VIEW POINT

A ROADMAP FOR SUSTAINABLE MINING

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1. Introduction

1.1 Sustainability in mining

Mining companies have evolved and remain competitive despite changes in the dynamics of economies, commodity markets, perception of stakeholders, and government policies. In the last decade, mining enterprises have striven to implement sustainable business policies in the context of the United Nations Framework Convention on Climate Change, the Paris Climate Agreement, and legislation framed for decarbonization. Since the mining and metals industry provides a key raw material input to several sectors, investors, customers, and governments demand sustainable business operations across the lifecycle and transparency in reporting.

Consequently, the mining industry is exploring climate mitigation solutions such as electrification, green energy, water management as well as compliance with greenhouse gas emissions thresholds and payment of taxes. Enterprises also need to respond to events such as tailing dam failures, mitigate environment, health, and safety (EHS) risks, and fulfill their social responsibility as part of the sustainability agenda. Progressive mining enterprises make significant social investments at their mine sites and across their mining value chain. Most mining enterprises lack the skills, technologies and resources to achieve operational excellence at speed and scale in a landscape characterized by volatility, uncertainty, complexity and ambiguity (VUCA).

In this white paper, Infosys proposes a digital approach to sustainability through a five-point plan. Our experts devise point solutions for sustainability management based on a study of 20+ global mining companies, and industry reports and case studies of the United Nations (UN), World Economic Forum (WEF), International Energy Agency (IEA), and the London Metal Exchange (LME).

1.2 Influencing macroeconomic factors: PESTEL analysis

Sustainability encapsulates multiple dimensions that need to be considered for analyzing macroeconomic factors. We have adopted the Political, Economic, Social, Technological, Environmental and Legal (PESTEL) analysis framework to assess the macro environment of sustainability in the mining industry.

