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LOCAL CONTENT POLICY: SUPPLEMENTARY GUIDANCE

Leveraging Renewable Energy Infrastructure for Mining Community Resilience

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Executive Summary

Since the beginning of modern mining, resource-rich countries have attempted, with mixed results, to translate mining investments into broader benefits for host states and communities. As global demand for minerals and metals rises to meet the needs of the energy and digital transitions, the number of mining operations, particularly in developing countries, is expected to grow significantly in the coming decade. This presents both risks and opportunities: a chance not only to increase fiscal and export revenues but also to promote local economic development and improve livelihoods in mining areas.

Mining is among the most energy-intensive industries globally and has historically relied heavily on fossil fuels for extraction, processing, and transportation. At the same time, the sector plays a central role in the energy transition by supplying the critical minerals required for clean technologies such as electric vehicles (EVs), solar panels, and wind turbines. In response to this contradiction, mining companies are beginning to invest in renewable energy infrastructure as part of their decarbonization efforts.

For many resource-producing countries, these investments serve a dual purpose. They help reduce the carbon footprint of mining operations and offer a way to improve energy access, particularly in remote areas. Nearly 700 million people worldwide still lack electricity, and around 2.3 billion continue to rely on fossil fuels or wood for cooking. Renewable energy deployed through mining operations can help address these gaps while contributing to broader development goals.

When renewable energy infrastructure developed by mining companies is made accessible to surrounding communities, the socio-economic benefits can be substantial. These include job creation, better public services, improved supply chains, and greater financial inclusion. This approach can also support countries in achieving climate targets and advancing economic diversification.

However, realizing these benefits depends on inclusive and deliberate policy choices. The energy transition offers a unique opportunity to reduce inequalities, particularly for women, Indigenous Peoples, elderly people, persons with disabilities, and youth who are often most affected by energy poverty. Gender-responsive and socially inclusive policies can help close persistent gaps in access to education, training, and employment in the renewable energy sector.

The use of renewable energy in mining remains relatively new in policy and regulatory terms. This report explores how governments and companies can work together to align renewable energy deployment in the mining sector with broader social and economic objectives. It considers how decarbonization strategies can serve both environmental and development goals, and what enabling conditions are needed for success.

To unlock these opportunities, governments must create the right environment for innovation and collaboration. This includes aligning mining and energy policies with community development plans, removing regulatory barriers, and encouraging companies to expand the benefits of renewable energy beyond their operational boundaries. Achieving this requires strong governance, inclusive planning, and strategic partnerships.

Examples from the field are encouraging. In northeastern Democratic Republic of Congo, the Kibali Mine (Barrick Gold) has replaced diesel with nearly 100% renewable energy through a mix of solar and hydropower. The infrastructure is expected to continue serving local communities after mine closure. In Colombia, a telecommunications company is supplying renewable energy to a large mine, which shares the excess power with nearby villages. These cases show that well-designed policies and investments can turn mine-related infrastructure into long-term community assets.

Governments have a critical role to play. By developing regulations that promote shared use of renewable energy infrastructure and by integrating energy planning into national development strategies, they can reduce dependence on the mining sector and promote broader social progress.

Based on consultations with governments, mining companies, civil society, and community stakeholders, this report offers the following key policy recommendations:

- **Strengthen local content policies** by incorporating renewable energy infrastructure to ensure benefits extend beyond mine sites.
- **Promote skills development** to prepare local communities, especially women and marginalized groups, for employment in the green economy.
- **Enhance policy coherence** by improving coordination between mining, energy, education, and development ministries.
- **Foster public–private partnerships** to support the sharing of renewable energy infrastructure with communities through fiscal incentives and investment frameworks.
- **Ensure sustainability and long-term planning** by including infrastructure maintenance and post-closure responsibilities in energy strategies.
- **Adopt circular economy approaches** to manage the environmental impacts of renewable infrastructure through recycling, reuse, and sustainable design.
- **Address the gender energy divide** by making education, financing, and technologies more accessible to women and historically underserved groups.

This report complements the Intergovernmental Forum for Mining, Minerals, Metals and Sustainable Development's **2018 *Guidance on Local Content Policies*** and underscores the transformative potential of renewable energy infrastructure to enhance local development and resilience. While risks remain, particularly where policies fall short, there are clear lessons to be learned from success stories. With the right frameworks in place, countries can ensure that mining-led growth contributes to inclusive and sustainable development.

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Acronyms

EV	electric vehicle
GHG	greenhouse gas
IEA	International Energy Agency
IGF	Intergovernmental Forum for Mining, Minerals, Metals and Sustainable Development
IRENA	International Renewable Energy Agency
MW	megawatt
NREL	National Renewable Energy Laboratory
PPA	power purchase agreement
PV	photovoltaic
RREE	Regional Renewable Energy Ecosystem
STEM	science, technology, mathematics, and engineering

1.0 Introduction

The mining sector is highly energy intensive and is an important source of greenhouse gas (GHG) emissions: while these values can vary substantially between minerals, in 2021, average GHG emissions from the production of copper amounted to 4.6 t of CO_2 equivalent per tonne of metal content, versus 10 t for nickel sulfide and 16.7 t for cobalt (International Energy Agency [IEA], 2021). Along the mining value chain, midstream processing activities require the highest amount of energy, especially where pyrometallurgical processes such as smelting are involved. In nickel mining, for example, smelting and refining were identified as contributing to up to 60% of all GHG emissions (Harvey et al., 2022), with extraction, crushing, transportation, and corollary activities also requiring significant amounts of energy. The increasing global population and the economic shift of low-income nations to middle-income status are expected to drive up demand for minerals and metals. This demand, paired with declining mineral ore grades, will likely increase the energy consumption of the mining industry (National Renewable Energy Laboratory [NREL], 2020), thereby potentially raising emissions intensity levels.

It is therefore imperative that mining decarbonize its electricity and transport consumption. With the right resources and intentions, there are opportunities to reduce GHG emissions by adopting renewable energy systems, innovative transport methods, and decarbonizing metal processing. Data indicates that such efforts have already significantly contributed to reducing GHG emissions in the production of minerals such as copper, with global direct and indirect emissions from mining sites falling by over 5% between 2022 and 2024 (Skarn Associates, 2026). This was almost all due to power purchasing agreements enacted by copper mines in this period (Skarn Associates, 2026). Indicative of this, mining operations are increasingly turning to on-site solar, wind, and hybrid renewable microgrids to replace diesel generators and grid power, which has the potential to not only lower emissions but also to improve local energy access and security while reducing air pollution for nearby communities.

For ore movement, alternatives such as electric conveyor belts, battery-electric or hydrogen haul trucks, and aerial cableways are being tested as ways to reduce road traffic, dust, and noise, making transport safer and healthier for communities living along haul routes. For processing activities, companies are piloting low-carbon technologies like green hydrogen or biomass for smelting, electrified furnaces, and carbon capture in refining to cut industrial emissions and improve air quality while reducing risks of health impacts for workers and surrounding populations. These shifts demonstrate that decarbonization in mining, albeit challenging, is technically feasible and already underway in parts of the sector.

While significantly contributing to global GHG emissions and impacting local air quality, mining activities can, however, function as reliable energy consumers and enable the electrification of remote areas hitherto untouched by the main grid, indirectly contributing to local economic activity in ways that go beyond mining. Renewable energy systems can often be scaled and modulated appropriately, enabling the establishment of mining sites at lower costs while providing additional job opportunities for their installation and maintenance. In this sense, renewable energy systems perform a four-pronged function that can be detailed as

- enablers of mining activities in areas that are more difficult to access
- enablers of environmental and climate benefits in the form of lower GHG emission rates and lower rates of air pollution
- enablers of substantial operational savings by mitigating risks associated with fuel price volatility
- contributors to local prosperity by providing job opportunities and electrifying surrounding economic activities.

The energy landscape, however, is undergoing a significant transformation that presents new challenges for governments in terms of where to focus and what to prioritize. While the private sector is often more agile in pivoting toward renewable energy adoption, governments must create enabling policies, regulatory frameworks, and investment incentives to scale up these initiatives and align them with national climate commitments. This is particularly urgent given that many national mining and energy policies were mostly crafted in decades past during an era of fossil fuel-based economies, leaving policy-makers with the complex task of adapting outdated frameworks to support a rapidly evolving field of renewable energy infrastructure in and around the mining sector.

Policy-makers are now under pressure to move beyond policy development and regulatory reviews toward tangible implementation. This shift requires stronger policy alignment across national ministries, subnational governments and other regulatory bodies with responsibilities that often overlap on issues such as extractives, energy, labour, environment, water, and land use. At the same time, it creates cross-border and regional cooperation opportunities, allowing states to pursue scalable solutions at the regional level, share infrastructure, and generate benefits beyond individual borders.

Moreover, despite wide acknowledgement of the importance of meeting climate commitments, this study revealed a lack of available policies aiming to generate positive spillover effects for local economies and communities. There is generally little awareness about policies to encourage or require mining companies to share their infrastructure—or access to the renewable energy they generate—with local communities. For resource-rich countries, this represents a missed opportunity to align strategies to mutualize the benefits and support local economic development. While a few examples of good practice exist, in practice, renewable energy solutions will inevitably be shaped by specific country and project characteristics.

The Intergovernmental Forum on Mining, Minerals, Metals and Sustainable Development (IGF) has identified five broad categories of local content policies: (i) local procurement of goods and services; (ii) direct employment; (iii) downstream value addition; (iv) horizontal linkages, such as shared infrastructure; and (v) local ownership. **Renewable energy infrastructure falls under horizontal linkages,** since it can serve both mining and non-mining users. Framing renewable energy within this policy architecture allows governments to position it not only as an operational necessity for mines but also as a lever for local economic diversification and resilience.

