3. Connecting the mining sector to the green economy

This chapter explores different areas where public policy can support better environmental performance in the mining sector and build linkages to the green economy. This includes developing a whole of government approach and engaging a broad range of stakeholders. The chapter discusses regulatory approaches at different stages of the mining process, as well as the challenge of orphaned mines, and the potential to reprocess abandoned mines. It also looks at policies to support innovation and capacity building, as well as developing linkages to the circular economy. It concludes with a series of key recommendations.

3.1. Introduction

Effective environmental regulation is necessary to improve the performance of active mines, but it cannot achieve this on its own. The same dilemma is true for the proper monitoring and rehabilitation of closed and abandoned mine sites. Many countries in the Eastern Europe, Central Asia and Caucasus (EECCA) region have stringent environmental standards on paper. However, due to inconsistent compliance assurance and non-compliance enforcement, they do not have good environmental outcomes. The top-down, command and control approaches held over from the Soviet Union are difficult to enforce because of the wide number of pollutants covered. Due to low-compliance penalties, the approaches do not provide incentives to comply or go beyond compliance (OECD, 2017[45]).

Public policies can impact the environmental performance of mining companies in ways that go beyond regulatory decisions. Such policies include supporting and formalising collaborative efforts on innovation and linking the mining sector to other segments of the economy. Equally important are policies that ensure information transparency and active stakeholder consultation. Another example is policies that build capacity to ensure availability of skills to tackle new roles in the green economy.

This section presents a broad range of different policies related to better environmental performance in the mining sector. These policies are often treated differently due to the distinct dimensions they target, but in fact are linked and reinforce each other. The tools are starting points for policy makers, industry and other stakeholders to develop these policies. Solutions are unique to each country, and will vary based on national and sub-national priorities.

3.2. Government co-ordination and strategy

Governments need a co-ordinated approach to improve environmental performance of the mining sector. Inevitably, this will involve more than just a single ministry, and more than just a single layer of government.

A national strategy for the mining sector that clearly identifies goals helps governments co-ordinate their approach. In developing that strategy, engaging with a broad range of stakeholders legitimises outcomes and helps ensure action on the final product. Stakeholders include civil society, different levels and branches of government, local communities and the mining industry itself.

Governments may have different goals. Some may wish to attract investment, while ensuring that new mines reduce their environmental footprint. Others want to limit new mines and establish ecologically sensitive areas that are off-limits for development. Still others wish to focus on cleaning up old contaminated sites. Each goal requires a different mix of policies to achieve it.

A strategy resting at a supra-national level helps ensure continuity over time. In this way, it reduces duplication and policies from different government branches that contradict each other. These principles are fundamental to the OECD concept of policy coherence for sustainable development.

Mining can impact water supplies and quality, energy use, transportation infrastructure and employment, as well as the broader environment. Strategies may require the involvement

of many different branches and levels of government. Integrated and coherent policies, supported by strong institutional mechanisms, are vital (OECD, 2018[46]).

Transboundary co-operation and co-ordination may also be required. Some mining activities are close to the border or close to transboundary water systems, so impacts such as downstream water pollution may be felt in other countries. As a result, it's vital for affected countries to work together with regard to risk assessment and management. The UNECE Industrial Accidents Convention is relevant in this regard. It supports countries, notably competent authorities and operators, to prevent, prepare for and respond to industrial accidents with potential transboundary effects.

3.3. Stakeholder engagement and transparency

Large-scale industrial projects have stakeholders beyond simply the project proponent and the regulator. With the construction of a mine, the stakes are exceptionally high. In a sense, the resources constitute the wealth of the nation or community: there is only one chance to develop a given deposit. Mines have environmental impacts, no matter how well executed. If the larger systems (hydrological or climate) are damaged, impacts will be felt by area residents, as well as by those further abroad. As with any audit or even with writing a paper, third parties can often bring insight, perspective and objectivity that may otherwise be missed.

The most successful mining jurisdictions in terms of environmental performance have processes to ensure broad stakeholder involvement. They also have resources and information to ensure stakeholders can be informed participants in the approvals process for mines, as well as for operations and post-operations periods.

Ensuring that companies go above and beyond the letter of the law requires that local communities have a voice. Empowering expression of such a voice can also benefit mining operations. People living in the area, for example, are often more sensitive to environmental changes that occur outside the immediate vicinity of a mining site. Historically, public participation has often been ignored or considered only until a licence has been granted. As part of moving towards a green economy, public participation should be central to environmental assessments and ongoing operations.

Modern communication technology, including social media, means the public is involved whether companies want them to be or not. By embracing this engagement, mining companies can understand the stakes more clearly. They can ensure such engagement takes place by requiring public consultation as part of any environmental impact assessment (EIA) or strategic environmental assessment (SEA).

