and others (2017) have summarised the stages of the environmental effects of mining on local land, as shown in Table 5.

Table 5 Stages of the effect of underground mining (Skuta and others, 2017)

Stages	Type	Environmental Components	Manifestations
1	Impacts of underground mining	Rock mass and landscape relief	Subsidence, movements, de-levelling, curvature, deformations
2	Consequences of impacts of underground mining	Landscape and its constituents change (hydrosphere and so on)	Subsidence, shifting, expansion, tilting, water-logging, flooding, degradation
3	Removal and effacement of consequences	Landscape and its constituents	Repairs, decontamination, reclamation, demolition, regeneration

These stages include potentially significant changes to the landscape – the changes in the profile of the land when seen from a distance in terms of curvature. However, potential harmful effects such as subsidence, land shifting and waterlogging can also occur when large amounts of rock and topsoil are moved around, as is the case with all coal mines.

According to Donnelly (2016), the UK opencast mining industry operates to some of the world's most stringent regulations, including specific requirements for the lifting, storage and restoration of soils. For example, motor scrapers, which are used extensively elsewhere, are banned in the UK due to concerns over their impact on soil structure. This means soil movement must be carried out by truck and shovel. This type of activity is regulated to certain times of the year (April to September). Some areas have further restrictions on activity due to potential disturbance of birds and their habitats. Plans for the restoration of mining land are extensive and must be approved by the Mineral Planning Authority, including the specification of hedges and plants to be planted following reclamation of the site.

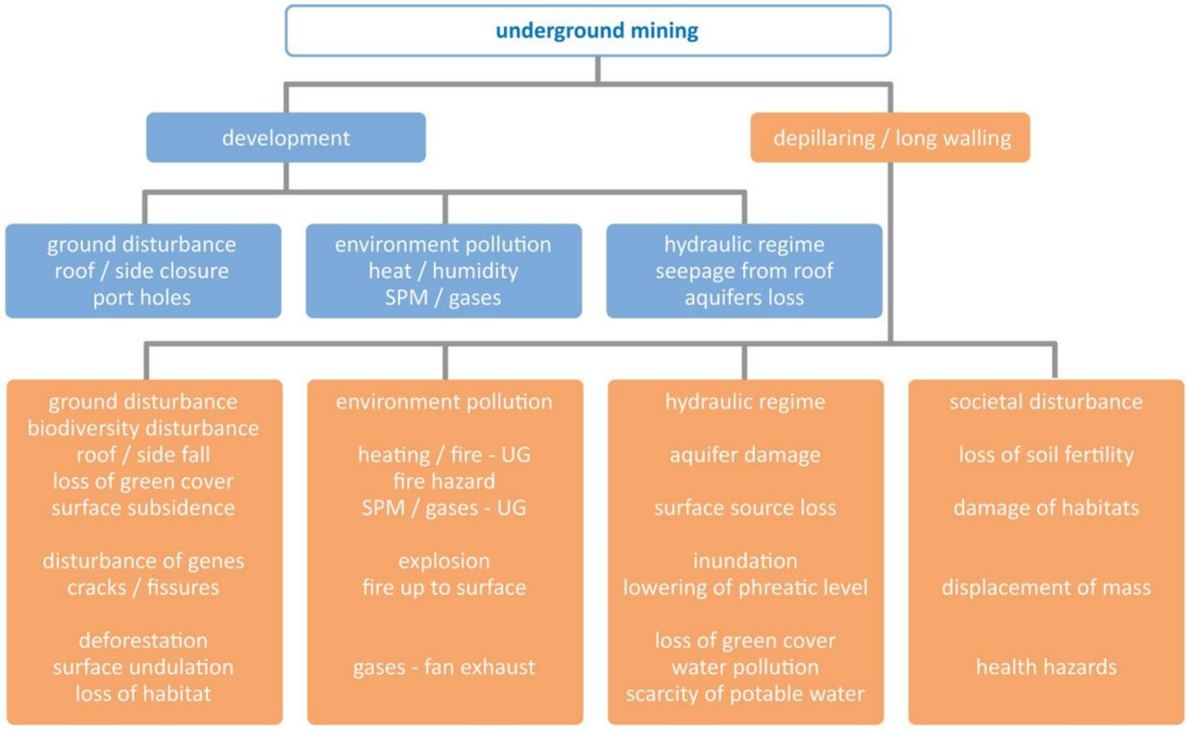

Figure 9 Dimension of disturbed domain due to underground mining (Goswami, 2013)

As shown in Figure 9, the effects of underground coal mining range from disturbance of the land through to disruption of the local community. Factors such as safety issues (fires and explosions), flooding, water pollution and changes to the local wildlife must all be taken into account when considering the entire potential impact of mining activities. Opencast mining can cause similar damage to landscapes, although often with fewer problems relating to subsidence and issues relating to the depth of the workings. However, conversely, opencast mines may have a greater environmental impact from the dust resulting from surface blasting.

4.2 Impacts on water

The World Economic Forum has described a shortage of clean water as the greatest global, societal and economic risk over the next decade. Coal mining can have a significant effect on local water availability and use. For example, Anglo American has around 75% of its mining operations located in regions of high water risk. Much of this water is used in tailings disposal facilities and for dust control. Every Anglo American site worldwide has a goal for water reduction of 14% by 2020. This target has been exceeded for three years in a row with an average of 16% reduced water consumption against the predicted usage. The saving is reported to be due to projects which target reducing water use in dust control and tailings dewatering (*see* Chapter 5). Recycling and re-use of water at each site is encouraged. This includes non-coal mines (Fleming, 2017).

According to Soni and Wolkersdorfer (2015), there are several guidelines published on mine water management worldwide including the Australian best practices, and similar guidance in the USA. In South Africa, regulations on mining water use are tightening (Coal International, 2016b).

Acid mine drainage was covered in a previous CCC report (Sloss, 2013). The priorities should be to minimise the risk and scale of the task by (Morgan, 2016):

- water recycling;
- capture and containment of drainage;
- encourage evaporation from open lagoons;
- diversion of drainage from exposed mine works or spoils; and
- covering and lining of structures to prevent water ingress.

'Intelligent mine water management systems' such as advanced membranes and nanofiltration systems, are available to help reduce contaminants from mine effluents. However, in some cases, expertise in mine water and ecosystems can result in the development of natural systems to remediate any negative changes in groundwater following mine closure. Reduced oxidation of tailings, controlled leaching of metals and anaerobic/aerobic treatment of acid mine drainage is the most cost-effective way to reduce environmental damage from coal mine water releases which can occur both during mining activities and following mine closure (Soni and Wolkersdorfer, 2015).

Mining activities have a significant effect on local water ecosystems, as shown in Figure 10.

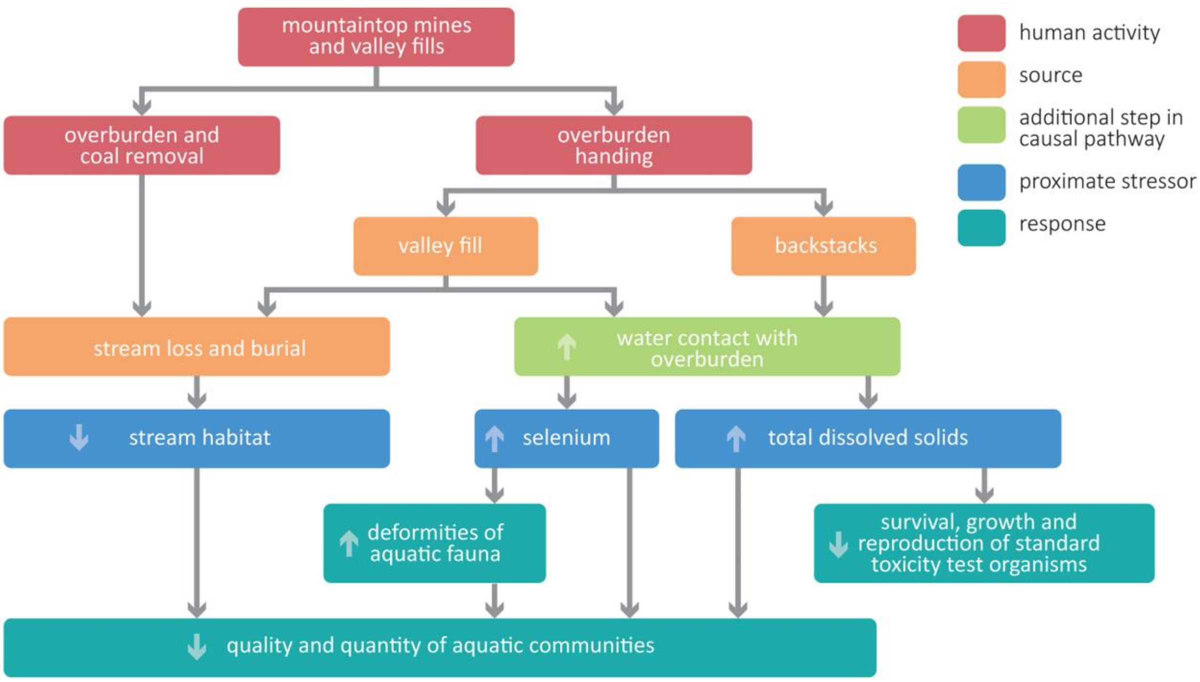

Figure 10 Observed and expected effects of coal mining on aquatic ecosystems (US EPA, 2017)

As shown in the figure, removal of topsoil and coal combined with the associated traffic around a mine site can result in the redirection or removal of springs and streams in the area. The removal of trees and changes in the undulation of the land will change the way rain water flows through the site. Unless kept separate, stockpiles of coal and coal waste will leach trace elements into the water course which may cause changes in the acidity and chemistry of water and lead to potential harm to fish, insects and birds. Even with extensive reclamation work following mine closure, some stream resources will never be returned to their original state (US EPA, 2017b), although forward planning and expertise should minimise any long-term damage.

Coal mining often involves blasting using chemical explosives. The blasting breaks up and disperses hard overburden rocks and provides easier access to the coal underneath. This process is often repeated several times during mining of some coal seams, as new areas of overburden and coal become exposed. These blasts require the use of controlled chemical explosives. During blasting campaigns, up to 28% of the nitrates from traditional ammonium nitrate fuel oil explosives can end up leaching into the water in an underground mine as the explosive materials are deposited around the blast site and become washed into the run-off areas during wet weather, if controls are not in place. Although best practice (controlled, efficient explosions) can reduce this to 2%, non-nitrate based explosives are often a better solution to the problem (Coal International, 2016b).

4.3 Environmental Impact Assessments (EIAs) and pre-planning

Within the 193 member states of the United Nations, 190 have Environmental Impact Assessment (EIA) regulations, defined as a systematic process to prevent and mitigate the potential environmental impacts of industry development projects before these occur (Harris and others, 2015). EIAs are commonly required by national legislation. For example, European member states must follow the European Economic Commission requirements following from the Second Environmental Action Programme of 1977. Countries including Denmark, Ireland and the UK, have incorporated EIA requirements into their existing national legislation whereas in others (such as the Netherlands and Greece) EIAs became part of national environment acts. Separate legal norms on EIAs were adopted in Belgium, the Czech Republic, Germany, and Spain. Although the details of the EIA requirements may vary from country to country, the basic process is the same: scoping and basic site inspections are combined with project evaluations and preferences to produce an impact prediction. By altering the project specification to implement impact reduction methods, a more detailed project plan is produced and subjected to further review and consultation, potentially with community involvement. The final report is then created and applications are submitted to commence mining activities.

Figure 11 shows the major steps in EIAs for sites such as coal mines. Along the top is the process for producing the EIA starting with a screening of the area, preparation of the scope of the work and then the production of a report for review. The EIA must also include a requirement for monitoring during and after the mining activity to ensure that all the required processes are carried out correctly. In terms of the potential contamination of the site, this will be covered in the contamination risk assessment, which will focus on factors such as hazards, risks, exposure assessments for workers but also, potentially for animals and wildlife. For the mine operation, the EIA will consider the methods used for prospecting for coal in advance of mining, through extraction and treatment (such as washing) to storage (stock-piling) and eventual removal or transport from the site. Thus, an EIA for a coal mining site must work through everything from exploration and development through production to closure and remediation.

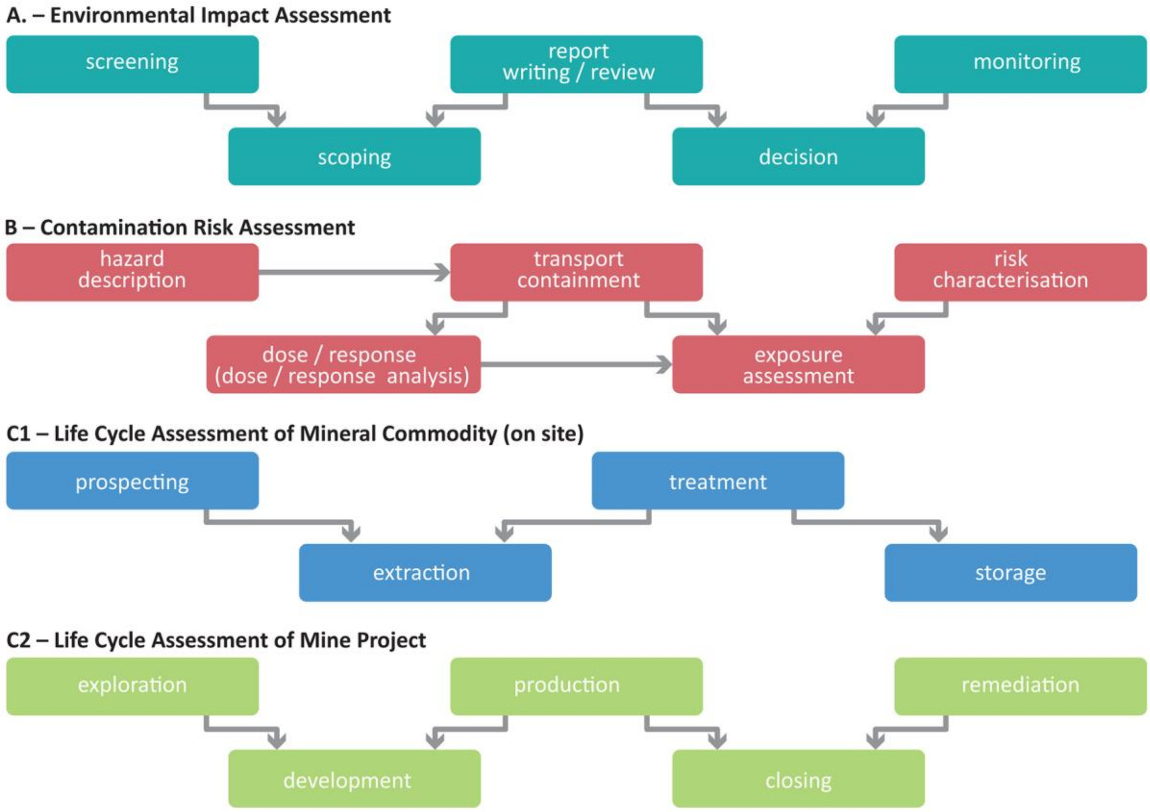

Figure 11 Major steps in an environmental risk assessment (Jordan and Abdaal, 2013)

Although it is possible for a company to produce an EIA summary based on professional analysis and internal reviews from experts alone, for the EIA to include potential effects on local communities, it must also consider the opinions and concerns of residents. Table 6 shows the EIA chart as it is applied in the Czech Republic, showing details of the amount of public interaction in the decision-making process.

Table 6 EIA chart, as per Czech legislation (Skuta and others, 2017)

Activity	Activity required	Arranged by	Recipient	Deadline
Plan	Plan prepared	Investor	Relevant authority	
Documentation	Documentation processed	Authorised person		
Handover	Sending of plan and documentation to relevant authorities	Investor to relevant authority	Relevant municipality and authorities in question	5 days
Public consultant	Consultation, written comments and statements	Relevant municipality and citizens	Relevant municipality and citizens	5 days warning, 30 days open
Statement	Written statements and documentation	From relevant municipality to authorities	Relevant authority	14 days for municipality comments, 50 days for authority comments
Expert opinion	Arrangement of opinion and processing	Relevant authority and authorised/qualified person	Relevant authority	60 days
Public hearing	Public hearing and associated summary report	Relevant authority		30 days
Opinion	Opinion issued	Relevant authority	Investor	

There are clearly several stages of the process where local residents can raise concerns about any potential issues relating to the effect of the proposed mine on the region. The importance of public consultation to achieving a successful, approved project should not be underestimated and this is discussed more in Chapter 6.