This report argues that while renewable energy adoption in the mining sector is growing, it is currently driven more by operational necessity than by public policy or community benefit. The central challenge, and hence the opportunity, is to design mining sector investments in renewable energy in such a way that they align with national energy access and security needs, development goals, and local community resilience. The report first sets out the global and sectoral context (Chapters 2–3), then examines how renewable energy infrastructure can be better integrated into policy-making (Chapter 4). It identifies key success factors and barriers (Chapter 5) before turning to a set of policy recommendations (Chapter 6). While recognizing the risks associated with poorly implemented policies, the report underscores the importance of learning from both successes and failures. Throughout, the report emphasizes the importance of coherence across policies, inclusive approaches that benefit communities, and the role of mining in enabling low-carbon value chains.

2.0 Renewable Energy in the Mining Sector

Energy is consumed in different ways and from different sources according to the type of mining operation in the value chain. In general, mining operations require either the consumption of electricity or the use of direct energy feedstock (mostly fossil fuels) for direct use in some processing activities. A stylized representation of these processes can be seen in Table 1.

TABLE 1. Energy uses in mining processes

	Exploration, extraction, and auxiliary operations	Material handling	Beneficiation and processing
Electricity	Ventilation, drilling, dewatering pumps, digging	Transportation, trucks, conveyor belts	Comminution, crushing, grinding, floating, electrowinning, refining
Diesel	Drilling, digging	Transportation trucks	
Fossil fuels	Ventilation, backup generators		Drying, firing, smelting, refining

Source: IGF elaboration from NREL, 2020.

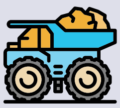
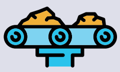
Renewable energy can be introduced with varying levels of ease in these processes. Where electricity is the main source of energy, renewables can be introduced as the sole or main source of power generation. This is particularly true in mining sites that are disconnected from the main grid, where solar photovoltaic (PV), wind, or hydropower can play an important role if coupled with storage options or with backup diesel generators.

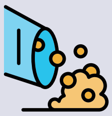
Similarly, other feedstocks can at times substitute fossil fuel feedstocks used in pyrometallurgical operations, such as in smelters. Charcoal, for example, can replace the use of coke as a reducing agent, but its sourcing and trade can raise different environmental and climate concerns. Renewables-sourced hydrogen is a potential solution as a reducing agent, but electrolyzer costs have slowed its deployment, currently posing an obstacle to the integration of these technologies at scale (Wang & Butterworth, 2025).

Renewables can also play a role in generating heat for processing operations. **Existing technologies allow for an increasingly wider deployment at temperatures at lower and medium range**, which in the mining sector are deployed in processes such as drying. Here, heat pumps, e-boilers, and electro-thermal energy storage units can be supplied with electricity from renewable energy sources (solar PV, wind, geothermal, hydropower, biomass) (IEA, 2025). Integrating renewable energy is harder for processes requiring higher temperatures, with concentrated solar power demonstrating some initially promising results but with the technology still to be applied at scale (Igogo et al., 2020).

Finally, "discrete" transportation systems, such as haul trucks, bulldozers, and other vehicles currently operating on diesel, can be electrified. Table 2 provides a concise visualization of how renewables can be integrated into all processes in mining and processing.

TABLE 2. Renewables adoption avenues for mining processes

 **Exploration, extraction, and auxiliary operations**	**Ventilation:** Electrical ventilators from main grid renewable power purchase agreements (PPAs) or on-site renewable generation
	Drilling and digging: Replacement of diesel-powered equipment with fully electric or hybrid plug-in
	Dewatering pumps: Electric pumps powered with local renewable generation
	Backup generation: Replacement of diesel generators with biodiesel, biogas digesters, or battery storage
 **Material handling**	**Conveyor belts:** Electrical belts powered by main grid (renewable PPAs or on-site renewable generation)
	EVs: Replacement of internal combustion engine trucks with electrified fleet
	Biodiesel vehicles: Replacement of internal combustion engine trucks with biodiesel

 **Beneficiation and processing**	**Comminution, crushing, grinding, floating, electrowinning, refining:** Electricity from main grid (renewable PPAs) or on-site generation, battery, biodiesel, or biogas storage backup
	Drying, firing: Replacement of natural gas in drying ovens with biogas or syngas
	Smelting, refining—high-temperature heat: Replace smelters using natural gas or coke coal with renewables-sourced hydrogen for the production of high-temperature heat, using electric arc furnaces powered with renewables (PPAs or on-site generation)
	Smelting, refining—reducing agents: Replacement of coke or coal or coal as reducing agents with renewables-sourced hydrogen or biomass (biochar, biocarbon)

Source: IGF elaboration.

3.0 Renewable Energy in Mining: Current practices and emerging lessons

The integration of renewable energy into mining operations is critical for meeting the industry's climate commitments and advancing countries' path to the United Nations Sustainable Development Goals. While the mining sector holds substantial potential to deploy renewable energy, recent research shows that technical and operational challenges continue to limit widespread uptake (Pouresmaieli et al., 2023). For instance, the electrification of haul trucks and other heavy vehicles increases electricity demand, requiring robust charging infrastructure.

For governments, the opportunities are clear: renewable energy adoption at mine sites can reduce GHG emissions and environmental pollution, lower operating costs, create local employment, and stimulate knowledge transfer. Such benefits extend beyond company operations to surrounding communities and national economies. These contributions can directly support progress on multiple sustainable development indicators, including energy access, climate action, and decent work.

At the same time, policy-makers must recognize the barriers that mining companies face: high upfront investment costs, limited availability of skilled labour, complex maintenance requirements, and a lack of information on the wider socio-economic benefits of renewable energy (Pouresmaieli et al., 2023). The inherently risk-averse culture of the mining industry, driven by safety and operational concerns, further slows the adoption of innovative solutions (Salgaocar, 2022).

To overcome these constraints, policy and regulatory frameworks must go beyond incentivizing technology deployment. They should also support the business model and cultural shifts required within companies to make renewable energy integration viable, scalable, and aligned with national development priorities, as well as ensuring the robustness of regulatory frameworks.

This chapter analyzes facts, provides a snapshot of their implications, and offers a set of recommendations to support community resilience through shared renewable energy infrastructure in the mining sector.

3.1 Opportunities for Renewable Energy

Opportunities for the deployment of renewable infrastructure in the mining industry are linked to functions that rely on electric power. For instance, renewables can serve as a substitute for fossil fuel-fired loads, meet feedstock demand, and support emerging applications, such as the production of green hydrogen (NREL, 2020). As renewable energy becomes more efficient, and power requirements in mines increase with dropping ore grades, it is likely that this will become a key operational cost consideration for energy supply across the sector.

Currently, most renewable energy-powered mines are gold, copper, and iron ore sites located in Australia and Chile, although more countries are installing capacity that could support their industries (Limpitlaw, 2021). Of the 51 published examples of renewable energy systems for mines reviewed, nearly 86% of installed capacity was solar PV, with the remainder generated by wind power (Limpitlaw, 2021).

3.2 Emerging Technologies

While solar and wind-based electricity dominate, several other low-GHG-emitting technologies are drawing attention. Green hydrogen can play a role both as a source of energy storage and as a reducing agent in processing operations, with potential applications in powering plants, machinery, and large equipment. Advances in automation and mini-grid applications, as well as EV deployment, also add to the toolbox available for reducing emissions in mining operations.

3.3 Shifting Operational Models

Another opportunity lies in adapting mine operations to work with variable power supply, rather than the traditional 24/7 energy model. This could potentially be achieved by pairing fossil fuel-based electricity with intermittent energy like solar and wind, complemented by improved and effective energy storage. This could involve demand-side management and programs to optimize operations by running energy-intensive processes when the energy is available, alongside feedstock stockpile management or similar. This will involve a major change to traditional thinking with respect to mine site operations (Allen, 2021).

3.4 Regional Developments

Latin America illustrates the diversity of approaches under consideration. Ecuador is beginning work on a green hydrogen roadmap in cooperation with research institutions. Argentina is exploring hydrogen applications, with studies underway by a major company in Patagonia. Brazil has widely adopted wind power nationally, but small-scale miners more commonly rely on solar. These are mid- to long-term initiatives, reflecting the need for a “basket” of renewable and low-GHG-emitting energy sources that can be tailored to national contexts.

3.5 Opportunities and Challenges for Local Socio-Economic Development

Advances in renewable energy technologies offer not only decarbonization but also opportunities for new economic activities, downstream linkages, and community benefits. Local content policies can amplify these gains by involving domestic suppliers and service providers in renewable value chains. However, significant challenges remain: conflicting business models between the mining and energy sectors, competing demands for land, limited awareness of renewable opportunities, shortages of skilled labour and expertise to operate and maintain the infrastructure, and the ongoing need for demonstration projects (NREL, 2020).

In sum, the priority for policy-makers is not only to facilitate the uptake of renewable technologies, such as solar, wind, hydrogen, or less energy-intensive smelting processes, such as hydrometallurgy, but to ensure these advances deliver benefits beyond the mine gate. By linking renewable deployment to local industries, skills development, and clean energy access for surrounding communities, governments can align decarbonization in the mining sector with broader national development goals and local socio-economic development. Clear policy signals, support for pilot projects, and investments in infrastructure and skills can help de-risk adoption while creating pathways for local participation. The following sections explore these opportunities in greater depth, with a focus on how mining-linked renewable investments can contribute to sustainable development and resilience.