Governments must go beyond ensuring stakeholder consultations take place. Project proponents must take results seriously and address concerns. Proponents – and regulators – must also be transparent about mining operations and closed mines, clearly informing the public about actual or potential environmental concerns.

The OECD is developing a Recommendation on Open Government, which aims to help the countries design and implement successful open government reforms. It will identify a clear, actionable, evidence-based and common framework for the governance of open government (OECD, 2017[47]).

The UNECE Aarhus Convention on Access to Information, Public Participation in Decision Making and Access to Justice in Environmental Matters is also relevant. Through the Convention, countries pledge to make the necessary provisions at the national, regional

and local level. These ensure the public has access to environmental information, access to justice around environmental issues and the right to participate in environmental decision making.

3.4. Regulatory tools

How governments regulate the mining sector shape its environmental impact, its attractiveness to investors, its value to public coffers and its acceptability to local communities. Each year, the Fraser Institute Survey of Mining Companies studies companies active in the mining sector, including both major multinational giants and small junior exploration companies. A recent survey found that public policy is a major determining factor for companies' decision to invest. Respondents on average valued public policy at 40% of their investment decision – almost as important as the geology (Stedman and Green, 2017[48]). In conjunction with policy itself, mining companies also consider whether a jurisdiction is favourable to investment, stable and predictable in the business climate (Wilkerson, 2010[49]).

Strong environmental protections are not a disincentive to investment. Indeed, jurisdictions with some of the most stringent environmental regulation consistently ranked among the most attractive[1] in terms of policy environment for mining (Stedman and Green, 2017[48]). There could be two reasons for this. First, international mining companies face significant scrutiny from regulators and the public. Second, they either develop or adopt the newest technologies first, which tend to be more environmentally friendly. In 2017, the top five jurisdictions for mining in the Fraser Institute's annual survey were Ireland, Finland, Saskatchewan, Sweden and Nevada.

Companies based in less stringently regulated environments, such as countries in the EECCA region, may initially have difficulty transitioning to more stringent regulations (Hilson, 2000[50]). Even in developed economies, it might take years for industry to adapt to a new regulatory paradigm. For instance, when Canada enacted its Metal Mining Liquid Effluent Regulations in 1977, it took until 1994 to reach a 98% industry compliance rate (Hilson, 2000[50]).

The Porter hypothesis argues that well-designed environmental regulation can stimulate innovation (Porter and Linde, 1995[51]), and can potentially increase economic productivity as well. Over the past decades, these hypotheses have been tested frequently. The latter "strong" conclusion (increase economic productivity) has lately begun to show evidence for validity. However, the former "weak" conclusion (stimulate innovation) is considered well-established (Ambec et al., 2013[52]).

3.4.1. Exploration

In all major mining jurisdictions, proponents of mines need permits for their activities. Sometimes separate permits are required for exploration and mine operations. Depending on the regulatory structure, EIAs may be included as a precondition for granting of the mining permit or as a separate process.

Exploration activities in themselves can have a significant environmental impact. Exploration may require cutting survey lines through vegetation, as well as constructing roads. This can have a substantive impact on ecosystems by destroying or otherwise disturbing them. It can also break up contiguous areas, making it hard for animals to move around or have the territory they need to live.

Through requirements for new mining projects, governments can set the stage for expectations. However, enormous uncertainty remains about whether and how a mine will be constructed at this point. Therefore, most jurisdictions approach exploration as a separate matter with its own distinct EIA process.

EIA processes for the exploration stage are critical. They should also require that companies consult with communities in the area, regardless of whether the latter control or have legal veto on the land being assessed. Making community consultation a requirement also benefits mine proponents. It can help ensure some degree of social licence for the inevitable disturbance of the natural ecology. In this sense, environmental assessments enable project proponents to demonstrate to regulators – and the community – that they assessed risks properly and have a plan to mitigate them (Kokko et al., 2015[53]).

As their name suggests, the junior companies that conduct most exploration tend to be smaller than the ones that actually build and operate mines. They do not necessarily have the resources or knowledge for thorough environmental or biodiversity assessments. Companies may need to rely on environmental consultants to support environmental assessments at the exploration phase.

Environmental assessments at the exploration phase are typically less onerous than those for a full mine. However, they should still have requirements for mitigating environmental damage and rehabilitating any damage caused. In addition, even at this preliminary stage, environmental regulators must assess suitability of the area for mining, and whether there are unacceptable threats to ecosystems or human health. The exploration stage thus provides an initial point of entry for regulators to determine whether a mine is environmentally feasible. The bar will be lower than for permitting development of the mine itself because the exploration phase does not consider various factors. These include the kind of mine that might eventually be developed; its size; the techniques involved; and a detailed survey of the water table and local geology.