Only once all the processes in Table 6 have been completed will the investor receive notification of the result of the EIA. Once received, the investor can move forward to complete funding and commence mining activities.

In addition to EIAs there are several other environmental management tools which can be used to improve mine preparations and operation (Krzemien and others, 2016):

- LCA – Life Cycle Assessments, to determine which approaches will cause the least environmental impact;
- MCDA – Multi-criteria decision analysis, coupling environment, social and economic criteria to compare options; and
- Risk evaluations – to compare estimated levels of risk with defined risk criteria.

The more investment there is in predictions and analysis prior to the breaking of soil, the less likely there are to be unforeseen issues and problems which may prove costly once work has started.

4.4 Closure, reclamation and remediation of mine land

A previous report by the CCC (Sloss, 2013) summarised the issue of coal mine site reclamation in more detail and the interested reader is referred to this document. The sections below provide an updated summary of the major issues of remediating and reclaiming closed and abandoned mine sites.

The Australian government has a strategic framework for mine closure which encourages the return of mines to self-sustaining ecosystems wherever possible. This work must be financed, implemented and monitored to reduce any negative local legacy. Similar systems are in place in Canada and the USA to ensure that legislation governs mining in such a way as to emphasise financial assurance of optimal mine closure projects (Krzemien and others, 2016).

The Department of Water Affairs and Forestry (DWAF) in South Africa has developed a series of best practice guidelines for water management strategies, technologies and tools. These guidelines allow mine operators to plan mine closure with water conservation in mind including the transfer of water related environmental and financial risk to the state and citizens (Krzemien and others, 2016).

The EC established a project between 2012 and 2014 for the demonstration of best practice in the 'Management of environmental risks during or after mine closure'. Factors to be considered include (Krzemien and others, 2016):

- water management – drainage from closed workings along with any associated contamination or flooding;
- air pollution from continued mine gas leakage;
- subsidence;
- residue deposits which may have toxic leakage or the potential for collapse;
- soil pollution;
- abandoned facilities such as shafts or dilapidated buildings that can become a hazard; and
- cumulative effects of some or all of the above.

One of the major issues with respect to closed, and sometimes abandoned, mines is potential subsidence as this can be a health and safety risk for decades or longer. According to Krzemien and others (2016), subsidence often occurs within 200 days after exploitation. From then on, until around two years after mine closure, residual movement may take place. Coalfields within Europe have allowed deformation criteria – maximum levels of compression, traction or slope which are deemed to be acceptable in terms of safety. Compliance with these levels ensures that any closed mines are not a risk for public use or development.

New technologies are useful to show changes in land morphology during mining. Drones can be flown remotely over areas of mine sites which may be inaccessible or dangerous for miners to reach. For example, the Aibot X6 is specifically designed for surveying mining sites, using high resolution cameras to create 3D computer models of the area. The drones can be used to check for the efficacy of blasts immediately and provide warnings of potential issues with subsidence or flooding by monitoring land and water changes.

Combining photographs with laser scanning technology can pinpoint vegetation changes, monitor them and highlight or predict dangerous or concerning changes with an accuracy up to 10-20 cm (Judd, 2017).

Figure 12 shows a proposed flow diagram for evaluating and reducing environmental risk during underground mine closure. The proposal combines historical data with the collation of existing data to create models to estimate potential risks associated with different aspects of the mine closure programme. The calculation of risk will determine which ones are a high priority and need addressing and which can be regarded as insignificant. Following this categorisation, a management plan can be formulated which will concentrate on dealing with the cost-benefit analysis of the closure plan.

Krzemien and others (2016) suggest that the current international standards for mine closure (ISO 31000 and IEC/ISO 31010) are very general, which makes it difficult to couple them with risk management strategies. They suggest that a methodology for the management of environmental risks for the closure of underground coal mines is lacking and so current practice tends to be carried out without specific guidance. However, Figure 12 could form the basis for the development of such guidance. For some countries, mine land reclamation is a legal requirement, for others the requirements can be entirely absent. Krzemien and others (2016) recommend a Closure Assessment Report which should list the significant risks associated with residual and latent issues at the mine site along with a management plan for the mitigation of negative effects and measures to verify compliance with the objectives of this plan. A detailed closure cost assessment and financial provision statement should also be included.

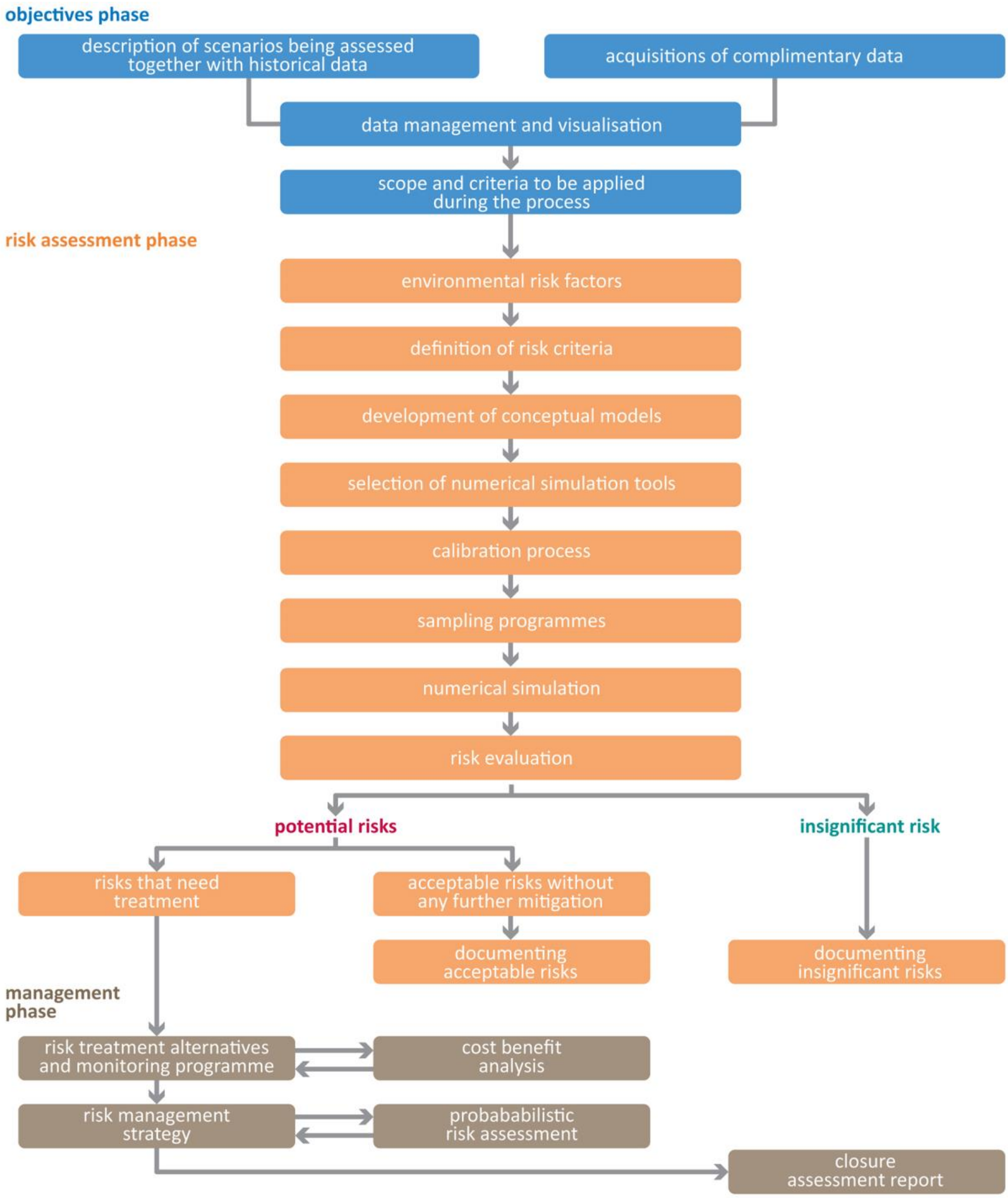

Figure 12 Methodology proposal for environmental risk management in underground mine closures (Krzemien and others, 2016)

Risk criteria are defined based on acceptable thresholds and regulatory requirements. The Mining Association of Canada established the Whitehorse Mining Initiative which suggests the following with respect to mine closure: “To ensure that comprehensive reclamation plans that return all mine sites to viable, and, wherever practicable, self-sustaining, ecosystems are developed and are adequately financed, implemented and monitored in all jurisdictions”.

Figure 13 shows the typical stages of a coal mine, from planning through to closure and remediation. As shown, remediation and reclamation can take several years depending on the size and depth of the mine, the nature of the location, and the proposed use for the closed mine land.

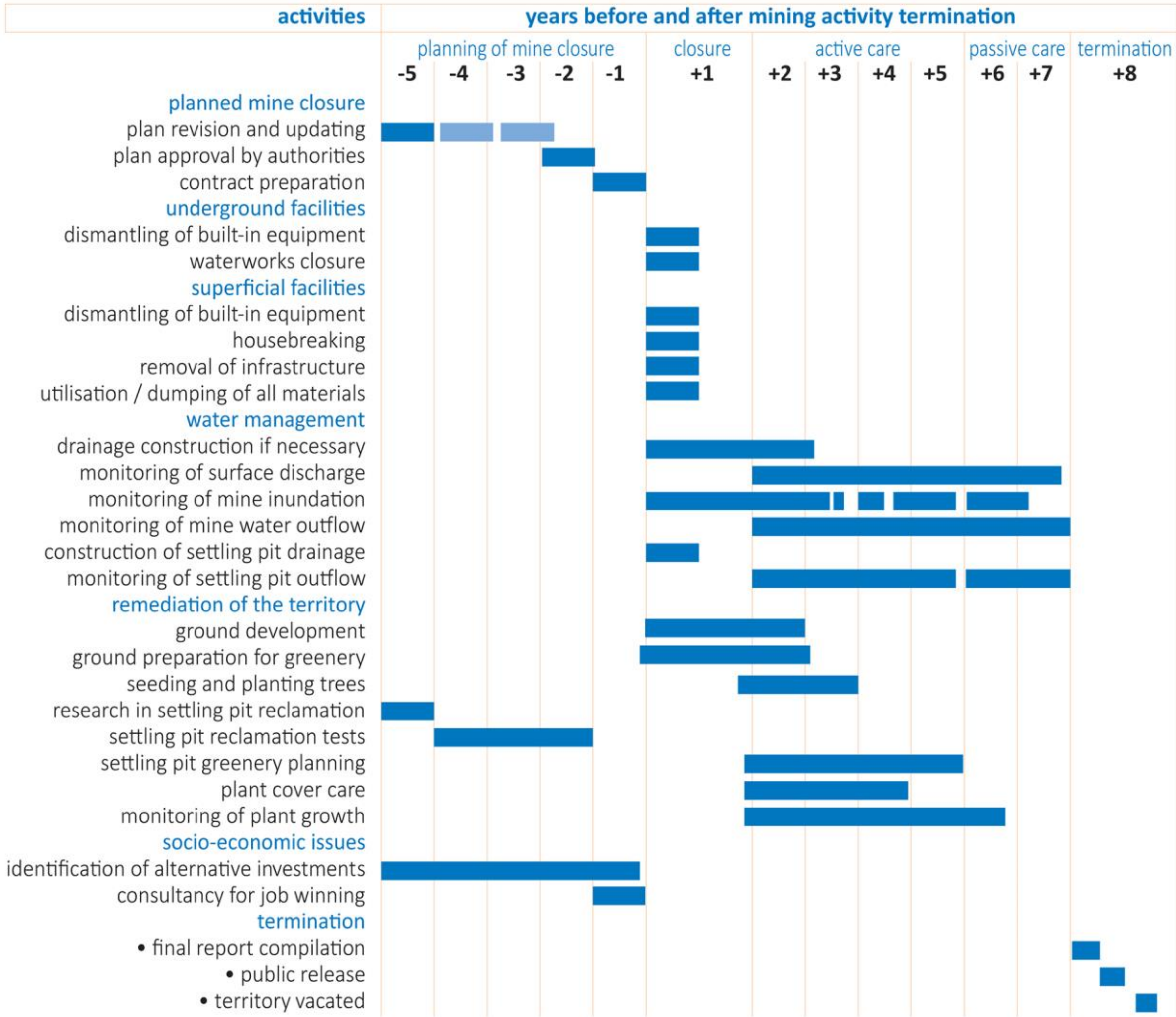

Figure 13 Typical plan of mine abandonment (Skuta and others, 2017)

In Finland, TEKES (Finnish Funding Agency for Technology and Innovation) have funded a project called 'Environmental techniques for the extractive industries' which produced guidelines related to the planning and implementation of mine closing strategies (Krzemien and others, 2016). The EC have produced various tools for the assessment of different aspects of mine closure:

- MANAGER and WATERCHEM concentrate on mine water discharge optimisation;
- PRESIDENCE focuses on subsidence hazard prediction and monitoring;
- FLOMINET focuses on flooding management in regional mining networks; and
- ESIAS was a project that directly addressed the development of an impact assessment system while conducting environmental simulations into European metal mines, looking at groundwater, river, air, soil pollution, noise and vibrational impact.

These EC tools and the details included in Figure 13 are what would ideally happen at all mines. Unfortunately, legislation was less stringent in the past and, in some regions, compliance with more recent legislation has been incomplete, and so there are still many sites around the world where old closed mine sites have been abandoned with little or no consideration of safety or environmental issues. In response to this issue, several countries are creating plans and funds to return to these areas to try to correct the mistakes of the past. For example, the French have developed a 'Mining risk prevention plan' (MRPP), designed to map and evaluate risks linked to pollution generated from historical mining activities.

There does not seem to be any published information on the environmental effects of the activities (machinery and so on) required in remediation work, in terms of additional activities or vehicle use, but the end effects are to remediate the damage and, commonly, to reintroduce indigenous plants and wildlife.

In New Zealand, the Wangaloa opencast coal mine, which closed in 1989, is used as a pilot-scale project to obtain information on successes and failures during rehabilitation so that other sites can be rehabilitated at lower cost (UoO, 2017).

Coal India Ltd started to reclaim land at the Gevra mine in 2008, installing parks, lakes and shrubs in completed areas using fly ash and topsoil from areas of the mine which are still operational. The Gevra mine is the largest opencast coal mine in Asia and so the project attracts much interest. According to Shah (2016) the increased focus and public awareness of environmental issues in India means that such projects are subject to significantly more scrutiny than in the past, with the Indian Government investigating progress made.

Yancoal Australia mainly produces coal from opencast mines. The company recognises the importance of mine reclamation and the restoration of mines to 'establish stable, compatible landforms on mined areas, revegetated with native species'. Previous reclamation work has produced recreation areas, aquaculture features and nature reserves. Around 80% of the land disturbed by opencast mines in Australia has been reclaimed and the country is reported to be a global leader in the field (Anming and Liangui, 2015).

There are still issues in some places, such as some historical coal mining regions in China and Indonesia, where mines have been abandoned without remediation. However, there are also many examples of mines where extensive efforts have been made to return the mining land either to as near its original state as possible or even to create new uses for this land which may benefit the local community. This is discussed in more detail in a previous CCC report (Sloss, 2013), including a case study of Northumberlandia, which is included below as an example of best practice.

4.5 Case study - Northumberlandia

Northumberlandia is a large land art sculpture of a woman created on a disused coal mine site in Newcastle, England. The public park, shown in Figure 14 is a demonstration of a rehabilitation of a mine site as intended to provide a legacy or benefit to the community.

Figure 14 Northumberlandia (photograph from thelandtrust.org)

The art, created by Charles Jencks, was created during 2010 and 2012 and cost £2.5 million. It was commissioned by the mining company (Banks Group) and the land owner (Blagdon Estates) in a 'restoration first' strategy. The bid for this artistic reclamation was initially refused by the local council but overturned on appeal by the local government. During this period of planning and early construction there was mixed feedback from the community. Whilst some liked it, other regarded it as a distraction from the damage that the mine had caused. Although reclamation of some form is obligatory, the mine and land owners had exceeded this to invest in good public relations and, while this worked for some, it did not appease all in the local community. In fact, some complained that the construction of the land art added a further 150 trucks a day on the local roads during its construction. During its operation, the mine had employed 116 local people and generated £20 million per year for the local community. A study by Chambers and Baines (2015) suggests that part of the issue was that the land art was announced as a gift to the community without any investigation into whether the local community wanted it. Some saw the art as corporate public relations spin to try to cover up negative environmental effects of the original mine. Despite this initial negative press, the site has won tourism awards and seems to be popular with many locals and visitors. The site is free to visit (www.northumberlandia.com). More information on public reaction to mining issues is given in Chapter 6.