4.0 Renewable Energy in Mining and Community Resilience

The adoption of renewable energy systems and renewable feedstocks in mining operations can contribute significantly to community resilience. This section analyzes how renewables and local community resilience interact, how one can benefit the other, and how governments can ensure that appropriate practices are put in place to harness the full potential of renewable energy deployment.

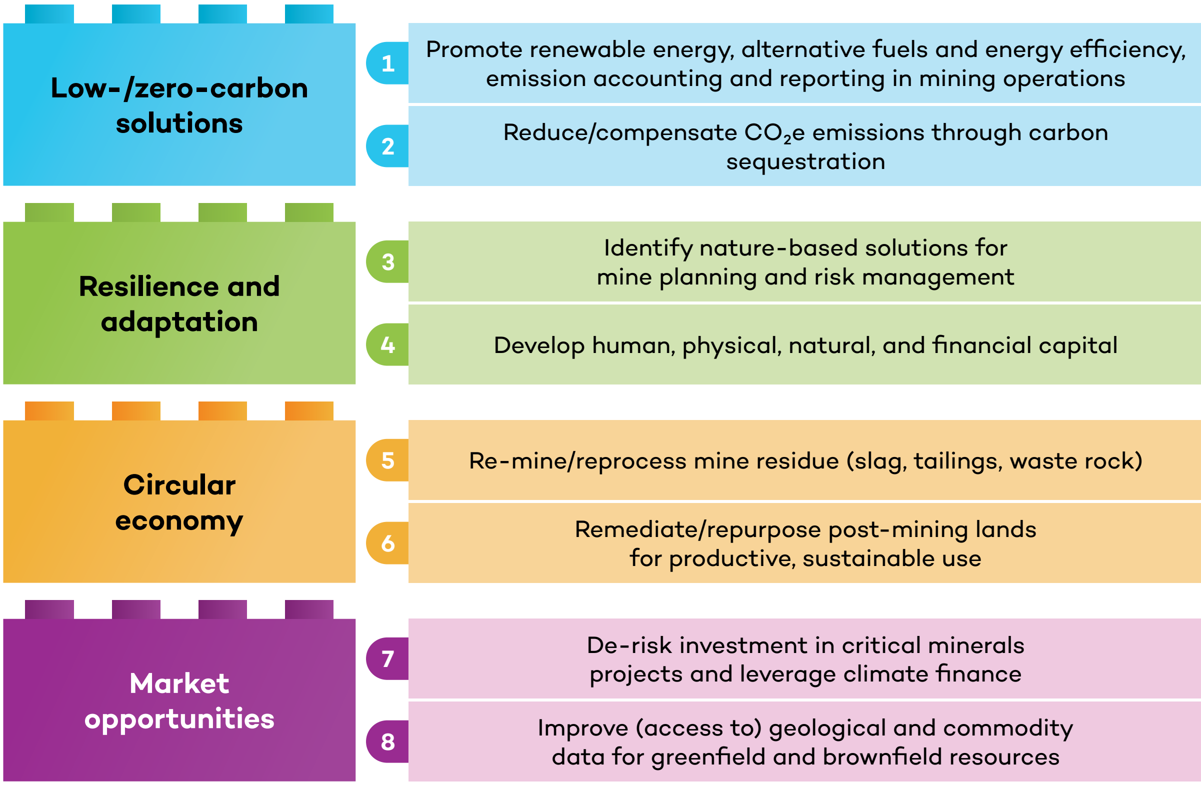
4.1 Community Resilience: Setting the scene

According to the International Council on Mining and Metals (2025), mining community resilience is defined by the extent to which mining activities can be carried out sustainably, ensuring social and economic development, and disseminating benefits that last beyond their window of operation. This is tracked across a series of economic parameters, such as: a) tax collection, b) employment, c) workforce development, d) procurement, e) the development of education and skills, and f) the development of institutional capacity and the enhancement of civic organizations.

Other scientific and research papers have stressed the importance of climate and air quality parameters, as well as the pressure exerted on the ecosystems of the communities surrounding the mining site (Davies et al., 2012). In its Climate-Smart Mining report, the World Bank (2024) put together a framework to ensure that mining operations reduce GHG emissions, improve their climate resilience as well as the resilience of surrounding communities, capture economic opportunities, and ensure the competitiveness of mining companies operating under supportive legislation. The resulting Climate-Smart Mining Framework is implemented across eight building blocks and is visualized in Figure 1.

This framework satisfies an ample spectrum of community needs, spanning from environmental and climate sustainability to economic resilience, circular economy requirements and economic viability of mining operations. The report identifies that renewable energy solutions contribute directly and positively to community resilience by strengthening Building Blocks 1, 2, 3, 4, and 6, and in a smaller and indirect way to the remaining ones. Similarly, there are ways in which renewable energy solutions can hamper or negatively impact these building blocks if implemented incorrectly.

FIGURE 1. Climate-smart framework building blocks



Source: World Bank, 2024.

4.2 Renewables in Mining Operations: Improving community resilience

4.2.1 Deployment of Low-Carbon Solutions

Building Block 1: Promote renewable energy, alternative fuels and energy efficiency, emission accounting and reporting in mining operations

Integrating renewable energy solutions into mining operations contributes directly to this first building block. It is also important to highlight how renewable energy systems can contribute positively to the second part of this definition, particularly in improving emissions accounting and reporting in mining operations.

Some renewable energy sources are highly intermittent, notably solar and wind technologies. This aspect often incentivizes grid operators to integrate enhanced energy planning and management solutions to hedge against the unpredictable nature of weather and sunlight, allowing for efficient generation and a better use of storage space if available (United Nations Framework Convention on Climate Change, 2025). These solutions are implemented through a mixed use of digital technologies, sensors, and software systems, which can, in turn, enhance the collection of data on energy use for the purpose of operations planning as well as mining emissions accounting and reporting. One renewable solution can, moreover, enable the production of alternative fuels on the mining site: the establishment of a solar PV microgrid, for example, can produce green hydrogen, which can in turn be used in processing operations both as a source of high heat and as a reductive agent.

In some contexts, renewable energy systems developed for mining operations may also support electricity access beyond the mine site, to reach local communities. Where such systems are intended to, or can serve surrounding communities or nearby services, ensuring reliability becomes essential, particularly in remote or weak-grid regions.

However, the intermittency of some renewable technologies can pose challenges. Such systems require integrating storage solutions when no other energy backup exists. In recent years, costs have dropped significantly: between 2010 and 2023, battery storage projects have seen installation costs decline by more than 89%, with further declines expected (International Renewable Energy Agency [IRENA], 2024).

Moreover, storage options in the form of lithium-ion batteries at the scale required for mining operations have decreased in cost and improved in efficiency. Some batteries are now being adapted for multi-hour storage potentials, compensating for longer periods of sub-optimal energy production and better adapting to the continuous nature of mining operations (IEA, 2024). However, the technology might not yet be mature enough to support the capacity required by mining operations, especially on larger sites, which could cause challenges (Igogo et al., 2020). In some cases, renewable energy options might be complemented by other existing energy sources and storage options, especially in isolated sites away from the grid.

The installation of such storage facilities is necessary when renewable energy systems are shared with local communities. They are needed to stabilize variable renewable energy sources such as solar and wind, battery storage, and hence enable a continuous and reliable electricity supply to local communities. Access to reliable energy is key to supporting livelihoods as well as essential services such as health care, refrigeration, water access, and digital connectivity. They can reduce the reliance of local economies on costly and high-GHG-emission energy sources.

CASE STUDY 1. FEKOLA GOLD MINE, MALI AND PORPHYRY GOLD MINE, AUSTRALIA

Some examples exist of the use of off-grid hybrid energy systems coupled with storage options for remote mining operations. The Fekola gold mine in Western Mali, for example, relies on on-site thermal generation from heavy fuel oil, which must be transported from outside at great cost and with significant logistical complications. The mine has been considering hybridizing its energy system by integrating solar PV generation. A feasibility study conducted by external consultants reveals a potential to shut down half of the heavy fuel oil generation in daylight hours, provided that careful energy management systems are put in place, as well as suitable battery storage options.[1]

The Porphyry gold mine in Western Australia has also been relying on diesel generation since 2022, but has recently switched to a hybrid system complemented by modular solar farms and an energy storage system.[2]

1 This is still at feasibility study and has not yet been fully implemented. BayWa r.e.: B2Gold Fekola feasibility study.

2 Aggreko Porphyry Gold Mine.

Building Block 2: Reduce/compensate CO_2e emissions through carbon sequestration

Deploying renewable energy solutions in mining operations would intuitively reduce the amount of CO_2e emissions released into the atmosphere, therefore reducing the need for the integration of carbon sequestration technologies or efforts/initiatives by the mining site to capture and store carbon.

Accordingly, beyond their role in reducing emissions from mining operations, renewable energy systems can help strengthen community resilience when combined with complementary measures, such as ecosystem restoration, including afforestation and land rehabilitation. This way, renewable energy deployment can, in parallel, improve air and water quality, reduce heat stress, and support ecosystem services that communities depend on for their health and livelihoods. These co-benefits are particularly significant in mining-affected regions, where environmental degradation can exacerbate vulnerabilities, especially for women and girls, who are often responsible for water collection, food provision, and caregiving and therefore disproportionately affected by environmental stressors, but can also benefit significantly from improved environmental conditions.

However, given the increasing focus on greenwashing by large conglomerates, it is important that investments in renewable energy do not crowd out efforts to sequester carbon, and that these two are pursued in tandem where possible.