Box 3.1. NeXT – New exploration technologies

New Exploration Technologies (NeXT) is an EU-funded multi-country project co-ordinated by Finland. NeXT supports the development and adoption of new exploration technologies into the mining sector. It brings together partners from the research institutes, academia, service providers and industry. In so doing, it aims to develop new geological models, analysis techniques and exploration technologies that are cost-effective, environmentally sensitive and socially acceptable. To that end, it supports the reduction of costs and exploration time. By earning a social licence for mineral operation, NeXT also aims to enhance the participation of stakeholders, including civil society. The project, which runs from 2018-21, covers the most significant metallogenetic belts in the European Union.

Source: (European Commission, 2018[54]).

As discussed in Section 2.2.4., new remote sensing technology means that exploration companies typically have a better idea of where to find valuable deposits before they need more environmentally invasive and expensive physical sampling. Governments can set out requirements for use of remote sensing techniques through limits on environmental impacts for a given exploration permit. In addition, a best available techniques approach lays out recommended practices and technologies to meet emission standards.

3.4.2. Mine approval and operation

Regulators may consider both economic and environmental factors in assessing the case for a mine. Every major mining jurisdiction considers mines on a case-by-case basis. The regulatory process governing the construction of new mines tends to be complex. This is due to the potential for environmental impact, as well as the wide variety of stakeholders.

EIAs and SEAs are the first entry point for governments into whether a mine should be permitted. Properly done, EIAs and SEAs serve multiple important purposes. They force companies to clearly identify the environmental risks for their mining project. Companies must also illustrate the mitigation measures they will use during operations, as well as after mine closure. In turn, they can also help the government communicate requirements clearly to mine proponents. Crucially, assessment processes also allow governments to mandate consultations with stakeholders, including communities likely to be impacted by the mine. They also open mining proposals for scrutiny from interested stakeholders such as environmental organisations with expertise in the sector.

Box 3.2. Balancing economic benefits and environmental risks in the mining lifecycle

Mines provide valuable opportunities for public revenue and local employment. However, any given resource deposit can only be extracted once, so it should be done well, as it constitutes the collective wealth of the people living in a given country or area. The mine proponent may argue that environmental regulations make it economically unfeasible to develop the mine. If that occurs, then the time may not be right to develop the mine. Perhaps the technology needs to be advanced further until it is economical to develop the mine in a way that does not engender significant environmental risks. Prices for the commodity may need to rise. Or perhaps the area under consideration is simply too sensitive.

Another consideration is the enormous length of time that stretches after a mine is closed. Indeed, much of the most significant environmental impacts from mining operations occur after mine closure, when monitoring and scrutiny weaken. If the geology raises the risk of acid rock drainage, the need for vigilance is severe. Once vigilance slips, it is hard to turn back the clock. Determining this at the onset – rather than along the way – is critical. Careful assessment can help ensure that environmentally unsound projects, such as ones with a high propensity for acid rock leakage or damage to vulnerable ecosystems, do not get built in the first place.

Once a mine has gone through an EIA process and been approved, the regulatory regime ensures it stays within the guidelines and establishes constraints. This entails more than just setting standards for compliance. There are two broad points to consider in this conception – the underlying philosophy of the environmental regulatory system, and how it functions. In the first case, there has been a shift in the nature of regulatory systems over the past decades. These systems are moving towards incentivising and encouraging compliance rather than those punishing non-compliance. In many EECCA countries, however, regulation of the mining sector remains focused on the latter.

In terms of functionality, adopting integrated permitting for proposed mine sites and environmental assessment can harmonise different levels of government and reduce duplication. In this way, it can support better environmental performance and reduce the regulatory burden on governments.

Although OECD jurisdictions regulate mining emissions in different ways, most focus on reducing ecosystem harm rather than on punishing non-compliance. At the same time, the polluter-pays principle ensures that companies are responsible and liable for the damage they cause to ecosystems. This approach can foster an environment that encourages mining companies to go beyond the bare minimum requirements for compliance and excel, reducing their environmental footprint.

Permitting and ensuring environmental compliance

The requirements for permitting a mine vary widely by country, but all they balance the same considerations – economic and environmental impacts of a mine. A 2014 study compared the environmental regimes governing mining in Sweden, Finland, the Russian Federation (hereafter "Russia"), Canada and Australia. It found significant diversity in approaches, stemming from different governance (Söderholm et al., 2014[55]):