4.6 Case study – Hawks Nest surface mine

In 2016 Alpha Natural Resources' Paramont Coal won a National Reclamation Award for their coal mine reclamation project in Buchanan County, VA, USA. The 1200-acre site (486 ha), shown in Figure 15 at the peak of production, produced coal between 2004 and 2011.

Figure 15 Hawks Nest mine site during coal production (Schmidt, 2016a)

Over 600,000 tonnes of coal were mined at the site. Reclamation is now complete and the reclaimed site, shown in Figure 16, includes residential areas, recreational areas, a community park, athletic fields, a large playground and gymnasium as well as industrial and business units (Schmidt, 2016a).

Figure 16 Hawks Next mine site following reclamation (Schmidt, 2016a)

Reclamation involved restoration of over 4500 feet (1372 m) of stream and extensive planting of hybrid American chestnut trees. The site has attracted wildlife, including elk (Coal Age, 2016e).

4.7 Comments

The effects of coal mining on a landscape can be extensive – the removal of trees and foliage and even a change in the land profile as soil and coal are removed. Uncontrolled subsidence, due to bad management and poor control of closed underground seams, can be dangerous for decades. A well prepared environmental impact assessment will predict potential issues from subsidence, changes in wildlife and disruption to natural water courses, and will help minimise and avoid these issues. Mining should not be initiated until the impact assessment has been completed to the satisfaction of both the local authorities and the local community.

Following completion of mine work, the mine land must be returned to a form which is appropriate – this may be a return to a safe site which will be used for industrial or commercial use, a return to the original state, with wildlife reinstated, or potentially improved to create a site of enhanced value, such as a public area or art installation. Remediation should take into account the original state and use of the land but also consider potential new uses. During this process, it is important to perform community outreach and engage the public in discussion to determine the final format of the post-mining land to ensure that an appropriate legacy remains.

5 Emissions from mining and control options

This chapter looks at the major emissions produced from coal mining activities as well as options to reduce them along the coal production chain from mining through transport and processing.

5.1 Emissions of concern

The two main emissions to the air from coal mining activity are greenhouses gases (GHG) and dust.

5.1.1 Greenhouse gases (GHG)

A previous CCC report (Mills, 2005) considered the life cycle analysis of the full coal chain and found that the focus was on emissions of greenhouse gases. Thus, the main issue of concern for coal mining was coalbed methane production and release. Coalbed methane has been the focus of several reports from the CCC (Sloss, 2005, 2006; Oprisan, 2011).

Figure 2 in Chapter 1 gave an indication of the potential scale of the emissions of GHG from fossil fuel production. As mentioned, few mining companies publish information on GHG emissions from the coal mining chain. However, coal mining is often assumed to be a dirty and GHG-intensive process. An investor-backed group, led by the Church of England, are demanding that the world's largest coal mining companies make public statements on how they plan to reduce GHG emissions under the Paris Accord. Currently, only two coal mining companies – Rio Tinto and Vale – have long term targets to reduce GHG emissions. Greater transparency by mining companies would allow investors to selectively fund those which are working to reduce emissions rather than avoiding funding these companies completely (Sanderson, 2017b).

Working mines record methane emissions in real time as part of safety requirements. Surface coal mines (including abandoned mines) release methane into the air during mining and after mining, and since these emissions are released in a fugitive manner, with little or no total monitoring, values for coal mine methane emissions are, at best, gross estimates and, at worse, best guesses. Figure 17 shows the estimated global emissions of coalbed methane released during mining in 2020 based on emission factors and modelling by the US EPA (2017).

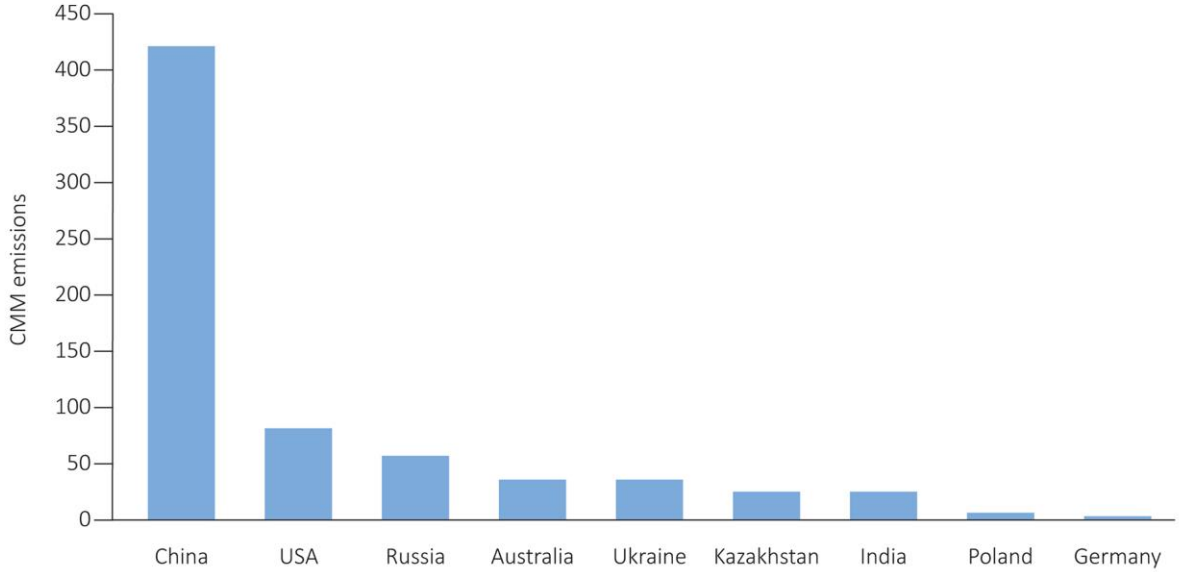

Figure 17 Estimated global coalbed methane emissions, 2020 (US EPA, 2017)

Although emissions depend on the amount of mining taking place, the methane content of coal varies greatly by region and even from seam to seam. Thus, although Kazakhstan is the world's 9th largest coal producing nation, the coal is very gassy and so Kazakhstan ranks 6th in terms of coalbed methane production. Coalbed methane can be a highly valuable source of natural gas and so, where possible, the methane is captured before and during mining activities. Since methane is highly combustible and is a potent greenhouse gas, methane monitoring and control is a major part of mine health and safety. The issue of spontaneous combustion and methane explosions is discussed in more detail in a separate report from the CCC (Sloss, 2015). Health and safety at mines is discussed in more detail in Chapter 6.

In addition to mine methane, GHG emissions can also arise because of mining activities, such as blasting and the vehicles used on mine sites. Although there is not much information published on this topic, Goswami (2016) has made estimates for the mining sector in Australia based on the three principal sources of energy used in surface mining:

- diesel for mobile machinery;
- electricity for other machinery (such as draglines); and
- explosives for fracturing and moving rock.

Figure 18 shows the relative emissions from surface mining in terms of GHG emissions per tonne of coal mined from the diesel vehicles, the mine itself, the explosives and from the machinery used on site. Although seam gas is the largest contributor to total emissions, the emissions from vehicles and machinery are not insignificant. As Goswami (2016) stresses, these emission factors are per tonne of coal mined, and not per tonne sold and so emissions must also include wasted and unsold coal.

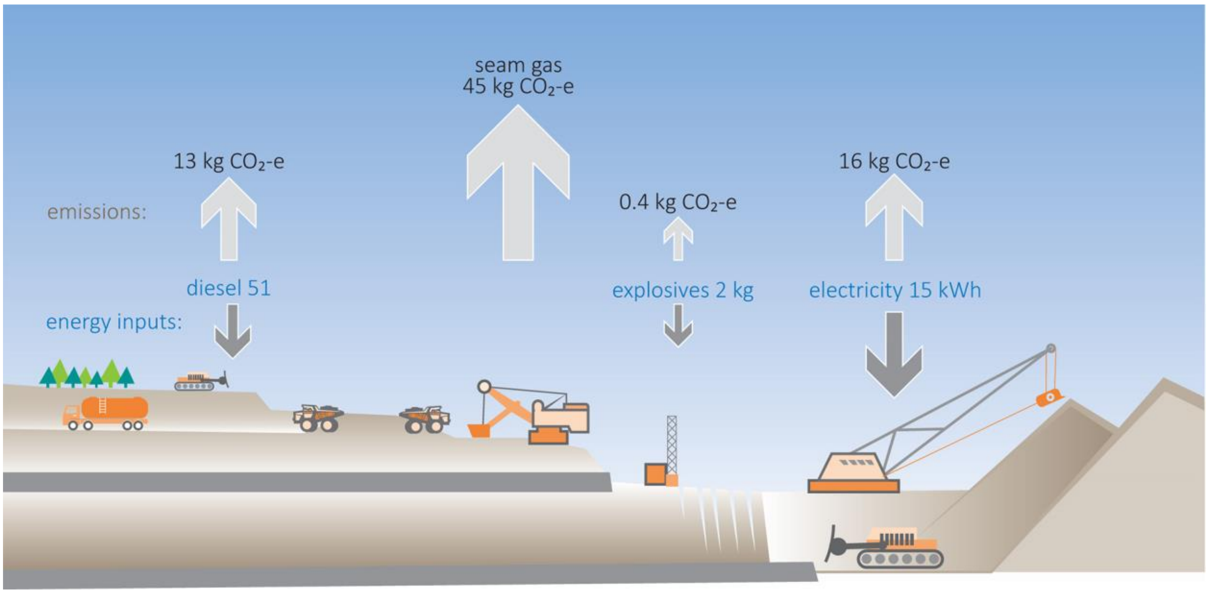

Figure 18 Energy inputs and GHG emissions per tonne of coal mined from surface coal mining in Australia (Goswami, 2016)

New blasting methods, in conjunction with better pre-analysis of seams prior to mining, mean that coal production rates are higher with fewer wasted zones and greater accuracy in mining the coal itself rather than surrounding rock. Improved blasting equipment and materials can also be effective in increasing coal productivity whilst reducing emissions.

Aguirre-Villegas and Benson (2017) studied the environmental impacts, particularly the GHG emissions in an average year, of an open coal mine in Indonesia producing 56 Mt/y of coal. The GHG emissions were calculated based on each GJ of energy in the form of the coal arriving at the ports of the import destination, taking the full transport chain into account. The modelling study obtained data on diesel use for transport vehicles and even included the delivery of this diesel from the refinery in Singapore. The work rates of the mining machinery were factored in along with overburden (OB) removal, administrative support (including generators and buses), crushing and loading activities. The GHG intensity of each of the processes are summarised in Figure 19.

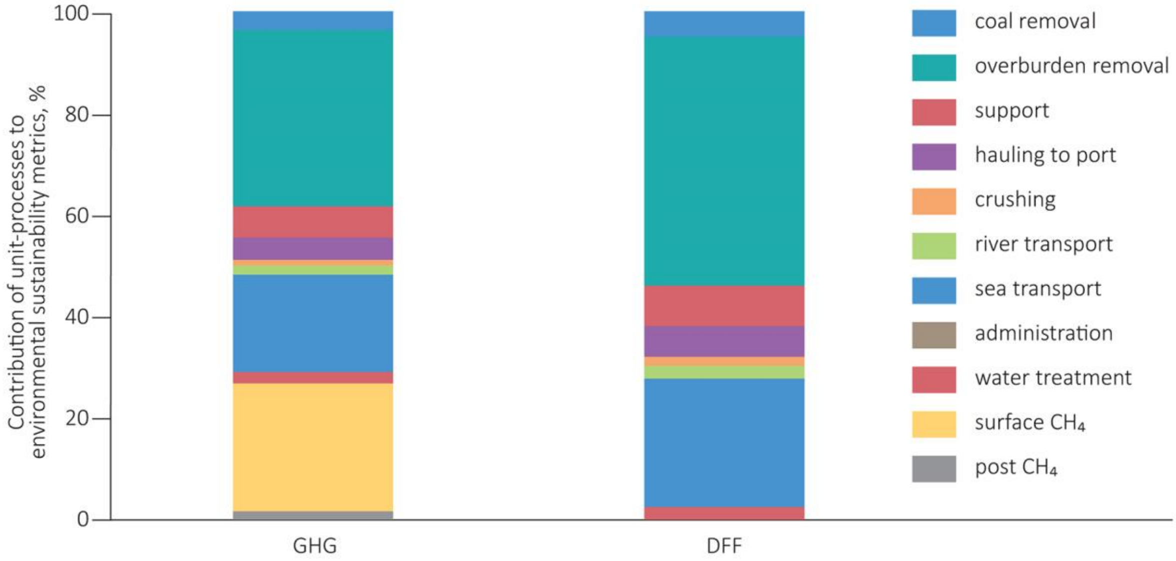

Figure 19 Contribution to GHG emissions and fossil fuel depletion (DFF) from mining activities and processes (Aguirre-Villegas and Benson, 2017)

As can be seen from the left column in Figure 19, most GHG emissions arise from the heavy machinery used in the removal of overburden at the mine site. Methane released during mining activities as well as the use of fuels for sea transport are also significant emitters of GHG in the coal chain. These data relate to Indonesian coals and, since the methane content of coal varies significantly with coal depth and location, the values may be different for other countries. For Indonesia, the removal of coal itself accounts for less than 5% of the total GHG emissions from the mining activity. In terms of the depletion of fossil fuel (DFF; in the form of energy production from coal and oil products) the greatest user of fuels is, again, overburden removal activities. The combustion of diesel in shipping is also a major contributor, along with fuel use in generators and public transport vehicles by the administration department, and haulage of the coal to the port.

Based on their analyses, Aguirre-Villegas and Benson (2017) proposed that GHG emissions could be reduced significantly at Indonesian (and possibly other) opencast mines by using conveyor belts for overburden removal rather than heavy vehicles.

5.1.2 Dust

Soil and coal are friable substances which release dust to the air during mining activities. The hauling, blasting and general movement and processing of coal leads to dust distribution into the air. According to Walker (2016), controlling dust is a profit and loss issue as well as a health concern. Coal dust in the air means less coal in the stockpile. Dust around mines and transport or storage hubs can cause aesthetic damage. Dust in the air and deposited around sites can be regarded as dirty and unattractive which can lead to complaints from the local community. Dust spread across machinery and instruments can cause physical damage such as faster wear or potential blockage leading to increased repair and maintenance costs. Staff involved in the cleaning of large industrial systems can be at high risk of physical injury (Strebel, 2017).

Dust emissions can be estimated in different ways:

- personal monitors worn on the body to monitor intake or exposure for health reasons;
- sampling and extractive monitors which measure dust loading by weight; and
- scanning systems, which can monitor airborne dust.

These systems provide only a snapshot of the dust loading in the selected sample area. Although numerous dust monitors can be placed around a site to give an idea of combined load, the total value for any site will always be an estimate. The advances in remote control drones mentioned earlier have led to several studies measuring dust around sites from above. For example, Alvarado and others (2017) used an unmanned aerial vehicle (UAV, or drone) to fly a laser particle counter over an open coal mining pit in Australia. Sampling occurs via a probe of 47 cm above the drone to ensure that air flow disruption to the sampling is minimal. Results from various tests suggest that this approach could be useful for emission estimates from mining activities and to improve existing emission factors.

The health effects of dust inhalation are discussed more in Chapter 6. The following sections look at options for reducing dust emissions at different points in the coal chain.

5.2 Emissions and control of dust from coal transport

There are several modes of transport available to move coal from its original location in the mine to its destination and each mode produces emissions. The dust from petrol and diesel vehicle engines combines with dust from the coal in the wagon or truck, and with dust from roads which will include dust deposited from previous transport activities. This all leads to a potentially significant amount of dust from a range of sources. The following sections focus on dust monitoring and control in different forms of coal transport.