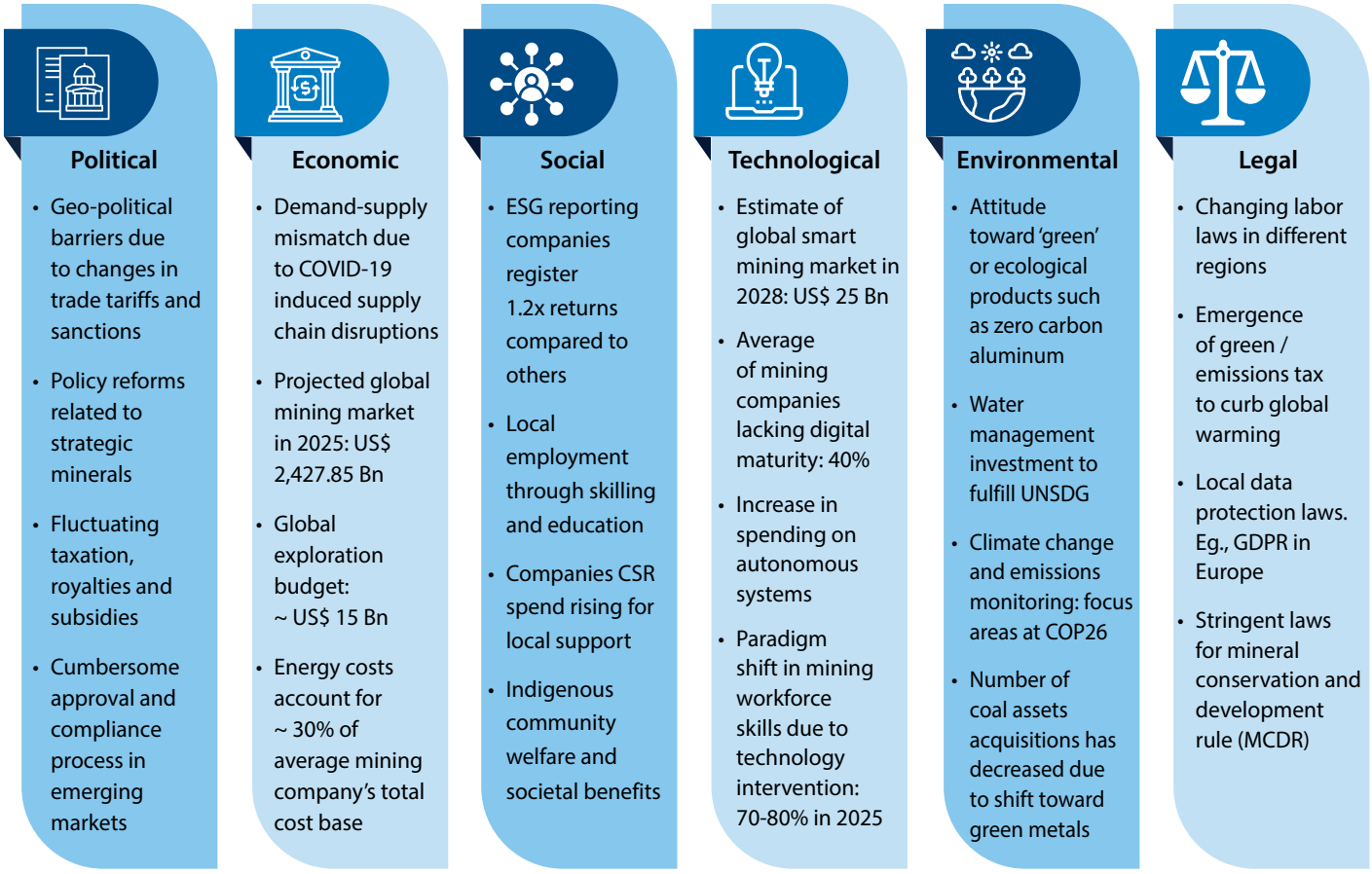

Figure 1: PESTEL analysis

2. Mining vision and mission

2.1 Vision

Sustainability in mining is based on the interpretation and study of current challenges and risks faced by global mining companies. Our five-point mission addresses key focus areas.

> To be a sustainable company by preserving natural resources thereby, transforming the mining business

2.2 Five-point mission

Our five-point mission addresses responsible mining and maintains balance in the elements of air, water, land, flora and fauna ecosystems. It demands a people, process, technology framework with specific targets set to be achieved in line with the United Nation Sustainable Goals (UNSDG). In the sections below, we focus on establishing an ecosystem for sustainable mining by leveraging digital technology to develop point solutions vis-à-vis UNSDG.

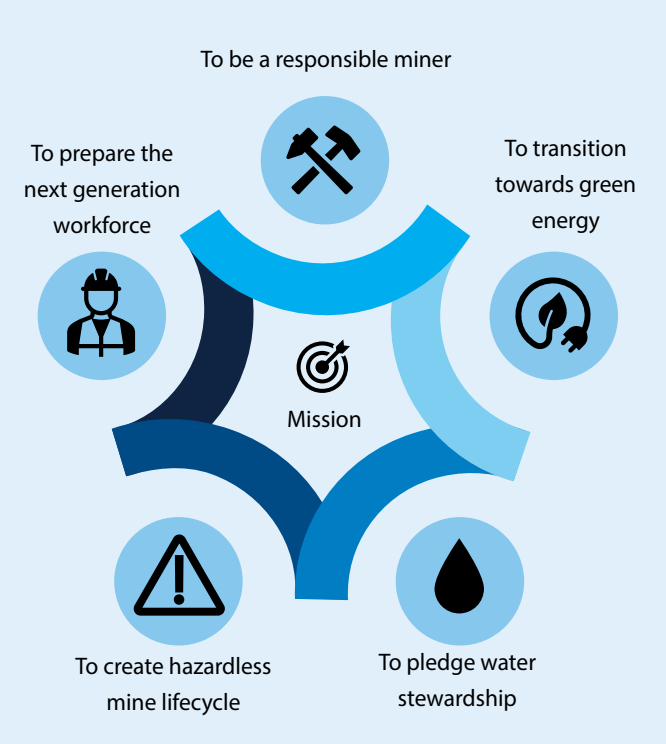

Figure 2: Five-point mission

Our point solutions are devised to create an integrated view by mapping the vision, mission, and UNSDG goals with the solutions (Figure 11: UNSDG Matrix Modelling with Sustainable Mining Operations). It provides an overview on how the point solutions address the risks and challenges to achieve the goals.

3. Addressing goals through point solutions

In 2015, the United Nations identified and set the agenda for 17 Sustainable Development Goals (SDGs)[1] to foster sustainability in the ecosystem (Figure 3). In 2019, world leaders convened for a SDG Summit calling for a decade of action to deliver on sustainable development goals, while pledging to mobilize financing, increase implementation, and strengthen institutions by the target date of 2030.

Figure 3: United Nation Sustainable Development Goals

Sustainability plays a key role in transitioning toward the mine of the future given the capital intensive and volatile nature of the industry. Transparency in sustainability reporting helps establish credentials of the mining enterprise, thereby increasing its brand value.

For a holistic sustainability view aligned with UNSDG across the mining lifecycle, Infosys proposes four-point solutions to achieve UNSDG goals based on the SDG compass[2], a guide to align strategy and measure contribution to realize SDGs.

Our four-point solutions (Figure 4) focus on the business imperatives of mining enterprises across the mining value chain.

Energy management and integrated water management are considered to be two-point solutions given the central role of energy and water as key raw materials of mining. Solutions demand sustainable consumption and utilization due to the negative effects of using fossil fuels and high emissions causing pollution and water scarcity, and operations in water stressed areas.

The ESG risk matrix is the third point solution. ESG reporting performs a key role in increasing market returns and restricting penalties as well as legal fees in the regulatory / legislative framework. Our solution creates a channel to increase value for stakeholders by addressing hazards across the mining lifecycle.