- Russia has based its approach on a licensing regime, which requires proponents to conduct an EIA before a licence is issued. The licence obligated the licensee to follow specific environmental requirements. For example, it would need to prevent contamination of water sources through waste accumulation. Despite more stringent technical and emission standards than other jurisdictions, enforcement was not necessarily consistent or effective (Söderholm et al., 2014[55]). As of 2018, Russia began transitioning to a system of integrated permits modelled on the EU's Industrial Emissions Directive. It added a Reference Document on best available techniques (BREF) for the mining sector. This establishes emission limit values.
- Sweden and Finland share similar mining regulatory regimes, shaped in part by their shared membership in the European Union. Both require environmental permits based on national legislation, an EIA and general environmental requirements drawn from a best available techniques (BATs) approach. In both countries, mining facilities are also impacted by EU BREFS for specific processes, even though there is no EU BREF for mining.
- Governance of the mining sector in Australia and Canada varies across different provinces/states and territories. In Australia, the federal government is only involved in specific cases triggered by national legislation like the Environmental Protection and Biodiversity Conservation Act. In Canada, the development of new mines is regulated at the provincial and federal level. They require both provincial permitting as well as federal EIAs (Söderholm et al., 2014[55]).

Permitting requirements that support the mining sector to become more environmentally innovative need to be performance-based. This is the case even if the limit values are drawn from analysis of the BATs. This helps drive innovation, as well as allowing flexibility in reaching targets (Bergquist et al., 2013[56]). Governments need to set limits that reduce the environmental impact of mining. However, mine operators are generally best suited to know what technique or technology can ensure compliance.

Compliance assurance and non-compliance responses should aim to ensure good environmental performance rather than to generate revenue. At the same time, compliance monitoring and enforcement are resource-intensive and complex. Political considerations, as well as socio-economic ones, can also impact compliance enforcement. This is especially true when a mining facility is a vital local source of employment (OECD, 2009[57]).

Compliance activities should be risk-based to prioritise resources, and transparent to promote public knowledge of specific mining operations. They should aim to help non-

compliant operations to become compliant, using monetary penalties as a last resort. Support for compliance can include technical advice and support on BATs to improve environmental performance in specific circumstances (OECD, 2009[57]). An important consideration is the time allowed for operators to become compliant with regulatory changes. Longer compliance periods extend environmental damage, but allow more potential time for operators to innovate and come into compliance (Bergquist et al., 2013[56]). Thus, the focus of compliance assurance becomes better environmental outcomes rather than punishing companies for non-compliance.

3.4.3. Mine closure, site rehabilitation and biodiversity offsets

Most major OECD mining jurisdictions require mining companies to restore a mine site to something approaching its original state. Companies provide details in a closure plan that is part of the initial permitting process. Traditionally, this requirement was interpreted narrowly. Companies had merely to stabilise and revegetate the immediate mine site (Morton, Sheppard and Lonsdale, 2014[58]). More recently, site rehabilitation has focused on ecosystems – restoring the interlinked relationships between flora and fauna that existed before the mining operation. Thus, topsoil removed during mine construction is stored and then replaced once the site is closed. Native plant and tree species are seeded, and native animals are reintroduced.

Although this sounds ideal, it is exceptionally difficult to restore an ecosystem exactly as it was. Generally, ecosystems are the by-product of decades, centuries or even millennia of environmental changes. The soil bacteria, fungi and other organisms living in the topsoil may not survive years or decades of storage. The geological material now beneath the topsoil may have changed the hydrological conditions. The term "ecosystem" suggests something knowable, a whole made up of an assemblage of parts whose interactions are understood. Yet the difficulty in recreating ecosystems underscores the falsity of this belief.

In response to the challenge of restoration, mining companies are increasingly pursuing biodiversity "offsets" in addition to rehabilitation. Biodiversity offsets acknowledge that mine construction will damage ecosystem services and biodiversity; even after closure, they may not return. To offset the damage, project proponents will support conservation in an equivalent ecosystem or area. This, in turn, is part of a broader movement towards "no net loss" or "net gain" approach to mining projects (Virah-Sawmy, Ebeling and Taplin, 2014[59]). Often, this involves protecting an equivalent amount of land from use. Sometimes providing funding to a conversation organisation, or in some cases buying "offset credits" from an established market (UNDP, 2017[60]).

However, the use of offsets potentially creates moral hazard. Mining companies may no longer feel they need to properly rehabilitate the site Consequently, it is vital that requirements for rehabilitation remain. Offsets also raise questions of how we properly value ecosystems. What is considered an "equivalent" ecosystem? Does it make sense to permit destruction of one ecosystem while protecting another, especially if the latter might need protection anyway (Grinlinton, 2017[61])?

In some cases, in conjunction with offsets protecting an equivalent area, it may make sense to permit novel ecosystems on a reclaimed mine site rather than an exact reclamation. Developing a mine, whether surface or underground, changes the hydrology, geography and geology of the area. By the time a mine is closed, and assuming loss of the site has already been offset, rehabilitation can potentially be adapted to the new reality of the site. For instance, filling in an open-pit mine with the removed overburden may be ineffective at recreating what was there. However, it may be possible to develop a new functional

ecosystem (Doley and Audet, 2013[62]). With that said, these sorts of decisions must only be made through consultation with objective environmental experts.