5.2.1 Trucks and mine-site machinery

According to Pokorna and others (2016), particles larger than 1 micrometre (μm) in diameter can remain in the atmosphere for a few hours to a few days and thus have a significant effect on local air quality. For a village in the Czech Republic, around 30% of the coarse particles in the ambient air were traced to the coal surface mine ‘in proximity’ (exact distance not provided). For particles under 10 μm in diameter, <PM_{10}) it was found that coal contributed 22% to the ambient concentration, and that wood burning (34%) and re-suspended dust (30%) were slightly greater sources. Interestingly, 3% of the PM_{10} particulates were identified as gypsum, presumably also from the mine site. At the mine itself, 43% of the particles were re-suspended dust, 37% were from coal combustion, 16% from gypsum, and 4% from ‘mining technologies’ at the site.

Yadav and Jain (2017) report on the inhalable particles measured at different locations along the road network between the Jharia coalfield and other mining and non-mining regions in West Bengal, India. Unsurprisingly, inhalable particles were 2–2.5 times more concentrated in the mining area than in the non-mining area. High concentrations were also measured at several roadside locations between mining zones. Villages near the opencast mining regions of northern Colombia have also reported airborne dust concentrations which exceed daily and annual air quality standards (Yu, 2017).

The US EPA has tightened Tier 4 emission standards for off-road equipment since 2006, to help reduce emissions of particulates and NOx from engines used in off-road applications such as at mine sites. Tightening of these standards in 2015 is intended to reduce particulate matter by 80% and NOx by 45% compared with 2006 levels. These limits require the use of more efficient engines and highly controlled fuel injection systems; some need exhaust gas recycling (EGR) and selective catalytic reduction (SCR systems), both reduce NOx emissions (Tucker, 2017).

Ptak (2016) suggests that transport at mines is one of the most significant operational costs for any coal company. Productivity and safety are therefore of prime importance. Although standard dump trunks can carry out some mining work, many mine sites invest in purpose built trucks and machinery and this often pays for itself in terms of reduced running costs. For example, a 32 t four axle truck will use 12 L/h fuel less than a 40 t dump truck and, over a year of working 22 hours per day, 7 days a week for 360 days, this would mean an overall saving of 95,160 L fuel. These smaller, better designed trucks can save up to €95,000 per year (at a cost of €1/L) whilst also saving on maintenance costs.

Mining trucks can be designed to have hydraulic lifts and walls, covers and ramps and numerous modifications to make loading and unloading faster and more efficient and to reduce load loss during movement, even up steep inclines. New hydraulic cylinders allow faster movement of material; one commercial design (HYVA ALPHA) is 20% faster than alternatives allowing 388 more loadings in an average year for one mine site, resulting in 48 t more of material being moved. This can equate directly to increased profitability as well as reduced emissions (Ptak, 2016).

According to Walker (2016), simply slowing trucks down can reduce dust since less air flow and reduced particle momentum will mean that more dust remains and/or settles back on the original pile.

Dust settling on signage, especially important safety and speed signs, can be an issue. It can be tackled with specially designed reflector, wind-powered brushes and other cost-effective measures (Walker, 2016).

Other options for controlling dust during coal movement include (Posner, 2016):

- water sprays;
- chemical sprays; and
- dry fog technologies.

Water spraying is the oldest dust control method. Wetting the dust makes it too heavy and sticky to become airborne. However, wetting can cause damage to equipment by rusting and drying and, in many cases, it is impossible to wet the area evenly and sufficiently to control dust completely. Water tends to stay on the top of the pile meaning that any movement, such as during reclamation, simply results in delayed release of dust from the materials below the surface. Water sprays without surfactant are no use for controlling dust that is already airborne.

Water as a dust suppressant on roads within mine sites must be carefully controlled as too much water will lead to slippery roads and insufficient amounts will not control the dust. Computerised systems can regulate the amount of water used per area, vehicle speed and so on and expert systems can save water. For example, around 4 million litres per day can be saved by five trucks working an 18-hour day, totalling 1.4 billion litres per year of water saving. For Australia, this could mean a financial saving of AUS$2.9 million (>US$2 million) (Posner, 2016).

Chemical dust suppression works by binding dust particles together and by breaking the surface tension of water allowing it to penetrate deeper into the coal pile. Some chemicals act as binding agents and others create crusts to cover the surface of the coal pile (Strebel, 2017). However, these suppressants are reported to be only slightly better than water alone and can be costly. There may also be additional health and safety issues when new chemicals are required to be applied in bulk at a handling or storage site (Posner, 2016).

For loads travelling significant distances (such as by road or rail), the coal can be covered in a layer of chemical material, such as a latex sealing agent, to stop dust escaping. Natural materials, made from trees, can be used for this purpose. The material is sprayed on as a liquid but dries to a hard, durable surface (Walker, 2016).

Dry fog is becoming increasingly popular – dust is suppressed at the point of generation and agglomerated into dust particles which are heavy enough to drop back into the pile or process. Dry fog droplets are smaller (1–10 µm in diameter) than water droplets (30–100 µm) and therefore attract smaller dust particles without air stream issues allowing better conditions for agglomeration of $PM_{2.5}$ and PM_{10} particles. Dry fog systems create a blanket of fog over the process and will only wet the airborne dust, not the coal pile itself. Low quantities of water are used – a dry fog nozzle can produce enough fog to cover a football pitch from only 1 gallon (3.78 litres) of water. An unnamed coal loading facility in Europe has used dry fog systems at all times during coal reclamation and has reported an 80% reduction in dust emissions in the targeted areas (Posner, 2016).

Fugitive dust is unavoidable during the movement of coal from transport to storage sites and during reclamation and delivery to the place of final use. However, this dust can be minimised. Giant mobile dust controlling systems are available which can be delivered with their own diesel engines to be positioned at almost any location. One such system, provided by DustBoss, can run for 32 hours without refueling. The system runs a large fan plus a water pressure system to provide a low water use system that sprays 50–200 micron droplets directly over the area where fugitive dust emissions are expected to occur (Coal International, 2016d).

5.2.2 Rail transport

Figure 20 shows the coal chain in New South Wales (NSW), Australia, from the mine to the port, via the railway. Along this transport route, particulate emissions can arise from the surface of loaded wagons, from residual coal in empty wagons, from the diesel locomotives and from the roads and tracks being travelled, including re-entrainment of previously spilled or deposited coal and other dust.

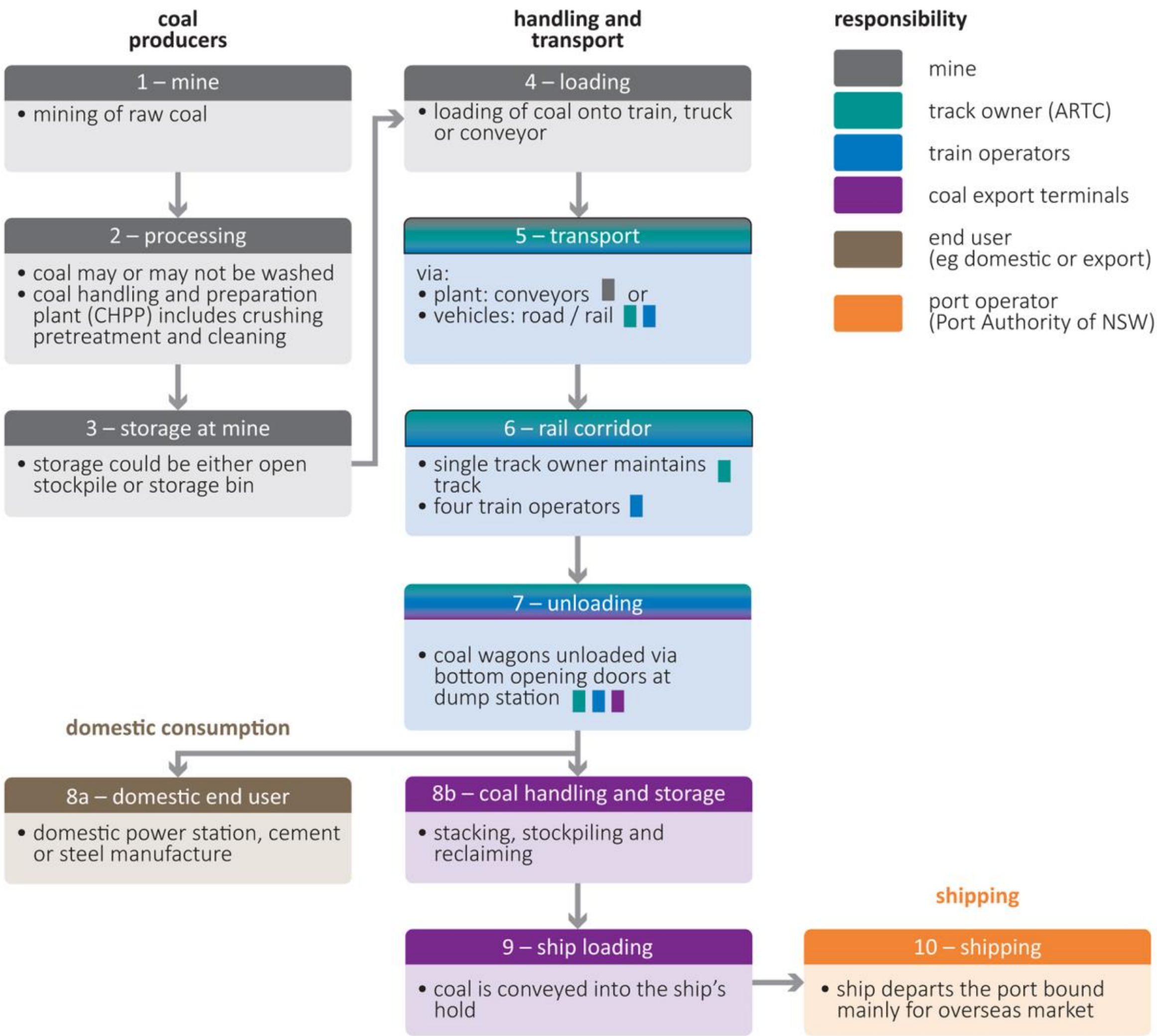

Figure 20 The coal transport chain in NSW, Australia (O'Kane, 2016)

Determining how much dust along a rail route comes from the coal and how much is from the diesel train or the disturbed track area has proven difficult. Whilst some studies suggest that up to 80% of dust emissions come from the coal in the carts, other studies have shown that this is not the case. Passing freight and coal trains can increase levels of particulates by 10% above baseline levels with data suggesting that this is more due to diesel emissions than coal dust. Re-entrainment of previously deposited dust was also shown to be more of an issue than coal dust released from the wagons. From the NSW review it was concluded that it was difficult to determine the behaviour of dust along a transport route with any accuracy, especially when weather and other factors are considered. Interestingly, the study also suggested that it is not possible to determine whether the change in dust levels and plume dispersion at any site are sufficient to affect health above that from background concentrations (O'Kane, 2016).

In Australia, the environmental impacts of the rail transport of materials falls under the responsibility of the rail operator. Any specific issues of potential effects (such as dust release) depend on the contractual arrangements between the transport operator and the suppliers of the materials to be transported. However, many sites will have requirements to monitor and minimise emissions from all activities on site within their own licencing and operating procedures. This means that, in addition to dust control strategies at the mine and in storage areas, similar strategies should be created and followed at transport depots and port terminals (O'Kane, 2016).

Dust control measures similar to those for trucks (*see* Section 4.2.1) are used in the rail industry. For example, Aurizon, the Australian coal mining company, ensures that all its coal loaded in Queensland is sprayed with a biodegradable veneer which helps reduce dust lift off by 85% (Aurizon, 2017). Interestingly, a study in Queensland, Australia, showed that as much dust was being released from unloaded coal wagons as from those loaded with coal. This result prompted the government to request that the rail operator clean the wagons fully with a combination of air and water before returning them to the mines (Thompson, 2013).

Figure 21 shows the major licences which have been created relating to coal and its transport within the Hunter Valley region of NSW. Between 2009 and 2016, several guidelines and initiatives have been established to evaluate areas of concern and to create strategies for control and mitigation of dust releases.

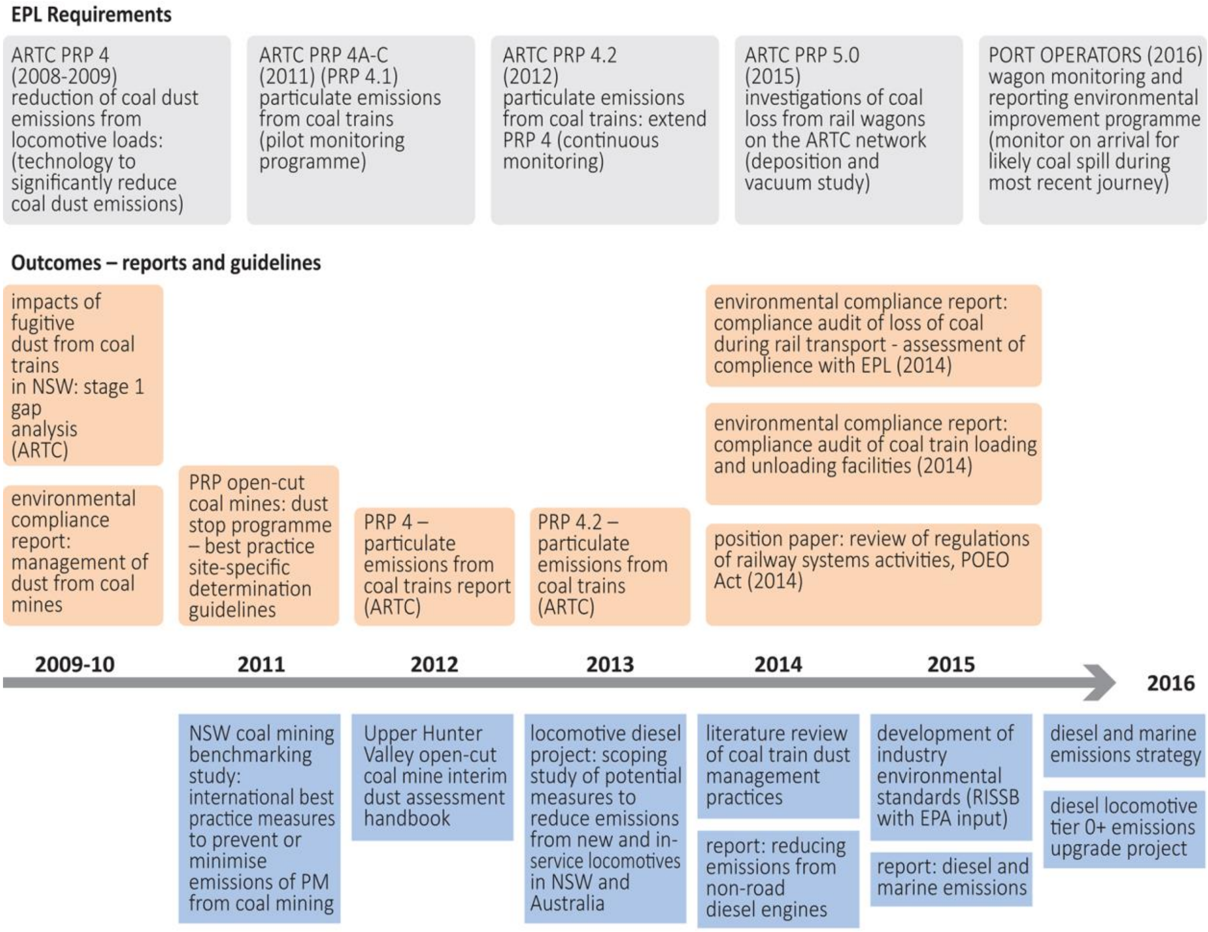

Figure 21 Special initiatives and studies related to coal and coal transport in NSW, Australia (O'Kane, 2016)

The strategies include guidance on:

- Asset design and operation management – selecting the best equipment for each job and operating it correctly.
- Wagon loading practices – optimisation of transfer between stockpiles, weighing machines, chutes and wagons.
- Rail transit – application of water or chemical suppressants to stop dust emissions. Also, best driving practices to reduce acceleration which could disrupt piles as well as keeping trees and other obstacles on the route to a minimum.
- Unloading practices and transfer methods – keeping disruption and leakage to a minimum.