Product traceability is the fourth point solution. Customers, regulatory and trading bodies are an intrinsic part of the mining lifecycle seeking eco-friendly products in a circular economy. These constituents demand that companies incorporate product traceability to reduce their carbon footprint across the product lifecycle.

Figure 4: Rationale for point solutions

3.1 Energy management

The dual role of the energy market in the mining industry is interpreted based on findings in 'Net Zero by 2050 – A Roadmap for the Global Energy Sector,' a report by the International Energy Agency (IEA)[3]. It reveals the impact on the bottomline and topline of mining companies as a source of revenue and raw material (Figure 5).

Key highlights:

1. Share of biomass, and solar, wind, hydro, and geothermal energy are expected to be 2/3ds of the total alternative and viable revenue streams and raw materials by 2050.
2. Stringent carbon neutrality targets by 2050 due to legislation addressing climate change and green energy
3. Pressure on adapting to GHG accounting standards by defining boundaries for Scope-1,2, and 3 emissions across the mining value chain

These factors will contribute to constraints (Figure 4) due to a demand-supply mismatch in the metals market by 2030:

1) Financial constraints caused by low-carbon technologies replacing fossil fuels and infrastructure will demand an eightfold increase in renewable energy investments. Consequently, mining enterprises will have to seek financing and investments.

2) Production constraints due to increased demand along with additional cost for green energy metals, such as lithium, cobalt, and nickel.

Our point solution focusses on clean energy and carbon neutrality. It provides an opportunity for miners to create a robust ecosystem for energy management, adhere to global norms, and collaborate with technology partners.

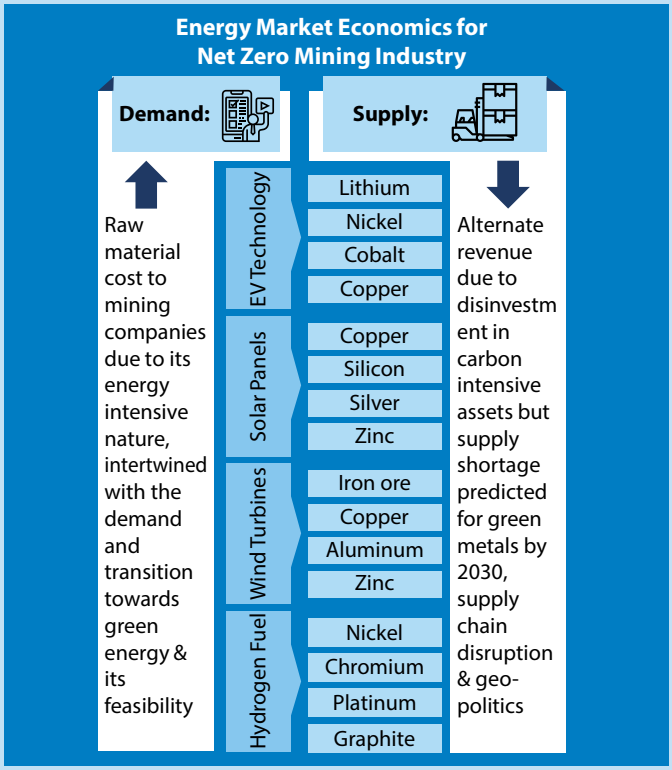

Figure 5: Green Energy Market Economics

Figure 6 illustrates how a smart energy management system addresses constraints in a people, process and technology continuum based on IS0: 50001[4] and ISO/IEC 17021 standards with a plan-do-check-act (PDCA) model.