Site rehabilitation can take decades before it is completed. Regardless of whether biodiversity offsets are established, third parties must monitor closed sites regularly to ensure that hazards are contained and that progress continues on reclamation.

In addition, during the mining process itself, companies often discover new deposits and gain greater knowledge of the area's geology. They modify, expand or sometimes reduce mine plans. All this means that the timeline and footprint of mining sites often change beyond initial expectations. This affects the eventual site closure and site rehabilitation. Closure plans thus need to be updated to reflect any changes in a mine's circumstances.

3.4.4. Orphaned mine sites

Most historic mining jurisdictions grapple with the legacy of "orphaned" mines. These are defined as closed mines that no longer have an active entity considered responsible for cleaning up the site. Orphaned mines are an issue for countries in the EECCA region due in part to the legacy of Soviet-era development. This legacy is compounded by the operation of most mines from that era by state-owned enterprises, which abandoned them when they were no longer productive. These enterprises themselves no longer exists, and in their absence, liability passes to the state. However, site rehabilitation is exorbitant. Most governments do not have the funds to address rehabilitation on that scale. For example, it's estimated that Canada has more than 10 000 abandoned sites. In 2002, the Office of the Auditor General of Canada estimated the cost of rehabilitating abandoned mines in northern Ontario alone at CAD 555 million (Hogan and Tremblay, 2006[63]). In the United States, the US Government Accountability Office (GAO) estimates 161 000 abandoned sites in the 12 western states and Alaska. Of these, 33 000 have contaminated the environment. The US Environmental Protection Agency spent a median of over USD 221 million a year on rehabilitation between 1998-2008 (US GAO, 2011[64]).

As one approach to this problem, current operators could feed into an industry-wide fund that supports the rehabilitation of orphaned sites. In Alberta, Canada, companies operating in the oil and gas sector pay annual fees into a fund. The regulator sets annual contributions based on estimates of current liabilities. Other jurisdictions have also tried variations of this model, including Western Australia and across the United States (through the Comprehensive Environmental Response, Compensation and Liability Act, better known as the Superfund). However, this approach has been criticised as raising insufficient funds, as it is difficult to estimate total liabilities for abandoned mines. For instance, of 52 mining operations on federal land in the United States, the US GAO estimated that operators' financial assurances fell USD 61 million short of requirements for reclamation.

An approach to orphaned mine sites is best developed through collaboration, enabling the state and industry to share the cost burden. Because of the costs involved and the number of sites that need rehabilitation, efforts need to be prioritised through a risk-based approach. This approach should also prioritise transparency with impacted stakeholders, including civil society, as they can be valuable sources of information.

3.4.5. Reprocessing non-operational mine sites

One of the most direct applications of circular economy principles in the mining sector is the reprocessing of tailings and waste from old mining operations. This holds potential in the EECCA region, given the significant numbers of abandoned mines. Waste could be

processed to recover metals, potentially creating jobs and improving environmental conditions. Reprocessing tailings can be profitable, and can also leave an abandoned mine site in better environmental condition.

However, government policies can impact the feasibility of these projects, and they may need to be treated differently from traditional mines (Box 3.3). Reprocessing waste from non-operational mine sites straddles the line between mining and recycling. Governments may want to adopt a specific tax regime to mine waste reprocessing operations that incentivises investment. This would enable royalty rates to consider the potential environmental benefits of cleaning up a hazardous site. This shift in how mining operations are defined is also relevant for the reprocessing of non-mining waste sites with significant metal, which can be integrated into commodity value chains (Knapp, 2016[65]).

Box 3.3. Mining waste – examples from Australia and Kazakhstan

Mount Morgan Mine, Australia

In Australia, the Mount Morgan mine in Central Queensland operated initially from 1882-1982, with a brief closure. During that time, environmental controls were extremely weak, and reactive waste rock and tailings were dumped into a nearby river. There was extensive environmental damage, including acid rock seepage. This resulted in dead fish as far as 40 km downstream from the site.

In 1982, a tailings reprocessing operation was begun. Due to low commodity prices and technical difficulties with recovery, however, the project caused further environmental damage. After eight years, operations were halted (Lèbre, Corder and Golev, 2017[66]). Following these events, the government took over the mine. It invested in measures such as new earthworks to prevent further leaking into the river. However, it was unable to pay the full cost of site rehabilitation, which was estimated at AUD 450 million for a partial rehabilitation. Site maintenance costs alone for the government were estimated at AUD 3 million per year (Terzon, 2018[67]).

In 2016, the company Carbine Resources completed a feasibility study to reprocess the waste at the Mount Morgan site. The study determined it would be economical to process the tailings for copper (in the form of copper sulphate), pyrite (in the form of iron pyrite concentrate) and gold bullion. The processing would also remove main acid forming materials in the tailings (in the form of sulphur) (Carbine Resources, 2018[68]).