SUEK, the Russian power company, actively co-operates with leading Russian machine-building companies and has been involved in the production of innovative train wagons with a carrying capacity of 75–77 tons (which is 5–7 tons greater carrying capacity than a standard wagon). In 2015, SUEK operated 9160 such innovative wagons, 20.3% of the total wagon fleet (SUEK, 2017). More coal in each wagon means a smaller surface area to volume ratio meaning less dust release and lower costs for dust suppression.

Katestone Environmental (2014) have produced an excellent review of coal train dust management practices and the interested reader is referred to this document for further information.

5.2.3 Ports

Ports are another area for potential dust release. Several companies have proposed building a coal port in the Pacific Northwest to expand the export of PRB coal. However, Gateway Pacific appears to be the only company still working towards building a port. The site chosen, at Cherry Point, Whatcomb County, would be used to export some of the world's cleanest coal to replace dirtier coals being burned in emerging economies. The site has excellent depth, for Panamax and Cape-size ships. Several plans have been submitted and modified, with the latest version having a reduced footprint and a wetland impact reduced by 49% (Gambrel, 2015a).

India has 12 major and 200 non-major ports along its 4671-mile (7517 km) coastline. Only three of these can accommodate Cape-size vessels. Delivery of coal via Indian ports has been problematic in the past. In June 2014, around 15 ships were stranded in Paradip Port, each carried 90 Mt of coal and took up to six days to unload. Mine workers often unload the coal using inefficient clam shell cranes, moving the material into piles and on to trucks and coal carts, causing dust and local spillage issues. Essar Energy, one of the more progressive companies in the region purchased two modern uploaders for dust-free loading but have struggled to use them in practice as there is insufficient space at the site to position the machines correctly (Gambrel, 2015b).

5.3 Dust control during storage, reclamation and blending

Coal is often stored for periods at mines, at transport hubs, blending sites, washing facilities and at the plant itself before it is finally used. During this time, there can be problems with spontaneous combustion and related emissions, dust emissions and water run-off. Spontaneous combustion and its control is covered in more detail by a previous CCC report (Sloss, 2013).

At sites where coverage is not in place, dust continues to be a concern, especially when coal is being moved, such as during reclamation and blending. According to Posner (2016), wind speeds as low as 9 mph (14.5 km/h) can stir up coal material enough for it to become airborne. Stronger winds can lift more material and carry it further. Drier materials, or piles which have been stored for longer periods without rainfall, will become airborne much more easily. Buckets, scoops and conveyors, used to move, lift and disperse coal, often create local clouds of dust. Dust emissions can be greatest at points where the flow or process changes speed or direction, such as the ends of conveyors, drop chutes and impact points. Fast moving conveyors can be significant sources of dust as particles are blown off due to the momentum as well as airflow. Strebel (2017) lists three main methods for reducing dust release during coal movement:

- Containment – coverage to reduce the escape of dust from the working zone. This can include hoods, lids, skirt seals, and deflector plates;
- Prevention – dust movement can be prevented by either reducing the air movement over the coal or by increasing the size of the particles to make them heavier. If space is available, settling areas can be created to give dust time to settle before the next stage of movement;
- Collect, suppress or clean the dust from the air. Positive air pressure within dust bags or closed areas can help to either resettle dust or to collect a filter cake that can return collected material to the conveyor (*see* Figure 22 below). Active dust collection systems can be added to filter dust from the surrounding area, either returning the dust to the process or to a disposal point.

Figure 22 shows a generic dust collection system. The ducting runs at negative air pressure, using a fan to pull the air flow from required areas and separates and collects the dust via cyclone or filtration systems. The pick-up hoods can be placed at required points over chutes, conveyors or another process, drawing in the airflow on a continuous basis (Bangalore Airtech, 2017).

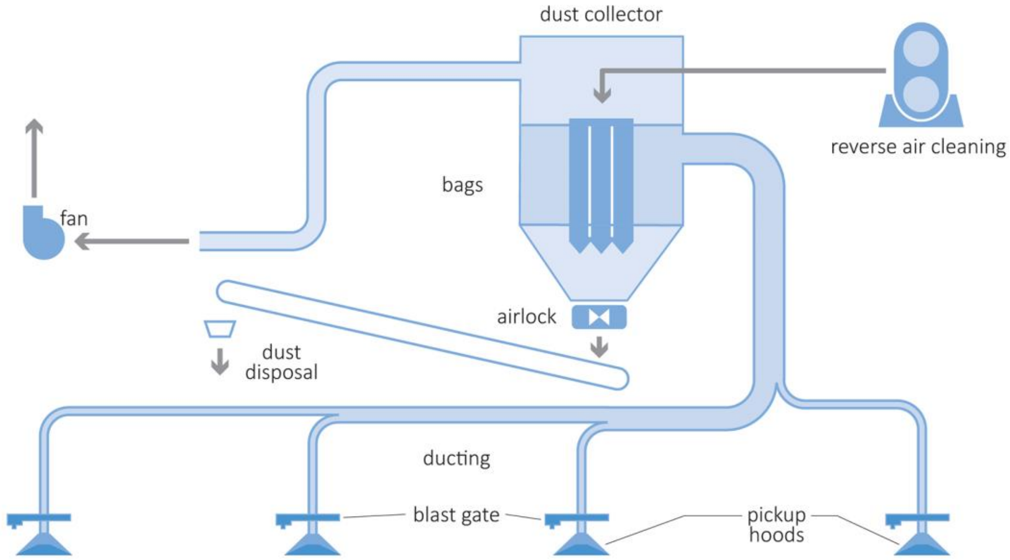

Figure 22 Dust extraction system (Bangalore Airtech, 2017)

Dupont has demonstrated its award winning 'smart' dust management system at the Newcastle Coal Terminal in Australia. The system is reactive, predictive and proactive, responding to changes in weather conditions and coal type. It can predict a dust risk up to 36 hours in advance, allowing mitigation measures to be instigated before adverse weather effects happen (Dupont, 2017).

When coal gets wet it can cause problems with clogging and, of course, a reduced efficiency during combustion. It is therefore increasingly common for coal to be covered during extended periods of storage. For some sites, especially older ones which were not designed with coverage, building new roofs and protection can be expensive and problematic. Some sites are too large or have uneven terrain (Alves, 2017). Commercial companies such as Geometrica have developed flexible and versatile systems which can be designed to adapt to any terrain and conditions. Figure 23 shows a coal storage dome built for a stockpile area in Tunisia.

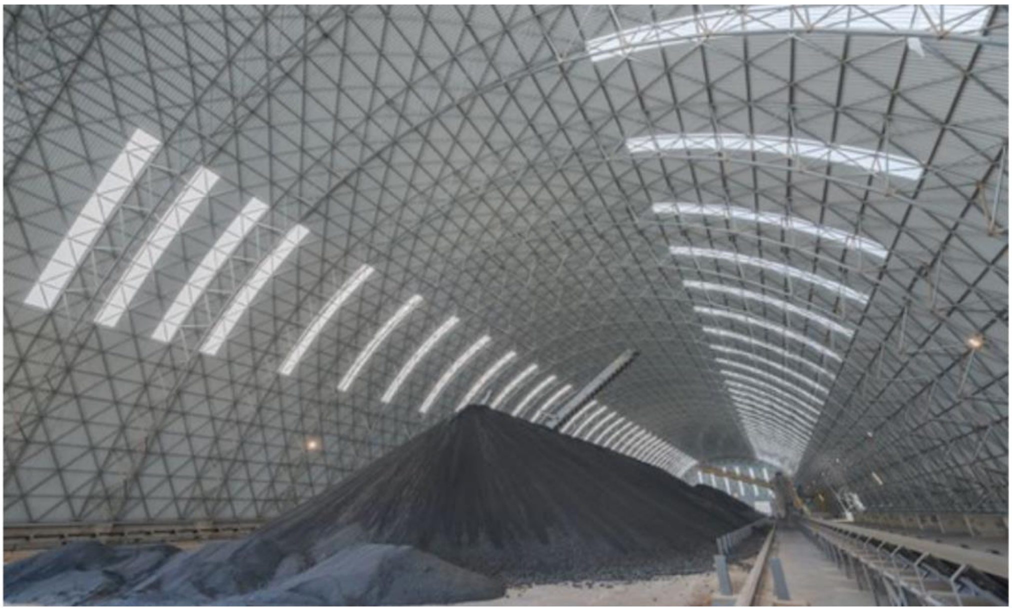

Figure 23 Coal storage dome in Tunisia (Geometrica, 2017)

The system requires no welding and construction can be carried out by locally-sourced labour. Similar facilities have been constructed in Indonesia, Taiwan, Qatar and Florida (Geometrica, 2017; Alves, 2017).

Dome technology, USA, provide similar silos and have fitted two large dome storage facilities for China Coal. The dome covers the coal arriving from the mine and stores it until it leaves, via the cleaning or washing system, to the mills before transfer to trains for transport. The height (unspecified) of the domes means that the 60 kt of coal inside can be stored on a small footprint compared with a warehouse or flat storage site. The site uses low volatility coal and therefore has a lower risk of spontaneous combustion than other sites. The coal is also processed in a first in-first out manner to keep residence time low. The structures have no internal support trusses or posts so there is nowhere for dust to settle; secondary explosions can be caused by the loosening of accumulated coal dust. The domes can also be sealed shut, cutting off oxygen and introducing nitrogen to suppress any ignition issues. Being sealed and seamless, the dome does not allow dust to escape from the storage facility and so run-off and leaching are not issues. Dust produced inside the dome is pulled through a wet scrubbing system and can be collected for combustion or disposal. There are six of these domes in Inner Mongolia with 100% live reclaim, fire prevention and environmental protection all secured by the design of the facility itself (Pyper, 2016; 2017).

5.4 Case study: dust management – Port Waratah Coal Services

Port Waratah Coal Services (PWCS) run a partnership of over 25 organisations which comprise the Hunter Valley coal chain in Australia. The area covered amounts to 450 km^2 and includes the mines, rail haulage, rail services, export terminals, port managers and the Hunter Valley Coal Chain Coordinator. The area covered is shown in Figure 24 and includes 40 mines, four main rail haulage providers, three load points and three terminals at the port.

Figure 24 Members of the Hunter Valley Coal Chain (PWCS, 2017)

The PWCS has an award winning 'intelligent dust management system' which predicts and manages dust emissions and has become a benchmark for similar systems globally. The website hosts monthly production statistics for the area and offers a 24-hour response guarantee for any concerns about air quality or noise in the region. Deposited dust is measured monthly and ambient dust is measured for a 24-hour period every six days using a high-volume air sampler. Water discharge is also monitored and pH, total suspended solids, and biochemical oxygen demand are all measured and reported.

The dust management process is summarised in Figure 25. The system considers the local weather and minimises dust emissions before they happen by increasing moisture levels.

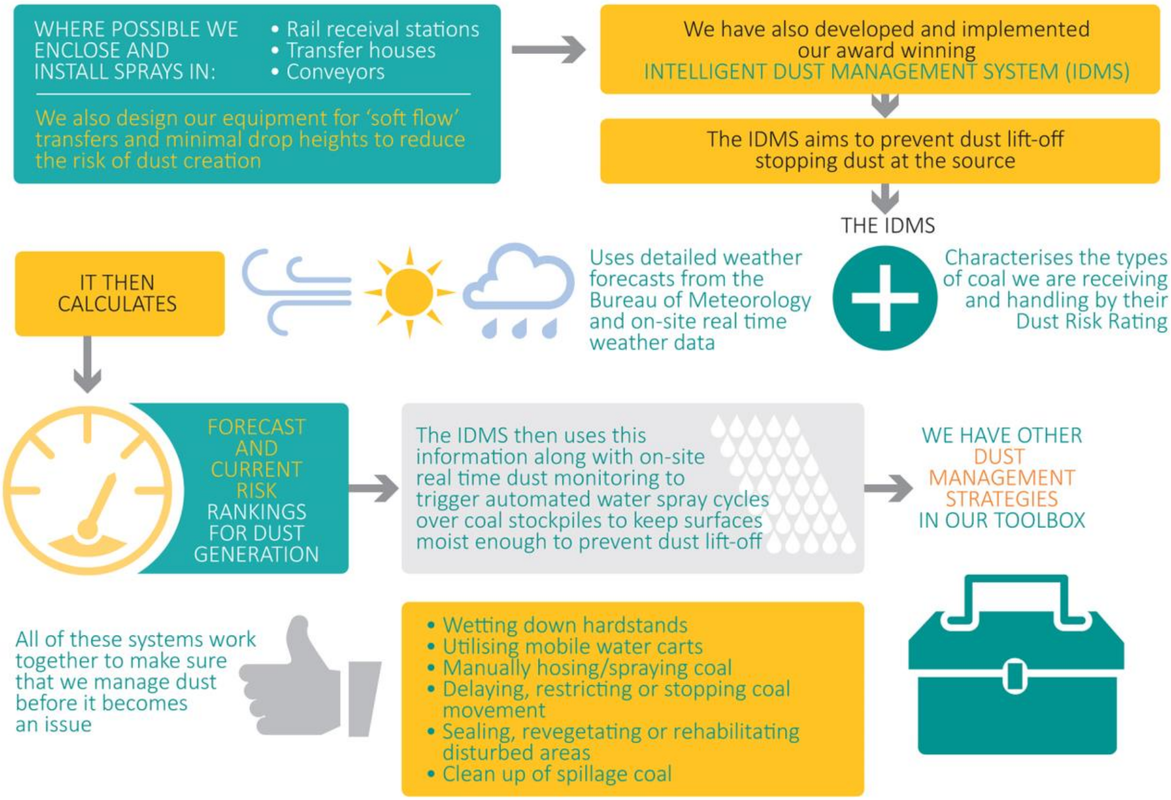

Figure 25 How dust is managed at Port Waratah (PWCS, 2017)

Noise is monitored on- and off-site quarterly. Water from the site is collected through a series of pipes and water channels and 85% of this is recycled for further use at the site. There is an efficiency management plan to increase the efficiency of machinery and systems on the site and a 10.7% reduction in kWh has been achieved over 10 years, equivalent to almost 16 kt CO_2.

5.5 Comments

Coal mining can release methane emissions. Methane is a major GHG and a combustion risk and so control, capture, and, if possible, use of coalbed methane for power projects can be a win-win situation. Dust is more of a problem. Dust arises from coal itself but also from vehicle engines and surrounding soil and road surfaces. Sampling of dust can pinpoint areas of concern but will never be able to give an accurate view of total emissions nor can it fully determine the source of the dust. To keep dust to a minimum, the whole coal transport chain must be considered, from mining vehicles through road trucks and rail wagons, to ports, if the coal is exported. Even stationary coal piles and areas for blending can be sources of wind-borne or agitated dust. Wetting and suppression techniques can work to keep coal dust in vehicles but are an added expense. Covering stockpiles and handling areas will reduce dust blow-off as well as providing an option to recapture this released dust. Port Waratah in NSW, Australia, is an excellent case study of a network of coal mines and transport organisations who have worked together to reduce dust emissions from the mine site all the way through to the shipping port. And, although the programme required investment to set up, savings are achieved in terms of improved working and environmental conditions as well as reduced noise, and GHG emissions from efficiency improvements.

6 Other major external effects of coal mining

In addition to the environmental effects discussed in previous chapters, there are other externalities of coal mining which relate to human health and local communities. First there are the health and safety risks for the individuals associated with mining. Then there are the socio-economic impacts – whilst coal mines can bring employment and economic benefit to communities, they can also cause disruption and potentially have long-term environmental impacts.

6.1 Health effects

Health and safety measures benefit everyone – staff and workers are protected from injury whilst the company saves on costs for damages, lost worker days, and potential law suits. Health and safety measures are a requirement for any workforce, but for mining, they cover more dangerous activities and exposures than for most other occupations. Although no data are available, it is generally accepted that the benefits of investment in health and safety far outweigh the costs. The ICMM (2017) separate health and safety at mines into two separate issues. Within health issues, the following subcategories apply:

- **Occupational health**, relating to impacts caused by the physical working environment, such as potential physical injury, musculoskeletal disorders, lung disease, noise-induced hearing loss and cancers.
- **Health risk assessment**, is the planning and organisation of mining activities in such a way as to pre-empt and prevent potential issues, to ensure minimal accidents and lost working days.
- **Community health**, relating to potential communicable diseases and other primary healthcare issues in the employees' community.