4.2.2 Resilience and Adaptation

Building Block 3: Plan for shared and extended use of renewable energy infrastructure

The benefits of renewable energy infrastructure for community resilience are not automatic. They need to be well planned and adequately supported. In general, renewable energy systems developed for mining operations are primarily designed to meet the operational needs of the industry. If they are not conceived to be shared beyond the mine gate, their potential to generate broader socio-economic benefits in resource-hosting regions remains limited (World Bank, 2019). In that regard, expanding the reach of such infrastructure beyond the mine site could present a significant opportunity to reduce energy poverty, support local economic development, and strengthen resilience to climate-related shocks, particularly in remote and underserved areas (IRENA, 2016; NREL, 2020).

Country experiences from Ghana and South Africa illustrate how having an enabling regulatory environment can foster infrastructure sharing. National policy frameworks can facilitate grid integration, support hybrid and mini-grid systems, and enable the sharing of excess generation capacity. In addition, mechanisms such as energy buy-back schemes, regulatory reforms allowing independent power production, and public–private partnerships can help align private sector investments with national development objectives and local community needs.

CASE STUDY 2. POLICIES TO IMPLEMENT RENEWABLE ENERGY

Ghana

Decisions to deploy renewable energy remain an individual corporate-level effort rather than a national policy drive. While there is general advocacy for renewable energy (especially solar) deployment across all industries, it is not specifically targeted at the mining sector. Ghanaian regulators are considering how to shift the energy mix to include renewable energy, given the increasing strain on the national grid over the last few years. To encourage industry initiatives, the Ghanaian Government offers a buy-back package where some of the energy generated can be shared with the national grid if another (renewable energy) source is used. This, however, excludes energy generated from hydropower.

South Africa

The recent amendment to the Electricity Regulation Act now permits private producers of independent power to feed electricity back into the grid, and local government and municipalities are reviewing how to take advantage of this opportunity. Several mining companies have embraced the opportunity to implement renewable energy at mine sites, as it allows them to embed self-generation from 1 MW to 100 MW without the need for a licence from the energy regulator.[3] The intervention to reform the electricity regulation regime has been hailed as a positive way forward by the energy sector and mining industry across the board (South Africa Electricity Regulation Act 4 of 2006, Amended 12 August 2021).

Beyond improving operational efficiency and emissions management, renewable energy infrastructure can also create opportunities beyond the mine gate when designed with broader use in mind. Infrastructure such as solar farms, wind installations, or transmission lines developed for mining operations can generate spillover benefits by improving access to electricity, reducing reliance on diesel generators, and enabling local economic activities. In remote areas, mining projects can also function as anchor electricity off-takers, helping improve the financial viability of renewable electrification efforts while allowing excess power to be supplied to nearby communities. (IRENA, 2016; NREL, 2020; World Bank, 2019).

Realizing these opportunities depends on how renewable energy infrastructure is planned and integrated from the early stages of mine development. Integrating considerations for shared use, grid connectivity, and long-term and inclusive community access into project design can shape whether renewable energy investments contribute, not only to operational decarbonization, but also to inclusive and sustainable development outcomes, with particular attention to whether women, youth, and marginalized groups are able to access the opportunities created by expanded energy systems. Without such alignment, the potential of renewable energy to support resilience beyond the mine gate will remain underutilized.

Building Block 4: Identify nature-based solutions for mine planning and risk management

Replacing fossil fuel feedstocks for processing operations with renewable alternatives (e.g., coal with biomass or green hydrogen) may reduce fire hazards or other incidents. At the

[3] Investment examples include a joint venture partnership between EDF Renewables and Anglo American to supply wind and solar energy to operations in South Africa, Namibia, and Zimbabwe; AngloGold Ashanti's Deep South mine in Gauteng, and Exxaro and Seriti Green in Mpumalanga.

same time, however, incorrect use of renewable energy systems may run counter to the implementation of nature-based solutions for mine planning. The World Bank identifies nature-based solutions as strategies that use reforestation, wetlands, or sandy beaches to help mining sites reduce risks associated with fires or flooding (World Bank, 2018).

Renewable energy systems can be a lever to enable the effective implementation of nature-based solutions and land restoration efforts in mining regions. For example, solar or hybrid-powered systems can support water pumping for reforestation, irrigation for land rehabilitation, and the operation of monitoring systems for ecosystem management. When combined with inclusive planning processes, these approaches can further support alternative livelihoods and new economic activities such as sustainable agriculture or ecosystem restoration services. All these strategies are important to help communities better withstand climate-related risks, such as erosion, water scarcity, and extreme weather events.

On the other hand, renewable energy systems, while directly contributing to a reduction in GHG emissions, can interfere with the application of these solutions in numerous ways: solar PV farms and nature-based solutions can compete for the use of land, and it is therefore advised for such technologies to be deployed on marginal lands or adapted to agricultural lands through the use of agrivoltaics (United Nations Framework Convention on Climate Change, 2025). Biomass projects can similarly reduce forested areas and encroach on the surrounding environment, creating incentives for local farming communities to clear land to grow special-purpose crops or cultivations that generate residues and risk food security. Finally, large-scale hydropower projects can often be tied to ecosystem destruction, and their installation should be carefully calibrated against the need to preserve such ecosystems to reduce risks to surrounding communities, underscoring the importance of favouring smaller-scale solutions where appropriate. Across all technologies, inclusive and participatory environmental and social impact assessments, combined with land-use planning frameworks, are essential to balance renewable energy goals with the protection of ecosystems and community well-being.

Building Block 5: Develop human, physical, natural, and financial capital

Developing renewable energy in and around mining regions depends not only on infrastructure, but also on the broader base of human, physical, natural, and financial capital that allows communities and institutions to use, manage, and benefit from it over time. In practice, the human capital dimension is particularly important, as the renewable energy transition is also set to reshape labour markets and therefore create demand for new and evolving skill sets across a wide range of occupations.

According to IRENA and the International Labour Organization (ILO) (2024), the most substantial shifts are expected in mid-level skills occupations, including roles such as solar panel installers and wind turbine technicians, while technical, managerial, and regulatory capacities will also remain important. (IRENA & ILO, 2024).

In this context, adapting academic programs and school curricula as well as rethinking, reskilling, and upskilling courses form a critical part of a just, fair, and inclusive energy transition. In particular, technical and vocational education and training programs need to be strengthened, while primary and tertiary education need to be inclusive to equip workers and communities in mining regions with the skills needed to participate in renewable energy value chains. Relevant capabilities range from basic installation to advanced maintenance, project management, and system oversight (IRENA & ILO, 2024). Experience to date suggests that collaboration between training institutions, employers, and labour organizations can strengthen the relevance and quality of these pathways (IRENA & ILO, 2024).

Digital and climate literacy are becoming increasingly important components of this skills base (IRENA & ILO, 2024). As renewable energy systems increasingly rely on digital technologies for monitoring, management, and optimization, workers and communities need to be equipped with the right skills to perform technology-driven roles and services.

Flexible learning pathways, targeted financial support, and efforts to enhance participation can widen the benefits from the transition (IRENA & ILO, 2024). This is particularly relevant for women, youth, and marginalized groups whose access to education, training, and emerging employment opportunities is often more constrained.

At the community level, stronger digital literacy and technical capacity are transferable skills. They can support employment not only in energy-related jobs, but also in wider local economic activities that renewable energy access may enable, including agro-processing, cold storage, digital services, and small enterprise development (IRENA Coalition for Action, 2024; Sustainable Energy for All, 2024). In this sense, building human capital does not simply support the deployment of renewable energy infrastructure; it helps determine whether the transition contributes to longer-term local development, resilience, and economic diversification in mining regions.

CASE STUDY 3. LIST OF TRAINING AND RESOURCES

- The European Energy Centre provides a range of courses, including solar PV, EVs, wind power, electronics, and heat pumps.
- The Open University has several renewables courses that count toward its qualifications.
- Find Courses lists almost every available training course in renewables. Providers include The Energy Institute, BPP Professional Education, the Institute of Engineering and Technology, and Activate Learning.
- Reed lists short, self-paced online courses in renewable energy, ideal for those new to renewables who want to get an introduction to the industry.

4.2.3 Circular Economy

Building Block 6: Remediate/repurpose post-mining lands for productive, sustainable use

Renewable energy systems have often been installed on closed mines' brownfields after the end of operation. Solar PV, in particular, is very adaptable to this type of endeavour due to its modular nature, allowing systems to be adapted and installed on different types of terrain. This type of solution is desirable to strengthen community resilience because it guarantees continuing electricity production in isolated areas that are still off the grid, allowing for a continuation of economic activity that might have arisen during mining operations and for a source of revenue by selling electricity back into the grid, were the main network to be extended.

CASE STUDY 4. RENEWABLE ENERGY BENEFITS AFTER MINE CLOSURE

The IGF has collected a number of useful case studies to display the benefits of renewable energy system installations after mine closures (IGF, 2022). In Kimberley, British Columbia, Canada, a lead-zinc mine closed its operations, and its brownfield was used for the installation of a 1.05 MW solar PV plant, generating 4,900 MWh of electricity for more than 250 homes in the surrounding community. In the Ruhr region, Germany, wind turbines were installed atop waste rock piles, benefiting from higher altitudes and hence reaping greater economic benefits from higher wind speeds.

In both cases, challenges arose that can serve as lessons for future conversion endeavours. In Kimberley, solar modules had to be better adapted to the topography of the site, which caused installation delays. The wind turbines in Germany, at the same time, caused resistance from local communities, suggesting that greater efforts must be undertaken to involve residents and explain potential benefits before construction plans are given a green light.

Gender Equality as a Cross-Cutting Theme

Together with fortifying the building blocks contributing to community resilience, renewable energy can act as a catalyst for gender equality and inclusive economic growth, as it offers opportunities to integrate women as both consumers and contributors across sectors. However, achieving this potential requires deliberate efforts to empower women as economic agents in the workforce and decision-making roles, not just in domestic settings.