However, in March 2018, Carbine Resources announced it could no longer continue with the project. Due to lower than anticipated levels of recoverable metal and changes in the exchange rate, returns were too marginal. The project was further impacted by the project's classification as a mining operation, which would require paying royalties (Terzon, 2018[67]).

Central Asia Metals, Kazakhstan

In Kazakhstan, near the city of Balkhash, the Kounrad copper mine was operational from 1936 until 2005. It left behind significant waste dumps containing recoverable copper. In 2007, Central Asian Metals PLC acquired an interest in the site. By 2012, it had constructed a solvent extraction – electrowinning (SX-EW) plant. The process produces copper cathode by using in-situ leaching to remove copper and other metals from the waste dump. It then

uses a concentrating and electro winning process to make copper cathode, which is exported mostly to Turkey (Central Asian Metals, 2018[69]).

The mine has been profitable. As it involves only reprocessing existing waste dumps, the mine has also had a low environmental impact. In 2016, the facility was further expanded, to continue extracting more copper. Central Asian Metals is a publicly traded company that pursued the project based on market principles. However, the operations demonstrate the potential opportunities for a circular economy approach to abandoned mining sites in EECCA region countries (Central Asian Metals, 2018[69]).

3.5. Innovation and capacity building

Public policy can support technical development and technology domestication in a range of different ways. Directly, some mining jurisdictions such as Canada, Australia and Norway have public research institutions that develop new technologies and approaches, contributing to better environmental performance of the mining sector. Some research is also done in collaboration with educational institutions (universities), as well as directly with mining companies themselves. At a more indirect level, policy can also support technical development and innovation in the mining sector by supporting access to finance. This could take the form of low-interest loans, research grants or tax policies that reward spending on research and development.

3.5.1. Innovation led by the public sector

The government can help fund, co-ordinate and facilitate innovation and research in the mining sector with the same approaches that support innovation throughout the economy. At a direct level, governments can establish national research laboratories to develop new technologies for industry. Collaboratively, these institutions can also work with academia, other research institutes and the private sector to develop and commercialise new technologies. Governments can also support innovation by providing access to finance for companies attempting to develop and commercialise new technology for the mining sector.

Box 3.4. Canada's approach to supporting innovation in the mining sector

Canada's Ministry of Natural Resources has a broad range of support programmes for the mining sector. Through its Green Mining Innovation programme, this includes support for:

- enhancing mine productivity
- energy efficiency in mining
- minimising and managing mine waste
- managing water in the mining cycle.

Within each category there are other research programmes. These include improving automation and equipment, developing safer underground mines, electrifying mine sites and improving water recycling. In all cases, the ministry's CanmetMINING laboratory is leading research in collaboration with mining companies, equipment suppliers and

academia. This helps ensure that research is directly relevant for industry needs. It also encourages development and deployment of new sustainable mining practices.

Source: NRCan, 2018, www.nrcan.gc.ca/mining-materials/green-mining/18312.

3.5.2. Facilitation of equipment upgrading

Public policy can help mining companies upgrade their equipment to improve environmental performance. In part, this is simply removing barriers that discourage companies to improve environmental performance beyond requirements. Removing such obstacles opens the door to investing in more efficient and effective equipment. Import duties on new equipment that supports better environmental performance, for example, can be waived. Companies can gain tax credits by investing in new equipment that improves environmental performance, whether through efficiency gains or better pollution control. This is especially important in countries with high import duties on equipment.

3.5.3. Support for skills development and vocational training

Improving the environmental performance of the mining sector requires potentially new skills from both the public and private sector. Environmental regulators need capacity and skills – as well as the numbers – to regulate the sector effectively. At the same time, mining companies need to be able to hire employees with the appropriate educational background. Third-party environmental service providers need the human capacity to conduct assessments and monitor mine sites. For their part, machinery and equipment companies need to be able to develop and construct new products. Research institutions also need in-house capacity to support innovation effectively.

By supporting environmental education criteria for mining and engineering programmes, governments can help ensure that curriculum reflects new developments in the industry. At the same time, public funding for education can help ensure that institutions are able to operate and provide courses and that education is accessible.

3.6. Developing linkages to other parts of the green economy

3.6.1. Environmental services

Any attempt to improve sustainability of the mining sector depends in part on environmental service providers. These third parties can help assess, monitor and rehabilitate mine sites, among other roles. As noted in section 3.5.3, public policies can support skills development and capacity building in this area by developing vocational training programmes. Meanwhile, environmental policies in the country and the region largely impact demand for environmental services. Unlike traditional service sectors, such as finance, telecommunications or transportation, growth in demand for environmental services tends to be driven by more stringent environmental regulation (Adlung, n.d.[70]). Regulation and social pressure, rather than economic demand, largely shape markets for environmental services.