With respect to safety, the ICMM recommend focus on:

- **Critical control management**, areas where decisions must be made to ensure continual improvement and learning.
- **Emergency preparedness**, to reduce risk and to limit damage in potentially dangerous situations.
- **Preventing fatalities**, by evaluating the risks of activities such as vehicle use, rock falls or explosions, and ensuring employees are trained appropriately and continue to work with good practice.
- **Safety data and indicators**, the efficient monitoring and logging of events or near misses, to encourage information and knowledge sharing.

The remainder of this section concentrates on dust inhalation and noise, particularly relevant concerns at coal mining operations.

6.1.1 Dust inhalation

Dust particles over 10 microns in diameter and up to 100 microns – PM_{10} – up to PM_{100} - are categorised as respirable or inhalable which means that they can travel via the airways into the nose, throat and upper respiratory tract. This is likely to lead to discomfort and coughing. In most cases, large particles will be removed by the body's natural cleaning mechanisms. Particles smaller than this – PM_{10}, $PM_{2.5}$ and below – can travel deeper into the lungs and alveoli where they can cause irritation and further health effects (Strebel, 2017). Although drastic detrimental health effects from coal mining are often considered a thing of the past, new cases of black lung (coal worker's pneumoconiosis) have been increasing in areas including the USA and Australia since the 1970s (Rowland, 2017).

Dust and fine particulate concentrations are regulated in most countries under air quality limits and most modern economies have networks of monitors throughout the country to report concentrations, often in real-time, from both urban and rural locations. Monitors may also be located close to areas of concern such as busy traffic junctions or industrial sites. Most industrial activities, such as combustion sources and mining activities, have their own site-specific monitoring requirements and limits. For example, in 2016 the USA reduced allowable dust levels in mines from 2.0 mg/m^3 to 1.5 mg/m^3 and introduced the requirement for continual dust monitoring. Alarms are raised if dust limits are exceeded and ongoing health surveillance, including X-rays, are required to track worker health. However, current methods of monitoring do not allow the immediate response to increased dust concentrations that is desired. Most monitors work by collecting particles of a respirable size on a filter over an extended period – usually about eight hours. The analysis then takes a further two weeks – meaning that, in some, cases, damage is already done. Alternative methods, which employ optical particle counters (OPCs), are reported to be prone to clogging, becoming inaccurate and then failing completely. However, open real-time open path OPCs are being developed which have no clogging or delay issues and can feed data from dust monitors within the mine directly to the supervisory control and data acquisition systems (SCADA). This allows for both early warning of potential high dust issues and acts as a log for the long-term concentrations workers are exposed to during shifts (Rowland, 2017).

In 2016, the US Mine Safety and Health Administration required coal operators to increase the number of air samples taken in underground mines as well as requiring real-time monitoring for miners working in the dustiest of conditions. The aim is to end black lung disease which still kills around 1000 miners per year in the USA. The National Mining Association (NMA) in the USA opposed the new rule, arguing that the increased requirement for sampling would cause operational issues by interrupting production but their opposition was overruled in the US Court of Appeals. Samples must be taken in areas of concern (high dust) at a rate of 15 samples per quarter, up from five samples every two months previously. This can be in the form of sampling in common working areas or from personal sampling equipment worn by individual miners. A further 15 samples from other mines must also be taken during the quarter. The aim is to collate the data to provide further information on black lung disease. It is alleged that cases of black lung among miners may be higher than reported. Over 700 cases were reported between October 2010 and September 2015. However, 3675 miners were awarded black lung benefits between 2010 and 2014 (Lovan, 2016).

6.1.2 Noise

Although not covered in any of the other literature reviewed for this report, Goswami (2013) reports on the elevated noise levels around some equipment used in mining. Underground equipment such as haulage gear, ventilators, fans, and cutting and drilling machines all add to combined noise levels which can range from 80–1040 dB (decibels). Permissible limits are set at 90 dB to prevent hearing damage in workers. Levels above the 90 dB limit for up to 8 hours a day can occur in Indian mines running older and poorly maintained machinery. Bauer and others (2006) carried out a study of eight underground coal mines, ten surface coal mines and eight coal preparation plants in the USA and found that over 40% of all workers monitored were subjected to noise exposure above the 90 dB limit.

Figure 26 shows the cumulative dose of noise received by a mechanic working at a coal preparation plant in an unspecified US mine.

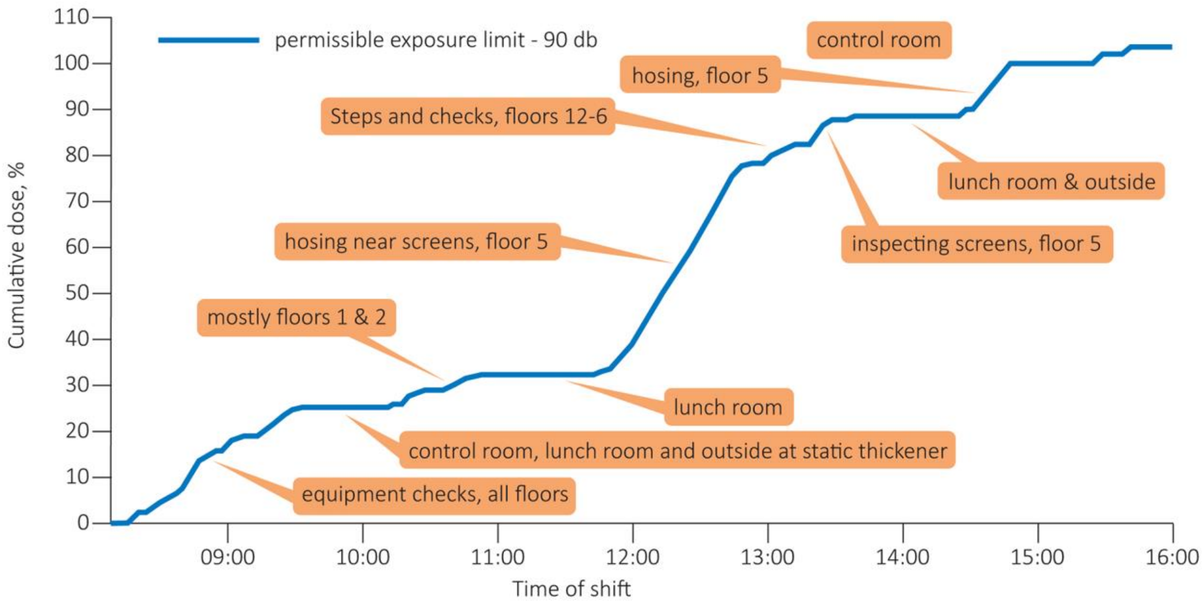

Figure 26 Cumulative dose plot for stationary equipment operator in coal preparation plant (Bauer and others, 2006)

The graph shows the additive effect of various equipment and background noises on the overall noise experienced by one operator over a full shift of work. As can be seen from the scale, this worker exceeds the recommended noise intake before the end of the shift. This is also the case for other workers using heavy machinery, where the overall recommended noise exposure is exceeded during a working day. Bauer and others (2006) recommended several ways to reduce worker noise accumulation which included modification of equipment, removal of the worker from noisy areas at regular periods, and adjustment of shifts and work duties to minimise noise exposure across the workforce. Noise reducing headwear and earphones can also be used but may introduce a safety risk in some situations where workers may be less likely to hear warning alarms.

6.2 Accidents and risk management

The US coal mining industry recorded 11 fatalities in 2015, a record low. Most of the incidents involved power haulage and machinery, eight were at underground mines and three at surface mines. Full investigations are required for any such accidents and the US Mine Safety and Health Administration (MSHA) issues a report on each, often with follow-up requirements for amendments or upgrades in the site health and safety guidelines and training requirements (Schmidt, 2016b). Measures for promoting health and safety in coal production range from warning posters to long term training and computer monitoring and training systems.

Countries including Finland, the Netherlands and Russia have 'zero accident' targets and initiatives, working through training programmes to increase safety in industries such as mining. However, although 27 European companies released corporate programmes based on 'zero injury' initiatives, none of these were related to mining or mineral production. There is no such information on programmes, nor official accident data provided for China (Kazanin and Rudakov, 2016).

Table 7 shows the number of accidents in the coal mining sector in the EU member states between 2009 and 2013. Numbers of fatalities are shown in parentheses.

Table 7 Number of accidents (fatalities) in the mining sector in EU member states (Kazanin and Rudakov, 2016)

Country	2009	2010	2011	2012	2013
Poland	2266 (36)	2201 (15)	1930 (18)	1766 (16)	1571 (8)
Spain	2624 (2)	2256 (1)	1798 (6)	1690 (1)	1372 (6)
Germany	558 (0)	520 (0)	430 (1)	272 (2)	297 (1)
Czech Republic	542 (1)	449 (2)	516 (7)	17 (5)	0 (0)
UK	290 (3)	224 (1)	282 (6)	271 (0)	157 (0)
Romania	281 (4)	241 (1)	182 (7)	159 (0)	111 (0)
Norway	128 (0)	28 (0)	140 (0)	100 (0)	24 (2)
Slovenia	117 (0)	115 (0)	78 (0)	110 (0)	89 (0)
Bulgaria	61 (3)	62 (1)	68 (1)	59 (1)	63 (7)
Italy	42 (0)	45 (0)	25 (0)	39 (0)	34 (0)
Slovakia	7 (0)	0 (0)	1 (0)	0 (0)	203 (1)
Hungary	2 (0)	3 (0)	2 (0)	1 (0)	84 (0)
Finland	0 (0)	0 (0)	18 (0)	0 (0)	32 (0)

These data suggest a general decrease in accidents and deaths over time, reflecting both reduction in mining activities as well as improvements in conditions and equipment technologies in some regions. However, single accidents which result in multiple injuries can affect performance statistics significantly. The Australian government noted a gradual but inconsistent decrease in occupational injury rates at coal mines following the introduction of the Safe Work Australia programme. Kazanin and Rudakov (2016) calculated absolute and relative values for occupational fatalities in the coal mining sector in the EU in 2012/2013 and found them to be highest for Spain in 2013 (3.33 fatalities/Mt in 2013) and Bulgaria (1.49 fatalities/Mt in 2013).

The US National Mining Association (NMA) has developed the CORESafety system, a health and safety management programme based on 20 elements to engage employees in accident prevention. Peabody

Energy was the first mining company to receive independent certification under the system in 2016 (Coal Age, 2016b).

Health and safety measures can contribute to increased productivity. Although it is possible that improved health and safety compliance could slow down some work practices, safer working conditions mean fewer days lost to injury and fewer equipment breakages. For example, the Hexagon Mining Collision Avoidance System (CAS) helps workers manoeuvring heavy machinery avoid accidents due to blind spots and other issues associated with working in physically constrained areas. The 360° proximity detection gives drivers early warning of potential accidents, especially during periods of fog or high dust or at night. Around 40% of vehicle collisions at the Barrick Cortez mine in Nevada were due to blind spots which are completely avoided with the CAS system. Following the introduction of the CAS system in Queensland, Australia, vehicle accidents dropped from 14 in a year to only two over the following two years. The CAS system can also be enhanced with vehicle tracking and speed monitoring to ensure that drivers remain within the speed limits in each working area. Although Judd (2017) notes that it is not possible to determine how much these systems save in terms of reduced time loss and vehicle offline and repair time, the effect is likely to be significant. For example, a mine with one 2-vehicle accident every year would spend US$4.3 million over this period on repairs, replacement and downtime. Since the CAS system costs US$1.8 million over the same period, the investment is valid – fatality costs are cited at around US$20 million. Fatigue monitors and alcohol testing systems can also be built into a CAS system. Ultimately a vehicle intervention system (VIS) option can be added. The VIS will activate automatically when a warning is given and can shut down the vehicle immediately if a potential incident is possible (Judd, 2017).

The CAS and VIS systems are just two examples of a growing number of automated systems designed to reduce injury in potentially dangerous work environments. A further example is Arch Coal's Thunder Basin Coal Company, which is using a Cat Minestar Command for bull-dozer work at their site in Wyoming, USA. One operator can operate multiple dozers from an office environment. Ultimately computer controlled mining systems will be safer and more efficient than human operators and are likely to be sound investments for future projects (Coal International, 2016c).

6.3 Socio-economic impacts and public attitude to mining

According to Yu (2017), some people believe nothing has changed for mining communities and that adverse effects on ways of life, health and the environment continue whereas others believe that new sustainable coal mining practices can have positive effects on local populations. Also, according to Krsemien and others (2016), following past incidents of bad mining practice in some regions, "the mining industry must regain its reputation which has been lost over decades of environmental degradation".

Mining is important for many communities in terms of employment, the economy and social development. Attitudes to mining will vary according to the information provided, the perception of this information and the resulting attitude. Also, those who are in employment at the mine are more likely to be in favour of mining activities. Of course, information can vary depending on the source – whether it is direct information from a company or organisation, whether it is impersonal or indirect information obtained from another source, or whether it is personally gained from first-hand experience. The real 'image' or facts about a mining project can be distorted by public opinion or a collective distortion of the reality. Although mining activities can be affected by justifiable concerns over environmental and social issues, pressure groups may target activities without sufficient justification. It is important that mining activities consider local concerns about potential detrimental issues but, at the same time, they deserve to make their case for their projects based on facts rather than unfounded rhetoric. Martin and others (2014) carried out a study to determine if it were possible to evaluate the reliability and validity of a scale to measure the image of the mining industry. Interviews were carried out with over 400 residents of the mining regions of Peñarroya-Pueblonuevo and Belmez in Spain and the results were collated using confirmatory factor analysis. A survey was taken of people involved with the mine either as owners or employees or simply as those who lived nearby and had no direct link to the mine, the results of which are shown in Figure 27.

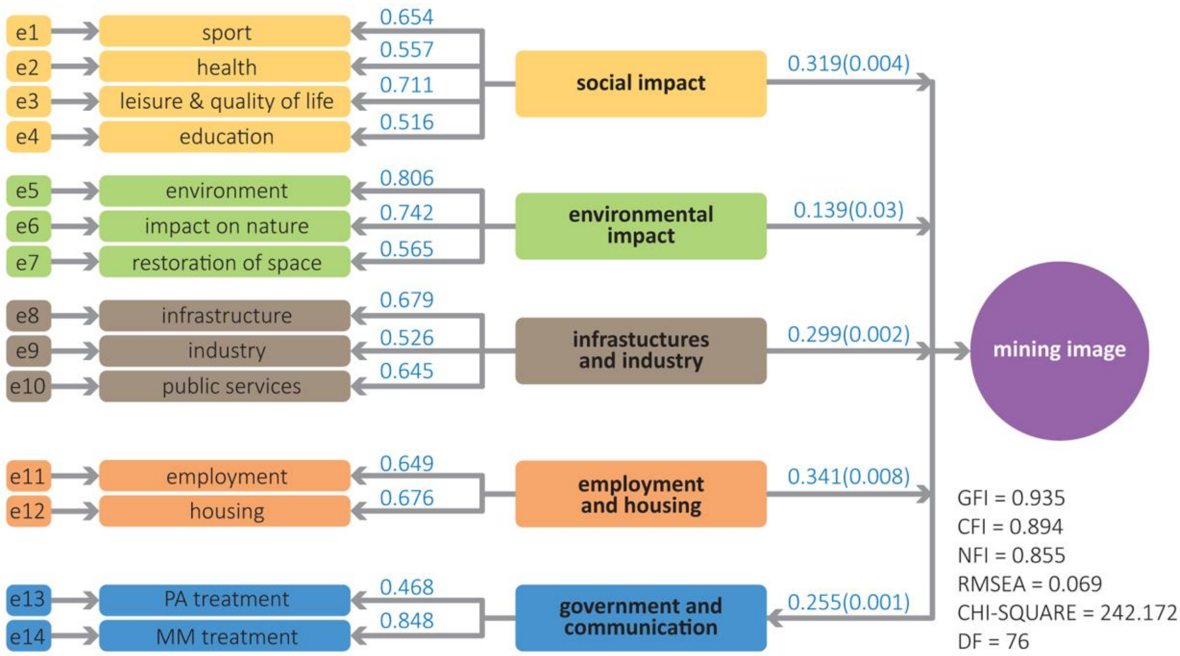

Figure 27 Impacts of different factors on the image of mining in a community (Martin and others, 2014)

It shows the value for social impact is a negative value – that is, mining is seen as having a negative effect on quality of life. Conversely, the relationship with environmental impact is slightly positive, suggesting that the interviewees were aware of the commitment of mining companies to protect the environment. The other factors, infrastructure and industry, employment and housing, governments and communication, all had even greater positive relationships, suggesting that the public appreciate that mining activities lead to employment and community growth. Martin and others (2014) suggest that, although the sample pool was small and the questions limited, the results imply a high potential to enhance further the public understanding of mining research and policy making.