Gender equity is intricately linked to socio-economic development and is a key upfront consideration in all policy formulations and should not be relegated gender to a lesser status. This approach aligns with the broader objectives of a just, fair, and inclusive energy transition, as highlighted in the IRENA Coalition for Action report (IRENA, 2023), which emphasizes that gender-responsive policies are essential for achieving equitable outcomes in the energy sector. Similarly, the Organisation for Security and Co-operation in Europe report (2024) on advancing a just energy transition in Central Asia underscores the importance of integrating gender considerations to ensure that women benefit equitably from the economic opportunities created by the energy transition.

As the mining sector transforms and increasingly adopts renewable energy and digitized processes, there must be a concerted effort to prioritize women's participation in the extraction and use of critical minerals for the energy transition. This shift presents significant opportunities to break down existing gender barriers in traditionally male-dominated sectors such as mining. Women are becoming increasingly involved in operations that were previously inaccessible to them, opening doors to more equitable workforce representation (IGF, 2023).

A critical aspect of ensuring successful gender equity in the energy transition is addressing the skills gap that often limits women's participation. In historically underserved and remote mining communities, women typically face barriers in accessing education and training in science, technology, engineering, and mathematics (STEM) fields, which are essential for roles in the renewable energy sector. Illustrative of this, in the U.S. energy sector, women and minorities remain significantly underrepresented, with women accounting for only 26% of the energy workforce, compared to their 47% share of the overall labour force, and holding just

19% of newly created energy jobs in 2023 (IRENA & ILO, 2024). The same report highlights that in renewable energy specifically, women occupy 30% of roles in wind and solar, which is higher than in fossil fuel industries but still below their presence in nuclear power (34%). African Americans also face disparities, holding only 9% of energy jobs despite comprising 13% of the national workforce. To address these gaps, tailored and inclusive education, skills training, and gender-responsive hiring practices are essential, alongside stronger corporate commitments to diversity and inclusion. According to the findings by IRENA and ILO, unionized firms, which are more likely to implement such programs, serve as a model for broader sector-wide adoption.

Colombia's guidelines for gender equity in the mining and energy sectors (Ministerio de Minas y Energía [Ministry of Mines and Energy], 2020) offer an example of good practice of a framework for policy formulation that supports socio-economic empowerment for women, especially those from communities located near mining projects. Such guidelines have helped ensure that women in these areas have greater access to new employment and entrepreneurial opportunities, thereby contributing to broader community development. These efforts showcase how intentional policy design can foster environments that promote inclusive development for women and youth, with positive implications for future generations.

5.0 Practical Policy Recommendations to Leverage Renewable Energy for Community Resilience

5.1 Setting Out the Conditions for Effective Renewable Energy Sharing Policies for Community Resilience

5.1.1 Planning, Institutional Strengthening, Policy Coherence and Coordination

Recommendation 1: Assessing the state of pre-existing energy infrastructure

The ability of mining operations to deploy renewable energy—and to extend its benefits to surrounding communities—depends fundamentally on the condition, capacity, and reach of existing energy infrastructure. In many resource-rich regions, mines operate in areas with weak, unreliable, or non-existent grid connectivity, limiting opportunities for broader energy access.

A robust, forward-looking assessment of infrastructure is therefore a critical first step. Governments need to understand where mining-related renewable energy systems can realistically be leveraged for community use, and where stand-alone or alternative solutions are more appropriate. Without this diagnostic foundation, renewable investments risk remaining isolated, with limited contribution to community resilience. Strengthening community resilience in this context includes not only access to electricity but also the ability of shared energy systems to support essential services and enable diversified local livelihoods over time.

Types of Measures

Governments can prioritize planning and diagnostic measures to guide decision making:

Strategic Infrastructure Planning and Mapping

- conduct integrated assessments of energy infrastructure in mining regions, including grid capacity, transmission constraints, and proximity to communities and demand centres.
- develop geospatial mapping tools combining mining activity, energy infrastructure, and population distribution to identify opportunities for shared systems.
- require energy infrastructure assessments as part of mining project approvals, feasibility studies, or environmental and social impact assessments.

Identification of Priority Zones and Use Cases

- identify priority zones where mining operations and nearby communities can be co-served through shared renewable energy systems.
- assess potential use cases for shared energy, including household access, public services (e.g., health centres, schools), and productive uses. Where supply is initially limited, governments may prioritize uses with the highest resilience value, such as health facilities, schools, water pumping, cold storage, and digital connectivity.
- establish screening criteria to determine where infrastructure sharing is technically, economically, and socially viable.

System Planning for Integration and Scalability

- integrate mining-related energy infrastructure into national and regional electrification planning.
- plan for different system configurations (grid-connected, hybrid, or decentralized), depending on local conditions.
- ensure that new systems are designed with future integration, scalability, and interoperability in mind.

Data Systems and Transparency

- strengthen data collection and management on grid performance, generation capacity, and local demand.
- encourage disclosure of relevant information on mining-related energy systems, including potential surplus generation. This should include, where feasible, transparent reporting on generation capacity, expected surplus power, connection potential, and constraints affecting access for surrounding communities.
- use data to inform planning decisions, investor engagement, and community-level energy strategies.

Strengths of These Measures

- **provide a strong foundation for decision making:** Evidence-based planning reduces the risk of poorly designed or isolated projects.
- **maximize opportunities for shared use:** Identifying viable zones increases the likelihood that mining energy systems can benefit communities.
- **improve system efficiency:** Coordinated planning reduces duplication of infrastructure and supports better resource allocation.
- **enhance investment clarity:** Clear infrastructure mapping and planning signals improve predictability for investors and partners.
- **support scalable solutions:** Early consideration of integration and interoperability enables long-term system development.

Potential Implementation and Sustainability Challenges

- **data limitations:** Reliable and up-to-date information on infrastructure and demand may be lacking.
- **high analytical and planning capacity needs:** Conducting integrated assessments requires technical expertise that may be limited in some contexts.
- **coordination constraints:** Effective assessment depends on collaboration across ministries and agencies.
- **uncertain demand profiles:** Low or dispersed demand may complicate the identification of viable shared systems.
- **dynamic conditions:** Changes in mining activity, energy demand, or technology costs may affect planning assumptions over time.

CASE STUDY 5. LEARNING FROM INTERNATIONAL EXPERIENCE: ECUADOR

With the support of the Inter-American Development Bank, the government has allocated funding to set up a regulatory framework and prepare a rollout that would enable the country to change its energy mix (Inter-American Development Bank, 2023). Ecuador's future-looking agenda is committed to driving a substantial change of the country's energy mix, with both the private and public sectors working together with the Ministry of Energy and Mines. A key objective of the program is to "promote access to electricity and strengthen conditions for increasing the use of renewable energy sources." While the project documents do not specifically refer to shared use of infrastructure, it is clear that there will be wider benefits to communities through the national plan. The program further seeks to advance the implementation of the country's commitments for the exchange of greater electricity in the region.[4]

[4] Further reading on energy projects supported by the Inter-American Development Bank in Ecuador both nationally and regionally (e.g., the Ecuador-Peru Power Interconnection System) can be accessed on its website: https://www.iadb.org/en/project-search?query=&f_sector=ENERGY&f_country_name=Ecuador&f_project_status=&f_operation_number=&f_from=&f_to=&f_approval_date=

Recommendation 2: Ensuring coherence with national strategies

Local renewable energy initiatives around mining sites are often the first entry point for expanding electricity access to nearby communities. However, without deliberate alignment with national energy strategies, these initiatives risk remaining fragmented, short-lived, or disconnected from broader development objectives.

Ensuring coherence between mining-led energy investments and national electrification, energy transition, and industrial strategies is therefore essential. This alignment enables governments to transform isolated projects into building blocks of a wider, resilient, and inclusive energy system.

Types of Measures

Governments can adopt institutional, regulatory, and planning measures to ensure that local renewable energy initiatives contribute to national priorities.

Integrated Policy and Planning Frameworks

- embed mining-related energy initiatives within national electrification plans, energy transition strategies, and climate commitments (e.g., nationally determined contributions).
- develop cross-sectoral frameworks linking mining, energy, and regional development policies.
- require alignment with national plans as part of project approval processes. National frameworks should also help identify which mining-linked renewable energy projects are most suitable for shared use, based on criteria such as mine lifespan, proximity to communities, expected surplus generation, and the ability of utilities or local operators to sustain service over time.

Standardized Guidelines and Planning Tools

- develop national guidelines for mining-related renewable energy projects, including provisions for community access and scalability.
- introduce standardized project evaluation criteria to assess consistency with national strategies.
- promote the use of integrated resource planning tools that incorporate both industrial and community energy needs.

Incentives for Alignment

- prioritize public support (e.g., subsidies, concessional finance, guarantees) for projects that demonstrably align with national strategies.
- link licensing or permitting conditions to broader development and electrification objectives.

Strengths of These Measures

- **transform pilots into systems-level solutions:** Alignment ensures that local initiatives contribute to long-term national energy pathways rather than remaining isolated projects.
- **improve policy predictability:** Clear strategic direction reduces uncertainty for investors and development partners.
- **enhance resource allocation:** Public and private investments can be directed toward priority areas with the highest development impact.
- **strengthen government ownership:** Aligning projects with national strategies reinforces state leadership and accountability.
- **support coherence across policy domains:** Links energy access, industrial development, and climate objectives into a unified framework.