The benefits of developing an environmental services sector go beyond the mining sector, and potentially beyond the country itself. Any significant industrial project requires EIAs, ongoing monitoring and, potentially, ecosystem rehabilitation. Although some EIA characteristics rely on industry-specific knowledge, much of it is transferable across sectors. The development of a capable environmental services sector can potentially help

improve environmental performance across the board. On a regional basis, it also creates the potential for service exports.

3.6.2. Green infrastructure

In addition to their direct environmental footprint, mining projects in remote areas also require significant infrastructure to support their operations. This includes transportation to move mine output to market and to import mine inputs. It includes power generation (whether off-grid or grid-connected). Finally, it includes water to support mine development and mineral and metal beneficiation (OECD, 2016[71]).

The benefits of mine development can be enhanced by constructing infrastructure with environmental performance in mind, as well as by considering shared usage. Infrastructure should be subject to low-carbon and climate resiliency requirements. These requirements should minimise its environmental impact during construction, while ensuring its long-term stability. Regions with weak transportation linkages, water processing or power generation would benefit from infrastructure. These regions can harness mining projects as a means to provide broader benefits, including industrial development and local procurement (OECD, 2016[71]).

3.7. The circular economy, mining and waste as resources

The concept of a circular economy is gaining momentum globally among governments, consumers and industry. In this re-envisioning of economies, linear use of materials (raw materials, production, use and disposal) moves to circular use (materials reused, repurposed or recycled at every economic stage). Initially, the concept focused on manufactured products and transferring from ownership models to "goods as services". Mining was not featured prominently in the picture. Some of the most influential models of the circular economy, such as that created by the Ellen MacArthur Foundation, have mining and beneficiation processes outside of the circular loop (Lèbre, Corder and Golev, 2017[72]) (Ellen MacArthur Foundation, 2014[73]). This may be in part because removing raw materials from the ground seems like the antithesis of the circular economy (Thimmiah, 2014[74]).

However, over the last few years, mining has quickly caught up. Major business consultancies and industry associations have published analysis and position papers that frame the circular economy transition as an opportunity rather than a threat (ICMM, 2014[75]) (ICMM, 2018[76]). Common themes run through the analysis:

- Metal is infinitely recyclable, and recycling can be significantly more cost-effective than mining new metal. Some analyses are referring to the "urban mine" of industrial appliances and electronics that can be recycled and processed.
- Tailings sites from older mining facilities may contain metals due to inefficient or uneconomic extraction techniques during their initial processing; technology developments, higher mineral prices or policy incentives may now make them economical.
- The increased ability to track metal and mineral commodities from their point of origin enables the potential for new business models. Specifically, mining companies can remain responsible for the processing and recycling of the metals they sell.

- In integrated business models, mining companies act more like commodities companies. They sell metals from their own recycling facilities, as well as from mines.

At the level of the economy, disparate sources have different takes on the potential impact of the circular economy. These sources include national governments, industry associations, management consultancy firms and environmental non-governmental organisations. Despite the attraction of a zero-waste society, a market and demand for virgin resources will likely continue for the foreseeable future. However, circular economy principles can, when supported by public policy and consumer buy-in, support new models for integrating the extractive industry into the global economy.

At the firm- or mine-level, circular economy principles can also help drive much more efficient operations. Inputs can be reused as much as possible on site. In some cases, they can be reused practically infinitely. Waste from beneficiation and metallurgic processes can also be reused or repurposed. For large vertically integrated firms, recycling may already be part of the business model. For example, Mitsubishi Materials has adopted circular economy concepts across the range of different firms within its group. That includes a recycling-focused approach that combines new commodities with metal. This metal can be recovered from home appliances, aluminium cans, metal processing plants and non-ferrous smelters. It uses waste material as inputs for cement. Smelting plants then use clinker dust waste from cement creation as inputs in the smelting process (Mitsubishi Materials, 2018[77]).

At the operational level, circular economy principles can also have a powerful impact. Non-operational mines can represent enormous environmental risk factors. At the same time, they can often contain substantial amounts of valuable metals within waste rock and tailings that can be reprocessed using modern techniques. Public policy can play a role in supporting these developments. Circular economy principles reduce or eliminate waste. They also reduce the need for new mines to be developed in the first place. In this sense, they can have broadly beneficial impacts on the environmental impact of mining.

3.8. Key recommendations

Successful OECD jurisdictions demonstrate a confluence of policies that together incentivise, support and regulate mining companies to adopt greener technologies, make processes more efficient and reduce their environmental impact.