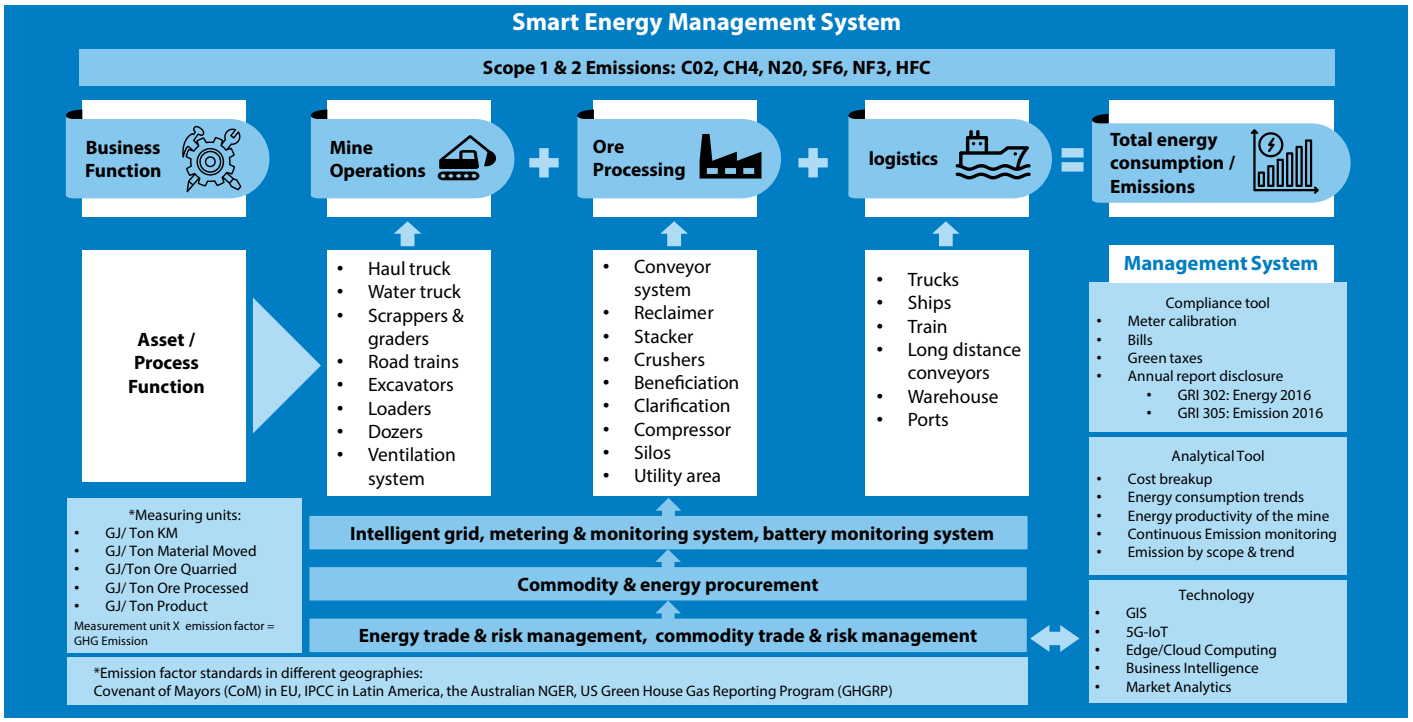

Figure 6: Smart Energy Management System

It enables executives to make informed decisions based on AI via a single source of truth and formulate strategies for -

- Electrification of hauls, excavators, and mobile equipment
- Battery storage and renewable energy harnessing technology
- Installation of the latest electrostatic precipitators
- Evaluate potential of LNG and biodiesel as a marine fuel

Scope 3 bifurcates the indirect emissions in upstream and downstream based on the financial aspects of the firm, where upstream includes indirect GHG emissions from acquired goods and services and downstream are covering indirect emissions from sold goods and services. Scope 3 accounting for 94% of the total mining emission, this has been a buzz word due to complexity in calculating and tracking the GHG emission.

3.2 Integrated Water Management

The mining industry requires a significant amount of water and accounts for 90% of waste, according to a report[5] by the Community Research and Development Information Service (CORDIS) of the European Commission. Water management practices and digital infrastructure incur a significant cost, which can be optimized to improve operating margins:

- Procurement cost: varies geographically based on climatic conditions, water scarcity, and logistics.
- Water application cost: varies depending on factors such as mine haulage path, and ventilation system.
- Community cost: varies geographically based on availability of potable water and CSR commitments.
- Environmental cost: varies according to the law of land mandating cess payments.

Apart from the cost, compliance and transparency are key factors. A survey of water practices conducted by the CDP revealed that 37% of mining companies did not make disclosures. Since transparency in disclosure has been beneficial in several areas of mining –eliminating corruption and fostering fairness in developing countries – it will pave the way for responsible water stewardship driven by community engagement and powered by technology. It helps miners address operational challenges of water scarcity and water stressed areas, thereby working toward waterless mining.

Protocols of the UN Global Compact CEO Water Mandate and Towards Sustainability Mining (TSM)[6] prescribe criteria for mining enterprises to address challenges of water governance, water operations management, water shed scale planning and water reporting. Figure 7 illustrates a Smart Integrated Water Management Plan (S-IWMP)[7]