Potential Implementation and Sustainability Challenges

- **institutional silos:** Coordination across ministries and levels of government can be difficult, particularly where mandates overlap or compete.
- **capacity constraints:** Limited technical and planning capacity may hinder the development and implementation of integrated strategies.
- **evolving policy landscapes:** National energy strategies may change over time, creating uncertainty for long-term projects.
- **balancing flexibility and control:** Overly rigid alignment requirements may discourage innovation or delay project development.
- **diverging stakeholder priorities:** Mining companies, local communities, and national authorities may have different timelines and objectives, complicating alignment.

Recommendation 3: Establishing an interministerial committee and decentralized coordination mechanisms

In many resource-rich countries, overlapping mandates across ministries—such as finance, water, environment, energy, mining, and planning—result in fragmented policies and misaligned regulatory frameworks. These institutional silos are often compounded by weak coordination between national and subnational authorities, even though provincial and local administrations are closest to the infrastructure, communities, and implementation realities.

To leverage renewable energy systems developed for mining operations in support of community resilience, governments need structured mechanisms to align decisions across sectors and levels of government. The objective is not to create new delivery institutions, but to ensure that existing public authorities work from a common policy direction, with clear mandates and coordinated decision making.

Types of Measures

Governments can establish structured mechanisms for interministerial and multi-level coordination on mining-linked renewable energy:

Formal Interministerial Coordination Platforms

- establish permanent or semi-permanent coordination bodies bringing together ministries responsible for energy, mining, environment, finance, water, and planning.
- where relevant, governments should also ensure systematic participation of public utilities and energy regulators, given their central role in interconnection, tariff setting, service continuity, and eventual asset transfer.
- mandate regular joint planning processes, including shared priority-setting, sequencing of actions, and synchronized timelines.
- create technical working groups focused on renewable energy sharing models in mining regions, including community access and resilience objectives.

Multi-Level Governance Integration

- institutionalize coordination between central governments and provincial, regional, or municipal authorities.
- establish formal channels for subnational input into national energy and mining strategies, especially where projects affect local infrastructure, land use, and service delivery.
- support decentralized administrations with technical guidance and budget visibility so they can participate effectively in implementation.

Linking Coordination to Public Planning and Budgeting

- align sectoral planning and budget processes around shared priorities, such as community electrification, grid extensions, or post-mining transition planning.
- introduce joint funding windows or coordinated budget lines where multiple ministries are involved.
- ensure that affordability considerations for low-income households are reflected in coordinated planning.

Clarification of Roles and Mandates

- clearly define which institutions are responsible for planning, approvals, community engagement, financing, implementation oversight, and post-closure transition.
- develop standard operating procedures for collaboration across ministries and levels of government.
- establish escalation mechanisms to resolve conflicts or delays between institutions.

Strengths of These Measures

- **improve implementation effectiveness:** Clear coordination mechanisms reduce delays, contradictions, and policy fragmentation.
- **bridge national policy and local realities:** Multi-level coordination helps ensure that national strategies reflect community needs and infrastructure constraints.
- **enhance fiscal efficiency:** Better alignment across ministries reduces duplication and supports more strategic use of public resources.
- **strengthen accountability:** Defined mandates and coordination procedures make responsibilities easier to track.
- **enable more inclusive outcomes:** Bringing local authorities into planning improves the likelihood that renewable energy sharing responds to community needs.

Potential Implementation and Sustainability Challenges

- **institutional resistance:** Ministries and agencies may be reluctant to share authority, budgets, or data.
- **complex governance structures:** In federal or highly decentralized systems, aligning priorities across levels of government can be difficult; conversely, in centralized systems, local realities may be overlooked.
- **capacity disparities:** Subnational administrations may lack the technical or financial capacity to engage effectively.
- **coordination fatigue:** Without clear mandates, deadlines, and incentives, coordination platforms may become procedural rather than outcome-oriented.
- **budget rigidity:** Public financial management systems may limit flexibility for joint or cross-sectoral funding arrangements.

CASE STUDY 6. LEARNING FROM INTERNATIONAL EXPERIENCE: ECUADOR AND BRAZIL

Ecuador

The Ministry of Energy and Mines is promoting policies[5] in both the energy and mining sectors to encourage companies to adopt renewable energy use, and also provide assistance to adjacent communities. While this goes beyond the scope or purview of the Energy Ministry, it does issue public guidance and recommendations that mining companies can adopt from the outset. Similar to Colombia and Brazil, most regulations target large-scale mining, which is a small percentage of the sector

[5] In 2021 the Ecuadorian President approved the issue of Decree 151: Action Plan for the Ecuadorian mining sector. This strategy aims to develop an efficient social and environmentally responsible mining industry. It also seeks to define the country's geological potential, foster national and international investments, and implement best practices for using the resources. Available at https://www.iea.org/policies/16644-decree-151-action-plan-for-the-ecuadorian-mining-sector.

compared with artisanal and small-scale mining, so the impact is very limited—under 10% of mining companies have embarked on processes to renew their energy mix.

Ecuador's Master Plan of Electrification (IEA, 2023) developed under the guidelines of the National Development Plan, seeks to optimize the use of power generation resources by harnessing the country's renewable energy potential. It also promotes energy efficiency and conservation, while aiming to provide electricity service with levels of high coverage, quality, and safety. The plan outlines how Ecuador's electricity sector will expand generation, transmission, and distribution infrastructure between 2016 and 2025, including both the national interconnected system and the Galapagos Islands (IEA, 2023).

Recommendation 4: Establish dedicated agencies or units to support delivery of shared energy infrastructure

Even where policies are aligned and coordination mechanisms exist, governments often lack a dedicated institutional home for the practical delivery of shared renewable energy infrastructure. Mining-linked renewable energy projects are complex to structure and manage: they involve technical design, contract negotiation, tariff issues, investor engagement, community service obligations, and long-term transition planning beyond mine closure.

Governments may therefore benefit from establishing specialized agencies or units with an operational mandate to support project preparation, implementation, and long-term oversight. Unlike interministerial coordination mechanisms, these entities should focus on delivery support and execution capacity.

Types of Measures

Governments can consider establishing or mandating dedicated entities with clearly defined implementation functions:

Specialized Implementation Support Units

- create dedicated public agencies or units to support renewable energy sharing initiatives linked to mining operations, including community electrification components.
- define their role as operational and technical support entities, rather than broad interministerial coordination bodies.
- ensure their mandate is clearly linked to shared infrastructure, service delivery, and long-term sustainability.

One-Stop-Shop or Single-Window Functions

- provide centralized support to investors, utilities, developers, and local authorities on project pipelines, permitting pathways, applicable standards, and available public support.
- facilitate access to technical and regulatory information needed to structure shared energy projects.
- reduce transaction costs for projects involving multiple actors and approvals.

Project Structuring, Technical Support, and Oversight

- assist governments and regulators in project preparation, tariff design, procurement, contract structuring, and compliance monitoring.
- support the negotiation and management of public–private partnerships, power purchase arrangements, and asset transfer agreements.
- monitor implementation performance, including delivery of community access commitments.
- where appropriate, these entities could also publish summary performance information on service delivery, connection targets, and compliance with community access commitments, while respecting legitimate commercial confidentiality.

Post-Closure Continuity and Service Transition

- prepare transition plans for the continued operation of shared infrastructure after mine closure.
- support transfer arrangements to utilities, local authorities, community entities, or third-party operators.
- help ensure that operation, maintenance, and service quality are sustained over time.

Strengths of These Measures

- **strengthen delivery capacity:** Dedicated entities can help governments move from policy intent to implementation.
- **reduce transaction costs:** Centralized expertise simplifies project preparation and reduces delays for complex shared infrastructure arrangements.
- **build specialized expertise:** These units can accumulate technical, contractual, financial, and operational knowledge often missing in fragmented administrations.
- **improve continuity:** A dedicated delivery body can help maintain focus on long-term service provision, including after mine closure.
- **keep community outcomes visible:** With the right mandate, such entities can ensure that access, affordability, and continuity of service remain central objectives.

Potential Implementation and Sustainability Challenges

- **institutional duplication risks:** New entities may overlap with existing agencies if mandates are not narrowly and clearly defined.
- **sustainability of funding:** Dedicated units require stable financing and political support to remain effective.
- **capacity constraints:** Recruiting and retaining the necessary technical expertise can be difficult, particularly in smaller administrations.
- **governance and accountability risks:** Without strong oversight, such bodies may become inefficient, captured, or disconnected from broader public objectives.
- **over-centralization risks:** If not designed carefully, specialized units may simplify investor engagement but weaken local ownership or subnational participation.

CASE STUDY 7. LEARNING FROM INTERNATIONAL EXPERIENCE: KIBALI MINE, DEMOCRATIC REPUBLIC OF CONGO

At the Kibali Mine in northeastern Democratic Republic of Congo, Barrick Gold has transitioned operations from diesel to nearly 100% renewable energy through solar and hydropower. Importantly, this infrastructure is being positioned as a legacy project for host communities, with local operations and maintenance crews trained to manage it post-closure. This approach ensures that renewable energy investments deliver enduring value beyond the life of the mine.

Recommendation 5: Plan for mine closure and post-mining transition

Renewable energy systems deployed by mining operations can play a critical role in strengthening community resilience—but only if their benefits extend beyond the life of the mine. Too often, energy infrastructure developed for operational needs is decommissioned, underutilized, or left without clear ownership once mining activities cease.

Importantly, mine closure and post-mining transition should not be treated as end-of-life considerations. **They are upfront enabling conditions** that must be integrated into project design from the earliest stages. Decisions taken at the outset—on system design, ownership models, financing, and governance—will determine whether renewable energy infrastructure can be successfully transferred, sustained, and used by communities over time.

Integrating renewable energy planning across the entire mine life cycle—from project design to closure and post-mining transition—is therefore essential. This ensures that energy assets become a lasting development legacy, supporting continued access to power, local services, and economic activities.