Frantal (2016) studied the public opinion of coal mining in two villages in the Most region of the Czech Republic where coal mining has caused significant damage to some regions and the displacement of over

90,000 people between 1949 and 1980. More than half of those that responded felt that coal production should be severely restricted and alternative sources of energy found. Over two-thirds of residents in Horní Jiŕetín and half of those in Janov have been involved in protests against the expansion of mining in the region. Conversely only 5% of those in Horní Jiŕetín and 16% of those in Janov were reported to support the mining. The breakdown of attitudes by age, sex, education and employment are summarised in Table 8.

Table 8 Geographical and socio-demographic differences in attitudes to coal mining in the Czech Republic (Frantal, 2016)

Variable		Attitude (%)			Value of correlation*
		Convinced pro-coal	Reserved	Anti-coal	
Residence	Horní Jiŕetín	7	32	61	0.359**
	Janov	19	32	49	
Place attachment	Low	22	34	44	0.262*
	Medium	15	30	55	
	high	0	31	69	
Gender	Males	15	34	51	NS
	Females	14	31	55	
Age	<20	0	50	50	NS
	20–29	20	13	67	
	30–39	18	27	55	
	40–49	20	30	50	
	50–59	11	44	45	
	60+	10	35	55	
Education	Elementary	10	35	55	NS
	Secondary	16	34	50	
	Tertiary	7	29	64	
Employment in coal industry	Yes	25	67	8	0.465
	No	4	32	64	
Total		14	32	54	

Note: values of correlation are significant at the level **<0.001 or *0.05. NS = non-significant

The data in the table suggest that those under 20 years old and those over 60, as well as those with a higher level of education, were more likely to oppose coal mining activities. Those with higher perceived attachment to their location were also more likely to oppose mining activities. The level of support for mining in both regions was low, with, unsurprisingly, those working in the coal mining industry the group most likely to support further mining. If further mining activity is to be established in this region, there will be a significant amount of work required to assure the current population that any future mining is necessary and will not cause further environmental damage.

Mining activities can have a significantly positive effect on employment and community growth. The mining industry in Poland has been established for decades and is vital to the country's economy. According to

Halasik and Kulczycka (2016), closure of Polish mines would have serious social, environmental and economic consequences. This would include mass layoffs, and reclamation of mining areas which would require 'enormous financial expenditure'. As Poland is heavily reliant on coal and the Polish public are generally supportive of the coal mining industry, meeting environmental standards in Poland for mine reclamation will require investment in social acceptance.

The UN's Berlin Guidelines (*see* Chapter 3) require that the community is consulted and encouraged to participate in all issues of mine planning, operation and closure (UN, 2002). Citing the World Bank's pollution prevention handbook from 1998, the UN suggests the following for the consultation and participatory process:

- start the participatory process as early as possible in the project design;
- ensure government support for a participatory approach;
- identify and then involve the stakeholders;
- involve intermediary NGOs who have local credibility;
- identify and involve responsive individuals or agencies in government;
- build community capacity to make decisions and to convey information back and forth;
- make a particular effort to understand the concerns of the poor, who are often not well represented;
- facilitate women's participation, as they may not be represented in the formal structures; and
- consider institutional or regulatory measures to support participation.

By engaging the local population early and effectively, there is a reduced risk of fear and suspicion and a greater potential for community engagement.

As social media grows and allows more sharing of information and opinions, it makes sense that new mining ventures work from the beginning of a project to engage public understanding and support. Advances in virtual reality can be used to bring interested parties 'into' the mine to understand the workings and scale of a project even before the mine has broken ground. For example, BGC engineering are developing Microsoft's Hololens Technology to provide 3D maps and immersive landscapes for visualising and demonstrating mine reclamation projects. It is proposed that this will clarify proposed projects to stakeholders and to local communities and could potentially be effective in engaging younger members of the community, fostering life-long changes in views and avoiding harmful preconceptions from an early age (Mining Magazine, 2017a).

6.4 Comments

Mining is a physical process involving dusty environments and large machinery; it is therefore a high-risk occupation. The risk can be reduced by monitoring and controlling the exposure of employees to dust and noise. Lung conditions are still reported to be an issue for miners in some regions, but advanced monitoring technologies and dust control systems reduce the risk to miners of developing these symptoms. Health and safety education and training have reduced the average number of accidents and fatalities in almost all mines. However, major accidents can still happen. The automation of large equipment and vehicles, to improve manageability and accident avoidance, is helping to reduce accident numbers. Automated vehicles which allow human operators to guide and manage large equipment remotely are becoming available and these will reduce the amount of time humans spend in the most dangerous working areas.

Coal mining still incites strong public opinions – while some see it as a source of stable employment and the potential to grow economically sound communities, others see it as a landscape changing, environmental eyesore. Surveys have shown that opinions vary with factors such as lifestyle, age, and level of education attained. However, studies also show that opinions change depending on the type of information being considered by the public – misinformation and media panic can disproportionally affect new mining projects. And so, in addition to ensuring that a new mine plan has an EIA in place to minimise environmental effects and maximise reclamation values, some mining companies to engage widely with local communities from the beginning to promote engagement and support.

7 Company standards and policies

Coal mining companies are being held to higher standards. Investment portfolios often favour companies with green credentials and good environmental sustainability practices whilst others simply exclude fossil fuel projects completely. According to the CCC report by Baruya (2017), many multilateral development banks are retreating from funding the coal sector, although banks and institutions in Asia provide the bulk of funds for further coal development. Baruya's report suggests that investment in coal mining between 2009 and 2014 from many major commercial banks fell significantly, in some cases by over 50%. In April 2016, Peabody Energy, the world's largest privately-owned coal producer, filed for bankruptcy protection in the USA following a collapse in commodity prices. Whilst financial experts blamed it on an overly-ambitious expansion into Australia, Macalister (2016) suggested that the issue was tightening environmental standards. Some governments are becoming more concerned with clean air and climate issues and this is felt by private corporations. For example, Norway's US$890 billion government pension fund has eliminated all links with fossil fuel companies. Gofossilfree.org lists organisations which have divested from fossil fuels, including coal, and puts the total value of divestment at US$5.53 trillion, 19% of which is government based. Fehrenbacher (2015) suggests that this is a result of climate change concerns, and also because of the percieved move from coal to gas in a number of countries as a result of both economics and tightening emission standards. The MSCI KLD 400 Social Index, which ranks businesses according to environmental, social and governance qualities, has no mining companies on the list (Sanderson, 2017a). If coal mining companies are to continue to receive funding then they must demonstrate that they operate in a manner which funding agencies deem responsible. This chapter looks at the ways in which coal mining companies can demonstrate to investors, partners and the public that they are carrying out best practice and operating within sustainable development and environmental protection guidelines. For many companies, this is carried out through corporate and social responsibility programmes.

7.1 The Equator Principles (EP)

Many financial institutions have adopted the Equator Principles (EP) – a risk management framework to determine, assess and manage environmental and social risk in projects. 'The Equator Principles aim to be a global benchmark, providing a framework for due diligence to support responsible risk decision-making on environmental and social issues in financing projects" (www.equator-principles.com)'. Currently 90 financial institutions worldwide have adopted these principles, covering over 70% of the international project finance debt in emerging markets. Below is an illustrative list of the issues to be addressed in the assessment documentation of any EP project:

- assessment of the baseline social and environmental conditions;
- consideration of feasible environmentally and socially preferable alternatives;
- requirements under host country laws and regulations, applicable international treaties and agreements;

- protection of human rights and community health, safety and security (including risks, impacts and management of project's use of security personnel);
- protection of cultural property and heritage;
- protection and conservation of biodiversity, including endangered species and sensitive ecosystems in modified, natural and critical habitats, and identification of legally protected areas;
- sustainable management and use of renewable natural resources (including sustainable resource management through appropriate independent certification systems);
- use and management of dangerous substances;
- major hazards assessment and management;
- labour issues and occupational health and safety;
- fire prevention and life safety;
- socio-economic impacts;
- land acquisition and involuntary resettlement;
- impacts on affected communities, and disadvantaged or vulnerable groups;
- impacts on indigenous peoples, and their unique cultural systems and values;
- cumulative impacts of existing projects, the proposed project, and anticipated future projects;
- consultation and participation of affected parties in the design, review and implementation of the project;
- efficient production, delivery and use of energy; and
- pollution prevention and waste minimisation, pollution controls (liquid effluents and air emissions) and solid and chemical waste management.

More details on the Equator Principles, including a list of member financial institutions and best practice reports, can be found at www.equator-principles.com. By 2016, 83 financial institutions had adopted the Equator Principles and use the guidelines within them to ensure that projects they fund are developed in a socially responsible manner. As the principles include impacts on the local community, they are similar to, but more rigorous than, the EIA requirements discussed in Chapter 4 and involve stakeholder engagement, independent monitoring and transparency through each project evaluation process. Although the principles have been adopted in many regions, they are voluntary and, as yet, have not been adopted by any financial institutions in China, India, Indonesia, Poland, Russian Federation, Spain or the USA (Baruya, 2017).

7.2 Corporate and social responsibility (CSR)

Globalisation and the growth in public interest in ethical, environmental and social matters means that companies must pay attention to emissions and environmental effects or risk legal action as well as the possibility of losing customers. Corporate and social responsibility (CSR) considerations are increasingly common in coal mining companies. The European Commission (EC) established a requirement in 2014 for all large companies (employing over 500 people and with a balance sheet of over €200 million, or income over €40 million) to disclose CSR information. The EC defined CSR as the means by which companies integrate social and environmental concerns into their business operations, taking responsibility for the impact of their activities on society and the environment (Halasik and Kulczycka, 2016).

Gibbs (2016) summarises the importance of CSR commitments for mining companies under the constraints of tightening environmental legislation and increased costs:

- CSR should not be reduced as a cost cutting measure. This can be taken by governments as a sign of wavering commitment to a project, increasing political risk. Insurers like to see ongoing CSR projects as important to mitigating social unrest and government interference. The CSR portion of a mining project can improve the risk profile of the company.
- Harness and optimise the power of social media. Good press can be beneficial but one widely-shared photograph of poor working conditions or pollution incidents can damage reputations quickly and dramatically.
- A CSR should include the complete supply chain to minimise potential criticism and scrutiny of conditions of workers not employed in the mine site itself.
- Build a strong reputation by being a leader – 'CSR is more than just a public relations exercise – it is an operational strategy. True commitment to CSR will pay dividends in terms of mitigating political risk' (Gibbs, 2016).

The promoted outreach and openness of CSR policies should go a long way to creating an open and honest debate with local communities, fostering support rather than resistance.

The US NMA awards companies which demonstrate excellent standards of safety under the Sentinels of Safety award and has done so since 1925. Awards are based on the number of hours without a 'lost-time injury' being recorded. The NMA has also created the CORESafety system and Peabody Energy is the first company to be independently certified under the scheme. The US Department of the Interior also issues awards for environmental performance, mine reclamation and community outreach programmes (World Coal, 2016).

CSR is still a relatively new concept in Poland. Halasik and Kuczycka (2016) reviewed the CSR in place in the main coal mining companies in Poland, which included social dialogue between the work force and union; development of a modern, organised, creative and efficient work system, including professional development; an integrated management system and a code of ethics. The CSR of Katowicka Grupa Kapitalowa also includes a code of promotion of cultural values, improvement in local quality of life, education in the mining region, charity work, sustainable development and care for the local environment and society. Although these initiatives are admirable and important, Halasik and Kuczycka (2016) note that these coal companies in Poland still do not treat CSR as a constant part of their management strategy and few share their CSR information publicly even though activity in this area brings measurable and intangible effects and could be a source of competitive advantage.

Bettercoal.org has been established to 'advance the continuous improvement of corporate responsibility in the coal supply chain by improving business practices through engagement with stakeholders and based on a shared set of standards'. Mines and coal companies are invited to self-assess or allow third-party assessments of operations with a view to improving practice. Members include Dong Energy, Drax, EDF, RWE, Vattenfall and Iberdrola. The association has produced a code which aims to become a 'benchmark for ethically, socially and environmentally responsible practices in the coal supply chain that can be assessed by independent, third part assessors (qualified by Bettercoal)'. The code covers ethical, social, and environmental principles and provisions that are relevant to coal mining companies, including:

- general performance requirements, including management systems;
- business ethics performance, including disclosure;
- human and labour rights and social performance, including health and safety; and
- environmental performance.

Part of the premise of CSR is that the performance of a company is clear and open to public scrutiny. The CSR of almost all companies, including mining organisations, can therefore usually be accessed via the company websites. For example, Aurizon, the Australian coal mining company, provides a vast amount of information on their website www.aurizon.com, including sustainability reports as well as numerous publications relating to dust monitoring and management projects. The sustainability report includes information on community engagement, GHG reduction programmes, data on operational efficiency, health and safety records (zero accidents), organisational capability (including statistics on female participation), and tax transparency data. By openly providing this data, companies such as Aurizon break barriers between large companies and local communities, enhancing public engagement and acceptance.

7.3 Case study – North Antelope Rochelle, the world's largest mine

Peabody's North Antelope Rochelle (NAR) mine in the Powder River Basin, USA, is the world's largest coal mine producing 40% of the USA's coal. The site stretches for over 50 miles (80 km) and employs the largest mining equipment in the world. The mine is expected to continue operation well beyond 2022. Over 20 long freight trains leave the site every day taking coal to around 100 coal-fired power plants across the country (Goldenberg, 2014). The site employs 1300 people. Two loading facilities handle 10 Mt/h coal each (Mining Technology, 2017).

The NAR mine is included here, not necessarily as an example of best practice, but rather as a demonstration of the many different aspects of mining operation and how attaining excellence in each can be a challenge. The NAR mine is a good example of mining reality – it emphasises the balance of trying to produce coal at a profit whilst minimising environmental effects and disturbance to the local communities.

Figure 28 shows a photo of the mine taken from the International Space Station by NASA, which gives an idea of the scale of the project. The active coal seam faces appear as black lines in the image. Other lines show the access routes for trucks and the draglines and shovels for moving the coal produced (NASA, 2017).

The NAR mine is one of 12 mines in the region of Gillette, Wyoming, where over 5000 local people, 1 in 10 of the residents, are involved in the mining industry. Since mining began here in 1892, the locals are used to coal being central to the economy. This is not to say there have not been objections to the mines – issues have been raised about potential health effects on local cattle, with one farmer claiming the loss of 25 calves due to aggravated pneumonia (Goldenberg, 2014).

Figure 28 North Antelope Rochelle mine (NASA, 2017)

The US EPA accepted wind as the cause of high-dust events at the mine in 2007, excluding them from being reported for violation of National Air Quality standards. Although the air quality limits were exceeded during these adverse weather situations, the state and industry officials accepted the extenuating circumstances and did not issue an official violation report. Such a report could have led to a 'non-attainment' designation which would have forced a moratorium on new industrial activity in the county. However, because of these exceedance incidents, modifications were made to operations to minimise dust on roads and conveyors and reactionary measures were introduced to cut back operations during periods of high wind (Bleizeffer, 2008).

Bluesource (2017), an environmental consultancy in the USA, developed a means for accurate estimation of methane emissions from the NAR mine, based on a 'radius of influence' approach to include methane emissions away from established emission sites. The new methodology was accepted by the Verified Carbon Standard (VCS) and recognised by the State of California in its Cap and Trace programme.

Coalbed methane (CBM) is captured at the mine and water is produced during the process. The system has been adjusted so that the resulting water is pumped to the mine for dust suppression and facilities use as well as in the establishment of wetlands and other reclamation features (Murphree, 2016). The site uses up to 3 million gallons per day or 2100 gallons per minute (11,356,236 L/d; 7950 L/min) during the summer months. Even in the winter around 170,000 gallons per day are required (773,000 L/d). Water use for haul roads across the whole mine site amounted to 338 million gallons (1537 L) in 2000. However, this is expected to increase as haul roads lengthen to reach new mining areas and dust control standards tighten. The CBM site produced around 500,000 gallons of water a day (2,273,000 L/d) in 2012 with more coming online since then (Murphree, 2016).