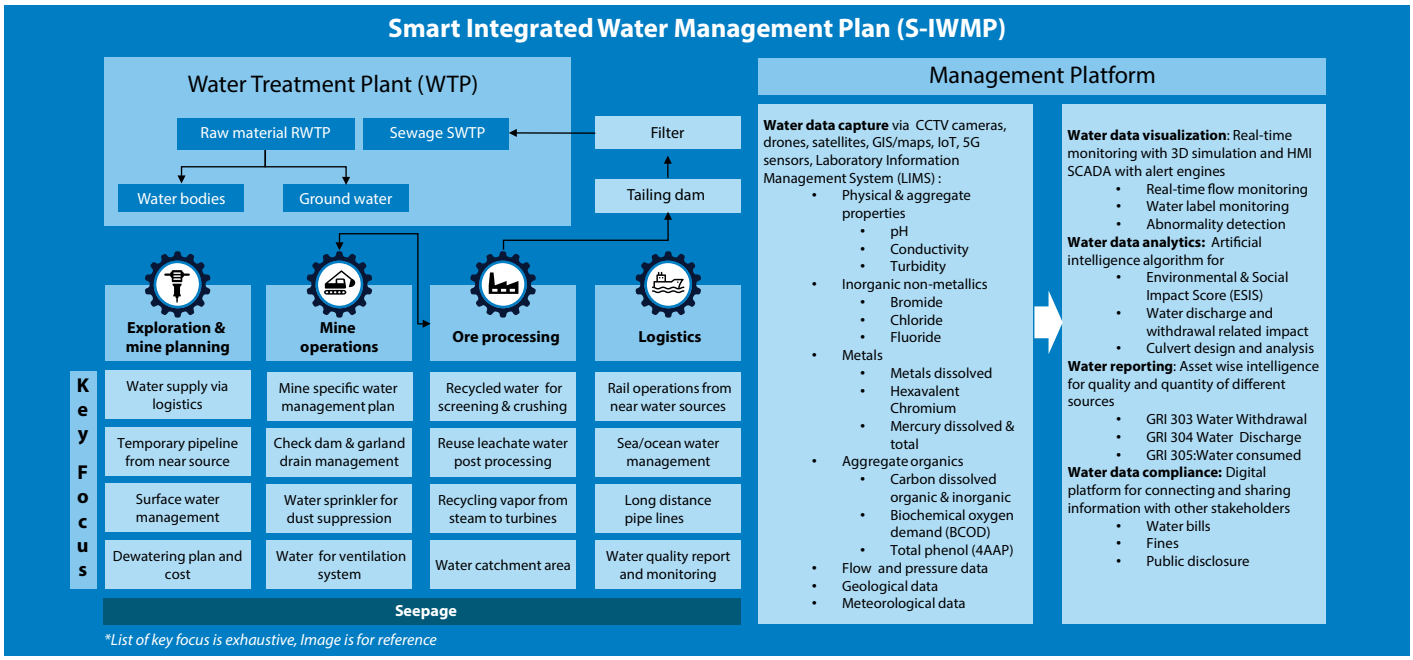

Figure 7: Smart Integrated Water Management Plan S-IWMP

Some of the key practices adopted by mining companies locally at mining sites include:

- Community engagement by creating voluntary water monitoring programs
- Water reuse from adjoining industries for refining
- Potable water availability for the local community
- Rainwater harvesting facility / capturing run-off water
- Desalination techniques for metal facilities operating close to oceans / seas[8]

3.3 ESG risk management

In the past, disruption in global mining has influenced the risk profile of business. Climate change and stakeholder expectations compel miners to work toward a sustainable and safe mining enterprise. Decarbonization, the Covid-19 pandemic, and workforce risk and safety have been major concerns for miners in recent times to drive action on persisting issues. The environment, employee health and safety, and governance are on the radar due to imperatives of decarbonization and workplace risks.

Infosys proposes an ESG risk assessment matrix (Figure 8) to apply risk analytics based on business priorities to drive sustainable mining operations. It focuses on a hazardless mining lifecycle to ensure balance in the ecosystem while enabling governance, skilling, and CSR activities while ensuring compliance with the latest regulations and policies.