Types of Measures

Governments can embed long-term energy resilience into mining frameworks through the following measures:

Early Integration Into Project Design

- require renewable energy planning to be included in community development agreements and project approvals from the outset.
- define clear pathways for asset transfer, ownership models, and long-term use early in the project life cycle.
- align energy planning with anticipated post-mining land use and local development strategies.

Financial Mechanisms for Post-Closure Sustainability

- establish dedicated funds, escrow accounts, or financial guarantees to cover operation and maintenance of energy systems after mine closure.
- require provisions for long-term cost recovery (e.g., tariffs, community financing models, public support where needed).
- encourage blended finance approaches to support post-closure energy continuity.

Formalization of Roles and Responsibilities

- use legally binding agreements (e.g., memoranda of understanding, contractual obligations) to assign responsibility for post-closure energy service provision.
- define roles for utilities, local authorities, community organizations, or private operators in managing infrastructure. Particular attention should be given to whether utilities have the technical and financial capacity to assume responsibility for service provision, and whether tariff structures can sustain operation without pricing communities out of access.
- ensure accountability mechanisms are in place for service continuity.

Integration Into Closure Plans and Transition Frameworks

- require renewable energy infrastructure and access provisions to be explicitly included in mine closure plans and financial assurance mechanisms.
- link energy transition planning to broader post-mining economic diversification strategies.
- monitor and enforce compliance with closure commitments related to energy access.

Strengths of These Measures

- **secure long-term community benefits:** Ensures that energy access continues to support livelihoods, services, and local development after mine closure.

- **reduce risk of asset abandonment:** Clear planning and financing prevent infrastructure from becoming stranded or non-operational.
- **strengthen closure credibility:** Integrating energy into closure plans enhances trust and accountability in mine life-cycle management.
- **support economic transition:** Reliable energy access enables new economic activities in post-mining regions.
- **align with sustainability and environment, social, and governance expectations:** Demonstrates responsible resource development with lasting social impact.

Potential Implementation and Sustainability Challenges

- **uncertainty over mine lifespans:** Changes in market conditions may affect closure timelines, complicating long-term planning.
- **financial adequacy risks:** Ensuring that funds set aside are sufficient for long-term operation and maintenance can be difficult.
- **institutional readiness:** Local entities (utilities or communities) may lack the capacity to manage infrastructure post-closure.
- **tariff and affordability constraints:** Maintaining financially viable systems while ensuring affordability for communities remains a key challenge.
- **enforcement gaps:** Weak monitoring and enforcement of closure obligations may undermine implementation.

5.1.2 Consultations and Partnerships

Recommendation 6: Designing and implementing inclusive consultative processes and mechanisms

Leveraging renewable energy systems developed by mining operations for community resilience requires more than technical solutions—it requires meaningful and sustained community participation. Too often, decisions about energy infrastructure are made without adequately reflecting local needs, priorities, and capacities, limiting both impact and long-term sustainability.

Inclusive and well-designed consultative processes are therefore essential. When communities are engaged early and continuously—not only as beneficiaries, but as partners—they can help shape energy solutions that support livelihoods, strengthen resilience, and endure beyond the life of the mine.

Types of Measures

Governments, in collaboration with mining companies, can establish regulatory and institutional mechanisms to ensure inclusive and sustained participation:

Early and Inclusive Consultation Requirements

- mandate community consultation at the early stages of project design, including during environmental and social impact assessments.
- ensure representation of women, Indigenous Peoples, youth, and marginalized groups through targeted engagement strategies.
- require consultation on renewable energy use cases (e.g., household access, productive uses, public services such as schools and health centres).
- consultation processes should also identify and address potential conflicts over land, water, ecosystem services, and livelihood uses, so that renewable infrastructure does not unintentionally create new sources of exclusion or tension.

Co-Designed and Shared Decision-Making Mechanisms

- establish frameworks for co-design of energy sharing models, involving local authorities and community representatives
- formalize community–company agreements that define roles in planning, implementation, and oversight
- support community leadership roles in governance structures for shared energy systems.

Community Participation in Ownership and Financing

- enable models for community equity participation (e.g., cooperatives, trust funds, shared ownership schemes).
- provide financial and technical support to help communities take stakes in renewable energy projects.
- develop mechanisms to ensure revenues contribute to operation, maintenance, and long-term system sustainability.

Enabling Participation Through Practical Support and Digital Tools

- provide financial support for participation (e.g., travel, compensation for time, meeting logistics) to ensure inclusivity.
- leverage renewable energy-powered digital platforms (e.g., mobile consultations, community internet hubs) to broaden engagement.
- use digital tools to facilitate continuous feedback, transparency, and access to project information.

Strengths of These Measures

- **enhance community resilience and ownership:** Participation in design and governance leads to solutions better tailored to local needs and more likely to be sustained.
- **reduce conflict and strengthen social licence:** Early and meaningful engagement builds trust and mitigates risks of project delays or opposition.

- **improve development outcomes:** Energy systems are more likely to support livelihoods, services, and local economic activities when shaped by communities.
- **promote equity and inclusion:** Targeted measures ensure that benefits reach often excluded groups.
- **support long-term viability:** Community involvement in financing and management increases the likelihood of continued operation beyond mine closure.

Potential Implementation and Sustainability Challenges

- **representation gaps:** Ensuring that consultation processes are genuinely inclusive and not dominated by a small group of stakeholders can be difficult.
- **participation costs:** Financial, time, and logistical barriers may limit sustained community engagement without targeted support.
- **capacity constraints:** Communities may require technical, financial, and organizational support to engage effectively in decision-making and ownership models.
- **risk of consultation fatigue:** Repeated or poorly structured consultations can lead to disengagement if not clearly linked to outcomes.
- **digital divide:** While digital tools can expand participation, unequal access to technology may exclude some groups if not carefully managed.

Recommendation 7: Establish effective partnerships and multistakeholder engagement frameworks

Scaling renewable energy systems developed for or around mining operations—and extending their benefits to communities—requires collaboration across governments, mining companies, utilities, financiers, and local stakeholders. However, without clear governance frameworks, such partnerships risk becoming fragmented, misaligned, or inequitable.

Governments, therefore, play a critical role in structuring how partnerships function, ensuring that responsibilities are clearly defined, risks are appropriately allocated, and community resilience objectives are embedded from the outset.

Types of Measures

Governments can establish governance frameworks to guide partnerships:

Clear Definition of Roles, Responsibilities, and Safeguards

- require partnership agreements (e.g., public–private partnerships, joint ventures, community agreements) to clearly define responsibilities across the project life cycle: design, construction, operation, maintenance, and post-closure transition.

- clarify the roles of utilities, local authorities, and community entities, particularly in relation to service delivery and long-term asset management.
- establish transparent cost-sharing arrangements, including provisions for community access and public service delivery.
- define risk allocation frameworks to balance commercial viability with public interest objectives.

Governance Frameworks for Inclusive and Accountable Partnerships

- develop guidelines or regulations for partnerships involving mining-linked renewable energy systems, including minimum requirements for community access and resilience outcomes.
- require transparency and disclosure of key partnership terms where possible (e.g., service commitments, access provisions).
- establish accountability mechanisms to monitor delivery of commitments, including community access and service quality.

Such mechanisms should include clear indicators for access, reliability, affordability, and continuity of service, so that partnership performance can be assessed against community resilience objectives rather than solely against project completion.

Structured Engagement With Key Stakeholders

- require structured engagement with communities, local authorities, and utilities throughout project development and implementation.
- establish multistakeholder platforms to align expectations, resolve conflicts, and monitor progress.
- ensure that community participation is not limited to consultation but extends to oversight and feedback during implementation.

Engagement With International and Regional Partners

- leverage support from institutions such as the World Bank, African Development Bank, and Inter-American Development Bank to provide:
- technical assistance for project structuring and negotiation
- advisory support on governance and safeguards
- financing instruments aligned with national priorities.

Strengths of These Measures

- **improve governance quality:** Clear frameworks reduce ambiguity and strengthen accountability across partners.
- **reduce risk of conflict:** Structured engagement and transparency build trust and social licence.
- **align incentives:** Governance frameworks help balance commercial and community resilience objectives.

- **strengthen public oversight:** Governments retain visibility and control over outcomes linked to shared infrastructure.
- **support more equitable outcomes:** Clear rules increase the likelihood that communities benefit from mining-linked energy systems.

Potential Implementation and Sustainability Challenges

- **complexity of negotiations:** Defining roles, risks, and safeguards requires strong legal and institutional capacity.
- **risk of formalism without impact:** Governance frameworks may exist on paper but not translate into effective implementation.
- **power imbalances:** Communities or local authorities may have limited influence in negotiations.
- **capacity constraints:** Governments may lack expertise to design and oversee complex partnership arrangements.
- **transparency limitations:** Commercial confidentiality may restrict disclosure of key agreements.

CASE STUDY 8. LEARNING FROM INTERNATIONAL EXPERIENCE: SOUTH AFRICA

In 2022, Anglo American and EDF Renewables agreed to form Envusa Energy, a jointly owned company, to develop a regional renewable energy ecosystem (RREE) in South Africa (Anglo American, 2022a). The first phase involved a pipeline of more than 600 MW of wind and solar projects designed to meet Anglo American's operational power requirements, support the resilience of local electricity supply systems, and contribute to the wider decarbonization of South Africa's energy system (Anglo American, 2022a). This was presented as a major first step toward an ecosystem expected to catalyze economic activity in South Africa's renewable energy sector and support the country's broader ambitions around just energy transition (Anglo American, 2022a).