In 2013, three miners suffered second and third degree burns due to a spontaneous coal combustion event at a coal truck crusher dump during the changing of a chain on a conveyor. This led to an investigation and a review of safety guidelines (Ackermann, 2017). Safety and reclamation practices at the site have received numerous awards (Peabody, 2017).

Complaints have been raised against the mining company suggesting that they are in violation of mining laws due to the avoidance of hundreds of millions of dollars in bond payments by posting their assets as collateral on future reclamation costs. This practice, known as self-bonding, is arguably legal but creates a greater risk for mine clean-up when mine operators are struggling to stay in business (Storrow, 2016). Peabody moved into Chapter 11 bankruptcy protection in April 2016 but has since reduced its debt. The price of coal, especially recent falls in 2015/2016, have left some coal companies struggling (Reuters, 2017a).

Peabody, the owner of the NAR mine, has a website www.peabodyenergy.com which provides information on their mining activities, including the NAR. Figure 29 summarises their public information data, provided to the local and interested communities.

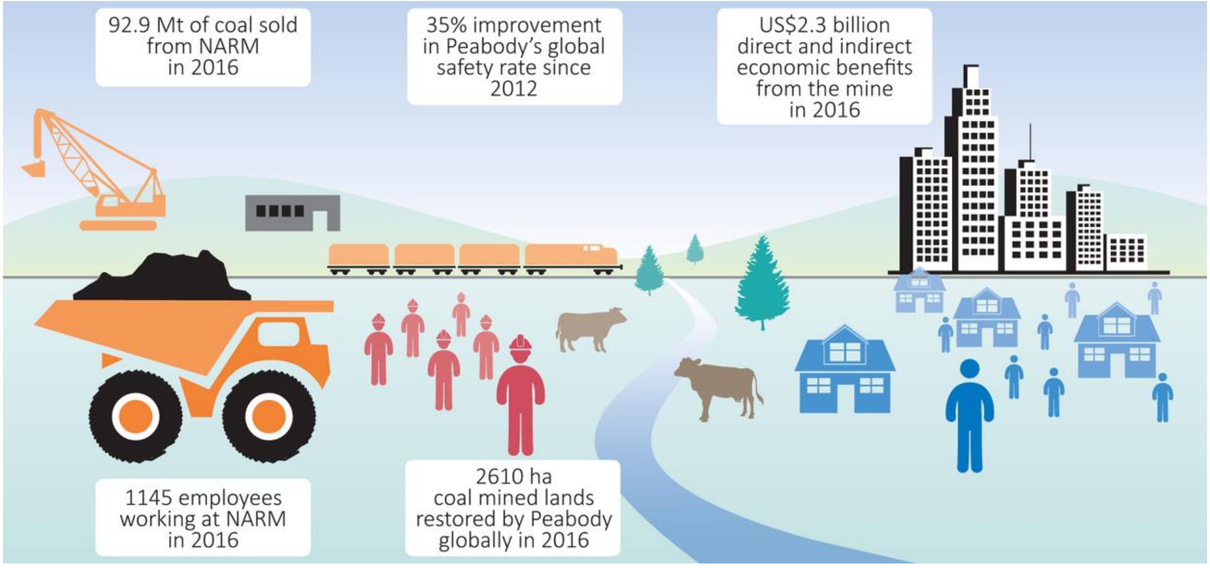

Figure 29 North Antelope Rochelle Mine facts (Peabody, 2017)

According to the Peabody website (2017), the NAR mine injects around US$175 million into the regional economy in wages and benefits which can mean as much as US$2.3 billion in total direct and indirect effects. As shown in the figure, the company has also improved its safety rate and restored significant areas of mined land.

Peabody has invested profits back into services for the community, including building a state-of-the-art recreation centre with indoor track and climbing wall. However, 235 workers lost their jobs in 2016 due to cutbacks and more than 1500 people moved out of the region with more expected to follow. Because of the large amount of mining in the region, Wyoming has received more than US$2 billion in coal bonus bids since 1992, which are paid to the state following the grant of a lease. The money has been invested in schools, highways and community colleges. This is healthy investment in economic diversification as the colleges teach skills that can be used in mining but also elsewhere. However, some of the local community do not believe the city will survive once the coal mines finally close (Patterson, 2016).

7.4 Case study – SUEK, Russia's largest coal producer

SUEK is Russia's largest coal producer and one of the top ten coal companies globally with 27 mines in Russia exporting to many countries. The company has published CSR reports since 2006. In the latest, 2015, report the company acknowledges that 2014-15 was a complicated period for the coal industry, prices dropped and the coal market stability declined. Whilst not unique (almost all large coal companies produce such reports) the SUEK CSR report is an excellent example of how large coal companies balance profits with environmental and social considerations (SUEK, 2015).

The business model for the company encompasses everything from production, through enrichment and processing to transport logistics and sales. The priorities for the company are summarised in Figure 30.

Figure 30 Priorities in the field of sustainable development (SUEK, 2015)

Looking more closely at the data for environmental protection, the company has invested significantly in dust control through each stage of coal movement through the Vanino bulk terminal. Fogging and foam generators are used to suppress dust in storage areas and a commercial (DUSTEX) dust suppression cannon is used at sorting stations. Over 80% of exported coal is shipped through SUEK's own ports, allowing the company to maintain complete control of the logistics and environmental effects of coal movement. Higher capacity rail cars have been introduced to increase the efficiency of coal movement as well as reducing emissions. Dust at the Vanino terminal is monitored and controlled in real-time. The company plans to copy this approach at the Murmansk terminal and will invest £13 million on dust-shielding screens at the commercial seaport in 2018 to (www.suek.com).

The volume of CBM recovered increased from 5.09 million m^3 in 2013 to 7.51 million m^3 in 2015 with 13.19 million m^3 used to generate 1917 GWh of electrical power and 2954 GWh of thermal energy. Pollution in water effluent at SUEK plants was reduced by 33% during the same period.

Between 2014 and 2015, there were several projects targeting environmental protection which, together, amounted to almost 900 million rubles of investment (over US$1.5 million). These included the design and installation of mine water cleaning systems at several mines and the upgrading and repair of dust management and collection systems.

SUEK also report decreases of 18% in the Lost Time Injury Frequency Rate between 2013 and 2015 and a significant investment in real-time monitoring health and safety systems. Money was reinvested in employees through training and health insurance benefits and was also invested in local communities through social projects, business programmes and environmental initiatives. For example, in 2014, SUEK launched a new project – 'Youth Entrepreneurship'. It involved 1500 students in 63 business projects which together produced a profit of over 200,000 rubles (over US$3300). This initiative received the 'Time for Innovation' award in the Social Innovation of the Year category, a competition established with support of the Ministry of Economics of the Russian Federation. SUEK won an award in 2016 for its waste water treatment facilities at the Rubana mine in Kuzbass, introducing a system which returned water used in the production processes to the environment cleaner than before it was used. A further award was received for a clean air project which aims to guarantee the full recovery of methane from longwall mining, also in the Kuzbass region (www.suek.com).

7.5 Case study – Coal India Ltd, a large coal producer in an emerging economy

Coal India Ltd is a state-owned coal mining corporation through which the Indian government took over private coal mines in 1975. It is the largest coal producer in the world, with seven coal producing subsidiary companies (CI, 2017c). Although there is no single corporate CSR document for Coal India Ltd, the company has published a CSR policy document which provides guidance for its subsidiary companies to carry out CSR activities. The fund for CSR activities is set at 2% of the average net profit for the subsidiary company for the previous three financial years or 2 R/t (0.03 US$/t). Suggested activities for this CSR funding include eradicating hunger and malnutrition, promoting education and gender equality, animal welfare, protection of national heritage and contribution to relief funds (CI, 2017a).

Between 2014 and 2015 Coal India Ltd carried out quite diverse CSR activities, including (CI, 2017b);

- construction of 100 charitable specialist hospital diagnostic centres;
- funding for training in plumbing and dress-making;
- installation of 11 deep bore wells for free drinking water;
- installation of solar street lights and hand pumps; and
- scholarships and housing for students.

The company has received praise for some community outreach programmes such as the provision of audio visual and communication tools to a school to help protect young girls from harassment (India CSR, 2016).

The types of CSR activities carried out by Coal India Ltd are distinct from those carried out by companies such as SUEK and this reflects the needs and priorities of each country. In both cases, the coal companies are taking action over their social and environmental responsibilities and are re-investing in local community development.

7.6 Comments

Along with other companies, coal mine owners and operators are being held to a higher standard of practice than previously and policies such as due diligence, environmental best practice and CSR are becoming more important. The case study of the North Antelope Rochelle Mine in Wyoming, USA, demonstrates just how many potentially environmentally damaging activities and actions a mine company must justify and minimise to produce coal. Over and above the mine work, the company must also adopt best practice with respect to how it operates its business and how it treats its staff and the community from which they come. Each of these activities must be monitored and managed to ensure that the environmental effects are minimised and sustainability is maximised. And, just as importantly, this information must be made available to the public.

8 Conclusions

Social interaction between local and international communities is growing, as is environmental awareness. Populations are raising their environmental expectations, and demand that the impacts of all industrial and commercial activities are considered, including coal mining. For example, in response to growing public concern, the Chinese government set significantly tighter legislation on new coal mining activities. Smaller mines are closing and the new focus is on developing larger, regional ‘coal bases’ which will be easier to monitor and control. Future mining policies in China focus on efficiency and emissions reduction. After centuries of coal mining, much of which has been completed or abandoned, the Chinese government is now applying retroactive treatment to secure and improve sites that the public consider unsafe or polluted. Abandoned and dangerous coal mines are also a major issue in Indonesia where there is continued public concern over the level of compliance of small mining companies with mining standards. Despite this, the country plans significant expansion of mining activities.

There is a surge in coal production in India as the country seeks to bring electricity to the 300+ million people who are still not on the electricity grid. However, public protests are common, with mines facing opposition from indigenous peoples and those who wish to protect animals such as elephants that inhabit proposed mine sites. The Indian government continues to try to override bans on mining in previously protected ‘no go’ regions, arguing that coal mining has priority over environmental issues due to economic interests.

In Australia, legislation on coal mining has been changing for decades and some argue that this is more to the advantage of the coal mines than to the local communities. Protests are increasing in frequency. The proposed new Carmichael coal mine and the associated port are under much public scrutiny with some international banks refusing to invest in the project due to the high level of public concern.

In countries with a high dependency on coal production, such as the Czech Republic, Colombia, Poland, Kazakhstan and Russia, the economics of employment and energy production often override environmental issues. Regulations on mine projects are complex, reflecting national concerns such as those discussed above as well as more general issues which would apply to land use anywhere in the world. These include wildlife preservation, water resources, air emission legislation, and health and safety requirements. Each mine will have a mine-specific plan which must comply with all relevant national legislation but may also include requirements which defer to the concerns of the local community, such as traffic, dust, wildlife protection, and noise minimisation.

The UN has published the Berlin Guidelines for best practice for mining which include considerations such as licencing, monitoring and environmental accountability. In addition, UNEP has created a decision tree to guide new mining proposals through the initial impact assessment and decision-making process. Environmental impact assessments are required in most countries to evaluate the potential consequences of mining prior to breaking ground. These assessments usually follow a process which involves experts, regional government and local authorities, and community input and feedback to create a plan that is acceptable to all. Such assessments must include a plan for clean-up and remediation of the site following mine closure. For some, remediation is simply returning the land back to its original condition. Others go further and create new uses for the land – leisure areas, commercial sites, housing, forestry or even land art, such as Northumberlandia in the UK. Whereas in the past, coal mining land would have simply been made safe and returned to its near original state, modern best practice involves the community in determining whether there are better ways of using the land. This means that the mine closure plan, which will be developed even before the first top soil is moved, will include an outline for creating a beneficial legacy for the local community.

Mining activities can be disruptive and polluting during operation. Coal mines can release a significant amount of methane to the air. Ideally this methane should be captured and used to produce power or controlled to reduce potential fire and explosion risks. But fugitive methane can still escape to the atmosphere to add to GHG concerns. GHG emissions can also arise from fuel use from mining machinery, but this can be reduced significantly through efficiency programmes and increased automation.

Dust emissions arise from coal and soil but also from the on-site machinery and can reach unhealthy concentrations around mines and transport hubs. Studies on dust emissions are sporadic and are based on individual sampling systems placed in selected locations and so it can be challenging to obtain a valid indication of the extent or source of a dust problem. In some situations, vehicle (fuel emissions as well as re-entrained dust) contribute significantly more emissions than the actual mining process. Agitation, uneven surfaces and air movement during the transport of coal in road and rail cars can result in dust blow-off. This can be reduced by water or chemical sprays and treatments. For coal deposited in stockpile and blending areas, storage buildings or coverage can be selected which will reduce drift and blow-off and facilitate recapture and use or disposal of drifting dust. State-of-the-art coal storage domes are used in Europe and China, which increase the safety of coal storage areas but also reduce dust issues to virtually zero.

Co-ordination of the whole transport chain, from mine to combustion facility, can go a long way towards minimising emissions, not only during transport stages but also at transfer points along the route. Port Waratah Coal Services in NSW, Australia, are an excellent example of how separate parts of the coal delivery chain can work together to reduce total emissions of both dust and GHGs, increasing overall efficiency and keeping costs down.

Coal mine operating plans reflect the commitment of the mining company itself to compliance with minimum environmental requirements and sustainability. The public's opinion of a mining company can be influenced by its corporate and social responsibility performance. Individual companies can demonstrate higher standards of performance and it is often in an organisation's commercial interest to establish an above-average standard of practice. This is especially true as the public becomes more aware and engaged in what is happening in their local communities. Large coal companies such as SUEK and Peabody have websites which report on the company's performance and on conditions at individual mines. The public can access these sites for information on the company's economic performance but also on issues relating to environmental quality (emissions to air and water). Coal companies now see this CSR and associated publicity as a means of demonstrating their environmental performance and commitment to the safety of their workforce as well as showcasing best practice in terms of community support and social outreach. The recent proliferation of such websites and the number of awards in the fields of mine safety and land reclamation practice awarded by mining associations and journals reflects the growth in these activities. Concern with environmental performance is also reflected in a tightening of funding practices – many international banks are investing less in coal projects which are likely to cause environmental damage or which may be perceived to do so by the public. Social media is motivating and moving populations faster than ever before and public protests can be organised more quickly and effectively than in the past. By working in an open and honest manner, mining companies can engage communities from the onset of a new project proposal, to pre-empt and minimise potential reactionary backlash.

And so, in brief, mining companies should comply with all environmental legislation obviously, but they can also demonstrate best practice and corporate and social responsibility. And if they do this openly and with as much public outreach and engagement as possible then local communities can be involved in the project, helping to ensure that the project is accepted and supported. This means that new mining projects should:

- prepare an environmental impact assessment before the project commences, based on expert guidance and early community interaction. The concept of 'restoration first' was used for the Northumberlandia land art created from a closed mine in the UK. The local community was involved in the planning of the final restoration work before it began;
- review case studies of projects which have demonstrated best practice in terms of efficiency improvement or emissions reduction, learn from these and create a site-specific mode of operation which reflects this. Chinese and Indonesian projects have shown that it is possible to analyse the coal delivery chain to identify where efficiency upgrades can be made with significant cost benefits as well as a reduction in greenhouse gas emissions;
- publish performance and emissions data – openness and honesty foster trust, as shown by companies such as SUEK and Peabody on their websites;
- use social media to spread awareness of the site operation to the local community;
- use state-of-the-art multi-media to engage younger members of the community, to override historical and potentially harmful images of coal mining at to replace these with more updated values;
- invest in staff training as well as community education and outreach programmes. This forms a major part of corporate and social responsibility programmes from the USA to India; and consider the long-term effects of eventual mine closure on the community and ensure that the mining area is left, not as a dangerous eyesore, but as a valuable legacy. Projects such as the Hawks Nest mine in Virginia, USA, are now winning awards for their investment in mine site reclamation.

The coal mining industry has matured in recent decades. In developed economies, examples demonstrate that the application of best practice across the coal production chain can not only reduce environmental damage but can create an industry with positive effects on a local community. Coal mines are transient – they provide work for a small community for several years and then they close. The industry is changing and its impact can be largely positive, with minimal disruption to the community and the environment during operation. It can leave a lasting ecological as well as economic benefit to the region once the site is closed. As coal mining becomes more prevalent in emerging nations and economies in transition, it is important that these new mining activities adopt this environmentally sound, mining ethos, making the most of published information and guidance on best practice options.

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