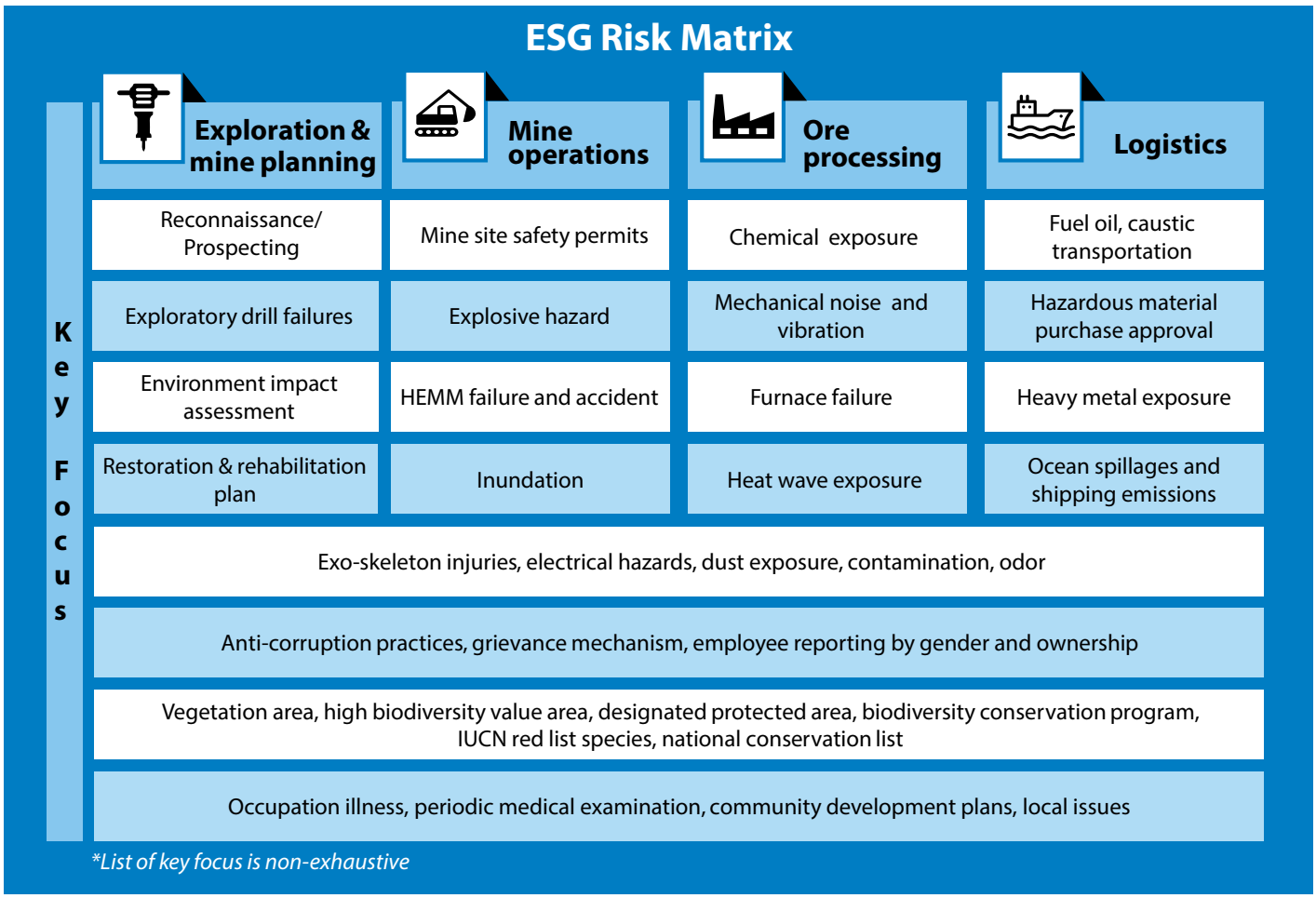

Figure 8: ESG Risks Assessment Matrix

Workforce: The workplace of the future needs to foster a work culture that provides purposeful career trajectories. Lack of mobility makes it challenging for the mining sector to find the finest talent. Miners should be equipped with smart vocational training classrooms that provide simulator-based training with extended reality (XR). High quality online learning in collaboration with third parties helps bridge the digital literacy gap. Priority should be accorded to enhancing workplace safety and recognizing mental health in the aftermath of the Covid-19 outbreak. Smart personal protective equipment (PPE) such as wearables in the form of wrist watches and skull caps enable continuous monitoring with GIS and mobile applications. Diversity and inclusion should be corporate priorities since governance is on the investor's agenda.

Environment: In the long term, mining enterprises that align their business with environmental, social, and governance (ESG) criteria will resonate with investors, shareholders, and other constituents. With increased scrutiny on biodiversity and water management, miners need to be responsible for the communities in their area of operations. Mining enterprises should maintain a taxonomy of flora and fauna, conduct an audit of biodiversity at mining sites, and assign a dedicated team for sustainable excavation and mine closure standard operating procedures (SOP).

3.4 Product traceability

Mining enterprises adopting sustainable practices have an edge over peers as demand for environment-friendly products grows. Product traceability and ESG disclosure continue to gather momentum for responsible metal production through metal logs, green energy, ore recovery technologies, and hydro-carbon management to decrease the cost of production and enhance their brand equity. Consequently, product traceability and bio-products have become focus areas, as discussed in the context of two metals below:

- **Steel:** According to the World Economic Forum, 'green iron' is gaining traction for its high utility in a variety of products ranging from turbines to automobiles[9] as well as accounting for 7% of GHG emissions. The dynamics of business point toward vertical integration and mergers and acquisitions to de-risk carbon intensive assets. At the same time, leading mining enterprises are using their financial leverage by diversifying into integrated green steel plants and developing intellectual property for production technologies.
- **Aluminum:** The physical properties of aluminum such as ductility, malleability, and low density along with its non-corrosive conductivity nature makes it a viable alternative for other metals in aerospace, automotive and consumer goods industries. The high demand for primary and secondary aluminum products provides an opportunity to diversify into more domains as substitutes. In primary aluminum production, inert anodes are required to reduce the carbon footprint with a levelized cost of aluminum being US$ 1589/ton. On recycling of aluminum run primarily on natural fuels carbon capturing units and hydrogen management that play a key role in reducing and reusing the carbon with a levelized cost of aluminum being US$ 1475/ton for carbon and US$ 1480/ton for hydrogen[10].