- **Implement comprehensive, clear and consistently enforced regulation.** This includes the environmental assessment process, as well as regulation and enforcement during operations. The regulatory system should promote good environmental management and prevent environmental harm rather than punish transgressors. The ultimate goal should be compliance with the regulations, or even going beyond them; it is not to generate revenue through penalties and taxes. This also means the regulatory framework needs to extend beyond the life of the mine. In so doing, it can ensure that waste dumps and tailings are properly managed and land affected by the mining operations is rehabilitated.
- **Support innovation and environmental performance in the mining sector through the funding of sector-specific and applied research.** In mining-intensive regions, government should develop innovation plans specifically targeted at the sector, independently or as part of national innovation policies. This helps facilitate collaboration between government researchers, universities,

institutions and the private sector. Government can also assist with financing to commercialise innovations.

- **Build human capacity through education, training and work experience.** Although mining companies conduct their own in-house training, ensuring that environmental concerns, solutions and new technologies are part of the curriculum in mining-related engineering and vocational programmes helps enable better environmental performance. It also helps ensure that skills are available for third parties. This will enable such parties to provide environmental services to mining companies. They could also potentially certify performance to the government or be employed directly by the regulating agency.
- **Develop policies to address abandoned and orphaned mine sites.** Legislation that ensures mine sites are monitored and rehabilitated is a relatively recent development. It has emerged in step with the growing recognition of environmental destruction in the latter half of the 20th century. Significant numbers of mine sites have been abandoned, with no party clearly responsible for their rehabilitation. If the operating company still exists, legislation can oblige them to cover the site. In many cases, however, the mines were created under entirely different economic systems or the company no longer exists. In such cases, the government needs to have an approach to orphaned mine sites. Approaches include setting aside funds by operators to cover post-mining activities, environmental liability insurance, environmental payments or earmarked royalties.
- **Ensure that mine operators can implement and, if necessary, import more efficient and environmentally sensitive equipment.** Governments need to ensure that companies are encouraged to access and uptake new technology. Furthermore, they must remove barriers to importing this technology. This may include tax structures that incentivise the purchase of new equipment or import duty exceptions on new equipment that meets environmental criteria.
- **Raise awareness about the mining industry's need to put safety and environmental sustainability first and to ensure a zero-failure objective to tailings management facilities.** Governments can facilitate this awareness in several ways. They can require mine operators to regularly update and publish disaster management plans. They can mandate third-party monitoring of mine and mine waste sites. Finally, they can require financial securities for the life of the mine, as well as transparent sharing of information with potentially impacted stakeholders.
- **Facilitate broad stakeholder participation in support of good environmental performance from mining operations.** Regulations governing the establishment, operation and closure of mines can require inclusion of all stakeholders in the process. Industry associations are valuable sources of information, and can help legitimise and communicate new policy developments to firms. The public (both locally and broadly) could be informed about new and potentially high-impact industrial development, and given space to voice their concerns. The operator can then address these concerns. These measures help involve environmental groups and other civil society organisations in both environmental assessment and compliance exercises.
- **Draw on international conventions and agreements for standards, co-ordination and information.** A broad array of international conventions and

agreements address everything from transboundary pollution to industrial incidents to general good practices. These initiatives are led by organisations such as the UN Economic Commission for Europe and the UN Environmental Programme. Together, they establish standards and frameworks for improving environmental performance in the mining sector. Valuable benchmarks include the legislation of common European standards for machinery operating within hazardous underground atmospheres; energy efficiency; and dust management.

- **Adopt a whole of government, co-ordinated approach to improving environmental performance in the mining sector.** Regulatory responsibility for a mining project may be shared over multiple agencies, depending on the pollutants, the stage of the project and the medium. Responsibility may also fall under different levels of government. Local, sub-national and national governments, for example, may regulate different aspects of the sector, introVducing challenges for governance and fiscal arrangements. Ensuring multi-level co-ordination between those actors and minimising duplication help improve clarity and efficiency with regard to communicating with operators. This also helps ensure that operators have a social licence to operate.
- **Support the development of a market for third-party green service providers in the mining sector, including accreditation processes.** Improving the environmental performance of the mining sector can be a catalyst for bringing green service providers into a country. Governments can support this outcome through access to capacity building programmes for independent consultants and support for vocational training. Policies should include accreditation for domestic and foreign green consultancy services to encourage market entrants and provide confidence to mining companies.
- **Quick wins should be prioritised, but depend on specific country contexts.** On an ongoing basis, the public sector, in collaboration with industry and civil society stakeholders, should work to diagnose the barriers and enabling factors for enhancing environmental performance in the sector to prioritise areas of action.

Notes

1. Factors considered in the Fraser survey for policy attractiveness include current regulations, environmental regulations, regulatory duplication, the legal system and taxation regime, uncertainty concerning protected areas and disputed land claims, infrastructure, socio-economic and community development conditions, trade barriers, political stability, labour regulations, quality of the geological database, security, and labour and skills availability (Stedman and Green, 2017[48]).

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