Sustainable mining demands responsible production, low carbon intensive processess and leaning into the circular economy. Policy and governance require extraction of ore in a sustainable and ethical manner, reducing waste and minimizing the carbon footprint to ensure long-term sustainability of the local community and natural habitat (Figure 9).

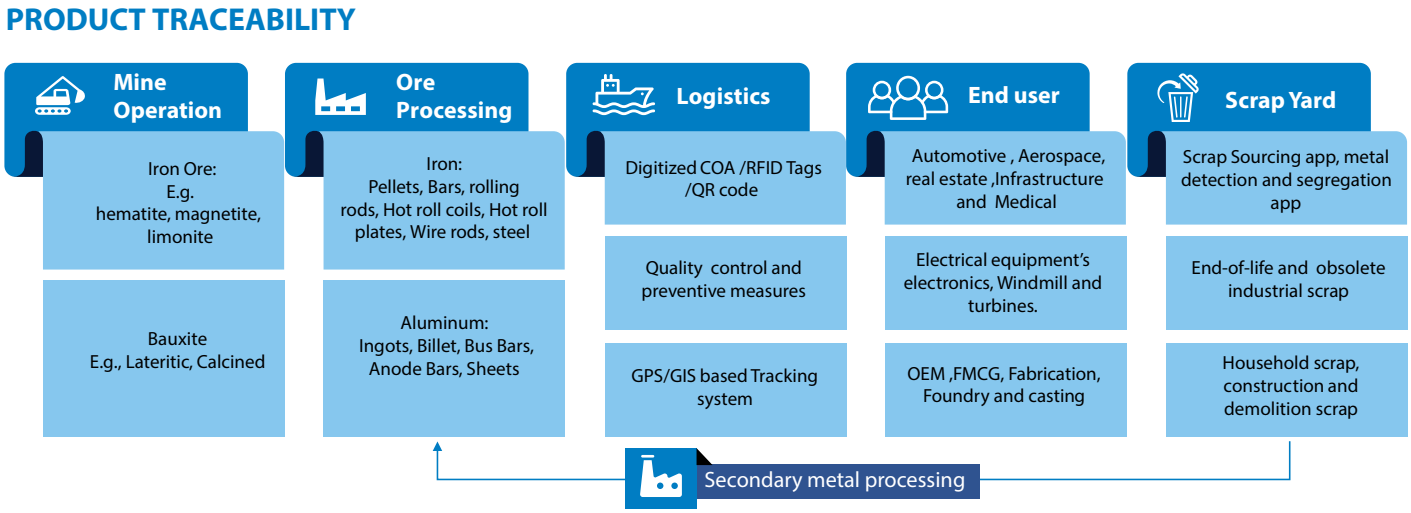

Figure 9: Product Traceability

- **LMEpassport**[11]: The London Metal Exchange provides Certificates of Analysis along with carbon, product tracking such as recipe of the metal, and warehousing details (Figure 9: Product Traceability). Mining companies can hold 21 certifications of bodies such as International Council on Mining and Metals (ICMM), Initiative for Responsible Mining Assurance (IRMA), Aluminum Stewardship Initiative (ASI), and Responsible Mining Initiative (RMI)[12].
- Blockchain is an emerging technology involving trading and metal trial logs facilitating seamless supply chain management
- Government support is required for private firms and research bodies to mitigate the risks for producing carbon-free metals due to associated financial liabilities.
- Government support is also imperative to drive cross industry collaboration:
- Encourage miners by incentivising usage or production with a lower carbon footprint
    - Public funding of green energy projects
    - Legalising standards and compliance
    - Local community acceptance

4. The sustainability journey

As seen in study, the mining sector needs to capitalize on new opportunities arising from sustainable mining. It will enhance transparency across the value chain, optimize production costs, ensure safer and healthier working conditions for miners, and reduce the carbon footprint. These point solutions for sustainability will drive operational excellence, carbon neutrality and digital innovation as key business benefits shown in Figure 10. In addition to this, industry must address their modus operandi based on the various business models.

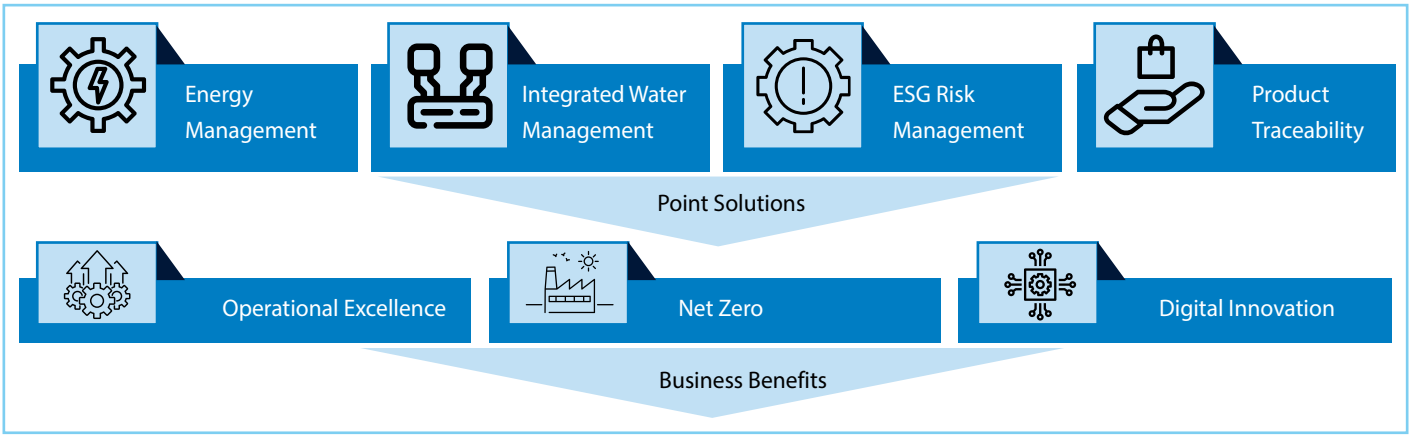

Figure 10: Business Benefits

Operational excellence: Optimal use of water and energy, key raw materials in mining operations, results in superior processes that eliminate waste streams by reutilizing or efficiently managing utilities across the value chain. Green energy will help reduce the carbon footprint, and clean energy processes will ensure higher uptime of machinery. Product waste streams will open new sources of revenue by increasing secondary metal production capacity, resulting in enhanced market penetration. Manpower utilization also plays a crucial role in increasing throughput of production. ESG risk management helps address hazards and other factors proactively rather than respond to risks reactively.

Net zero: The mine of the future needs to incorporate carbon neutrality across the product lifecycle. It demands designing carbon light processes and products. In addition, it addresses biodiversity imperatives covering the workforce and local population, vegetation, bio-habitat, ambient surroundings, and water bodies. Green and recycled products help miners gain a competitive edge in terms of market share and brand value, thereby introducing product traceability as an important element into their business. Upstream and downstream producers need to be cognizant of Scope 3 emissions and develop a mechanism to capture carbon and other emissions.

Digital innovation: The modern mining enterprise adopts extensive data modelling and algorithms, simulation and optimization-based solutions, and technologies such as IIoT, cloud/Edge, XR, AI/ML, and blockchain will support flexible and cost-related decision-making. Digital technology enhanced worksite health and safety during the Covid-19 pandemic, a prime example being the use of smart PPE. Mines with remote operation centers (ROCs) capabilities combined with utilities management performed better despite resource constraints during the pandemic. Simulators for training the workforce and digital platforms for community engagement has been a breakthrough in terms of hiring and utilizing talents both within and outside the organization. A digitized supply chain is a catalyst for the circular economy by fostering collaboration among stakeholders at the bottom of the pyramid and integrating technologies for sorting and segregation.

Achieving these business benefits depends on adopting an optimal business approach. The mine of the future needs to select one of the business models below that best suits its unique dynamics and needs:

- Circular business model focuses on reducing waste and emissions, thereby pivoting to carbon neutral production.
- Integration business model can be subdivided into vertical integration and horizontal integration.
    - Vertical integration involves acquisitions or mergers into downstream sectors. In this business strategy, the enterprise owns or controls its distributors, retailers, or suppliers to manage its supply chain and achieve operational excellence.
    - Horizontal integration fosters innovation via business ventures with IT service providers.
- Joint ventures: support industry with the contribution of partners backed by their assets and capabilities. Pooling of assets improves production yield exponentially.

To summarize, the point solution along with the UNSDG goals are mapped (Figure11) with vision and mission to create a relationship matrix based on the UNSDG compass discussed in Section 2 and 3.

Vision:
"To be a sustainable company by preserving natural resources thereby, transforming the mining business"

Mission

Point Solution	Responsible Miner	Hazardless Mine Lifecycle	Water Stewardship	Next Gen Workforce	Green Energy
Energy Management	13 17	14 15	7	8 9	7 9 12 16
Integrated Water Management	1 2 13 17	14 15	6 9 16	8	6 13
EHS Risk Management	1 2 11 13 17	3 9 14 15 16	6 13	1 2 4 5 8 10 11	7 13
Product Traceability	9 12 13 16 17	13 14 15	6 13	1 2 8 12	7 13

Figure 11: UNSDG Matrix Modelling with Sustainable Mining Operations

5. Conclusion

Sustainability across the value chain is a business priority for mining enterprises. Our PESTEL analysis is the starting point to assess policies and governance. Our five-point mission facilitates responsible mining, green energy, and water stewardship. Our point solutions are designed for the people, process and technology continuum to realize sustainable mining.

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