The RREE expected to support green hydrogen production by supplying renewable electricity for Anglo American's nuGen™ Zero Emission Haulage Solution, which includes ultra-class mine haul trucks powered by hydrogen fuel-cell technology. By replacing diesel use in mine haulage, this initiative could reduce operational emissions and contribute to the development of South Africa's "Hydrogen Valley" (Anglo American, 2022b). Envusa Energy is also examining community partnership models to help ensure that host communities can participate in, and benefit from, opportunities created throughout the RREE value chain (Anglo American, 2022a).

Recommendation 8: Leveraging mining–energy partnerships to deploy shared renewable infrastructure at scale

Mining companies are increasingly investing in renewable energy to decarbonize operations, often in remote regions where energy access remains limited. This creates a strategic opportunity: **governments can leverage these investments to develop shared energy infrastructure** that serves both industrial and community needs.

Well-designed mining–energy partnerships can move beyond isolated projects to deliver scaled, integrated energy systems that support electrification, local economic development, and long-term community resilience. Unlike local content obligations, which impose minimum requirements on companies, these partnership models focus on enabling larger shared infrastructure systems with broader development spillovers.

Types of Measures

Governments can enable partnerships to deliver shared infrastructure and broader development outcomes:

Shared Infrastructure and Pooled Investment Models

- enable joint investment frameworks involving mining companies, utilities, independent power producers, and public actors.
- promote clustering of mining operations and surrounding communities to develop shared renewable systems (e.g., solar parks, hybrid plants, microgrids).
- facilitate allocation of surplus electricity to nearby communities, public services, and productive sectors.
- ensure utilities are integrated where relevant to support system integration, scaling, and long-term service delivery.

Scalable and Integrated Energy System Design

- encourage development of systems that can evolve over time (e.g., modular expansion, future grid integration).
- promote interoperability between mine-based systems, mini-grids, and national grids.
- support integration of energy systems with other infrastructure (e.g., water, digital connectivity, transport).

Innovation and Technology Deployment

- support partnerships that deploy advanced technologies (e.g., energy storage, smart grids, green hydrogen, high-temperature renewable solutions).
- encourage pilot projects in mining regions to address technical constraints such as intermittency and storage.
- promote transfer of mining-driven innovation to local economies and public energy systems.

Local Value Creation and Productive Use of Energy

- require shared infrastructure models to support productive uses of energy (e.g., agro-processing, small and medium-sized enterprises [SMEs], local industries).
- encourage integration of skills development and local supply chains within infrastructure projects.
- support business models that enable communities to use energy for income-generating activities, not only household consumption.
- in parallel, governments may encourage shared infrastructure models that also prioritize essential resilience services, including water supply, health services, cold chains, telecommunications, and emergency response capacity.

Viable Business Models and System Sustainability

- develop regulatory and financial frameworks that balance affordability, reliability, and financial sustainability.
- enable participation of independent power producers through predictable tariff structures and revenue models.
- align incentives to support long-term operation, maintenance, and eventual system transition beyond the mine life cycle.

Strengths of These Measures

- **accelerate electrification at scale:** Shared infrastructure models expand access more rapidly than isolated systems.
- **maximize development impact:** Energy access supports livelihoods, services, and economic diversification.
- **improve infrastructure efficiency:** Pooling resources reduces duplication and lowers costs.
- **drive innovation:** Mining investments can catalyze the deployment of advanced technologies in challenging environments.
- **strengthen community resilience:** Reliable and scalable energy systems support essential services and long-term local development.

Potential Implementation and Sustainability Challenges

- **complex project design:** Structuring shared systems that meet multiple objectives is technically demanding.
- **uneven benefit distribution:** Without clear frameworks, communities may not fully benefit from shared infrastructure.
- **utility integration challenges:** Weak or under-resourced utilities may limit system integration and scaling.
- **technology risks:** Deployment of new technologies may involve operational uncertainties.
- **long payback periods:** Infrastructure investments may not align with private sector investment horizons.

5.1.3 Expanding the Scope of Local Content Policies

Local content policies offer a powerful and underutilized lever to ensure that renewable energy investments linked to mining generate broader and more durable socio-economic benefits. Traditionally focused on employment, procurement, and skills development, these policies can be expanded to include provisions that promote the sharing and productive use of renewable energy infrastructure—thereby strengthening community resilience and reducing long-term dependency on mining activities.

To be effective, governments should explicitly integrate renewable energy considerations into legal and regulatory frameworks, including local content policies, mining laws, and contractual arrangements. This includes creating both obligations and incentives for mining companies to design energy systems that can serve wider local needs. In this context, local content policy is a means of capturing wider development spillovers from privately developed renewable energy infrastructure associated with mining projects. As with other policy instruments, these measures must remain aligned with national energy strategies and broader development objectives to ensure coherence and long-term impact.

In practice, local content policies can be operationalized through two complementary approaches:

- **mandatory requirements,** which establish legal obligations for infrastructure sharing and community access; and
- **facilitative measures and incentives,** which encourage investment and reduce barriers to extending renewable energy benefits beyond mining operations.

The following recommendations outline how governments can leverage both approaches to maximize the contribution of mining-related renewable energy systems to community resilience.

Recommendation 9: Introduce mandatory requirements to integrate renewable energy into local economic development

Expanding local content policies to include renewable energy as a core component of local economic development can significantly enhance the long-term benefits of mining. By recognizing energy infrastructure as a strategic enabler of local economies, governments can ensure that investments made to power mining operations also support surrounding communities, productive sectors, and public services.

Embedding such requirements within legal and contractual frameworks creates a clear expectation that renewable energy systems developed for mining should contribute to broader resilience—reducing dependence on mining and enabling more diversified local development pathways.

Types of Measures

Governments can introduce mandatory provisions within local content policies, mining laws, and contracts to operationalize this objective:

Recognition of Energy as a Horizontal Linkage

- explicitly include renewable energy infrastructure within local content frameworks as a cross-cutting enabler of local economic development.
- require mining companies to assess and report on opportunities to extend energy access to communities and local enterprises.

Mandatory "Last-Mile" Electrification Provisions

- require companies to submit costed plans for extending renewable energy infrastructure to nearby communities ("last-mile" connections).
- prioritize last-mile extensions where they are technically feasible and cost-effective compared to stand-alone systems.
- where direct connections are not viable, require financial contributions to public or third-party electrification initiatives.

Integration Into Development and Procurement Obligations

- link renewable energy sharing to community development agreements and local development plans.
- require that energy systems support productive uses (e.g., agro-processing, small industries, services), not only household access.
- introduce obligations for local procurement and service provision related to energy infrastructure (installation, maintenance, operations).

Monitoring and Compliance Mechanisms

- establish clear reporting requirements on energy sharing commitments and outcomes.
- integrate renewable energy obligations into licensing conditions and compliance audits.
- consider applying penalties or corrective measures where commitments are not fulfilled.
- governments may also require periodic public reporting on delivery of access commitments, particularly where obligations relate to household connections, public services, or productive-use infrastructure.

Strengths of These Measures

- **create enforceable development outcomes:** Legal obligations could provide a framework to enhance tangible local benefits from renewable energy investments.
- **accelerate energy access:** Leveraging existing infrastructure reduces costs and speeds up electrification.
- **support economic diversification:** Reliable energy enables local businesses and services to emerge beyond mining.

- **improve accountability:** Clear requirements and monitoring frameworks strengthen oversight of company commitments.
- **maximize public value from private investment:** Ensures that mining-related infrastructure delivers broader societal returns.

Potential Implementation and Sustainability Challenges

- **risk of increased project costs:** Mandatory requirements may raise upfront investment costs for mining companies.
- **feasibility constraints:** Technical limitations (distance, load capacity, terrain) may restrict the viability of last-mile extensions in some contexts.
- **enforcement capacity:** Governments may face challenges in monitoring compliance and enforcing obligations.
- **potential investor concerns:** Overly rigid requirements could affect investment attractiveness if not carefully calibrated.
- **risk of investor–state disputes:** Introducing or modifying mandatory obligations—particularly where they affect existing contracts—may expose governments to disputes if investors perceive changes as altering agreed terms or undermining project economics.
- **defining appropriate thresholds:** Setting realistic and context-specific obligations requires robust data and careful policy design.

Recommendation 10: Strengthen skills development requirements for renewable energy in mining regions

The expansion of renewable energy systems linked to mining operations creates significant opportunities for local employment and economic participation. However, these opportunities often require specialized skills that differ from traditional mining roles, including installation, operation, maintenance, and energy system management.

To translate these opportunities into meaningful local content outcomes, education and skills development must be treated as essential preconditions for employment. Without a workforce equipped with relevant technical, managerial, and operational capabilities, local communities risk being excluded from emerging jobs and value chains associated with renewable energy.

Governments should therefore embed renewable energy skills development within local content policies, while aligning these with broader education and workforce strategies. This is essential not only to support the deployment of renewable technologies, but also to enable communities to manage and sustain energy systems over time—thereby strengthening long-term resilience.

Types of Measures

Governments can combine regulatory requirements, education policies, and partnerships to build a strong local skills base:

Embedding Skills Development in Local Content Frameworks

- require mining companies to implement renewable energy training programs for both employees and surrounding communities.
- mandate contributions (financial or in-kind) to training centres, equipment, and curricula development.
- link licensing conditions to demonstrable progress in local skills development.

National Education and Workforce Strategies

- integrate renewable energy into education curricula from primary to tertiary levels, with a focus on STEM subjects.
- develop national renewable energy skills roadmaps, explicitly including mining regions and rural areas.
- invest in enabling infrastructure (e.g., internet access, renewable-powered schools) to support learning.

Regional and Community-Level Training Initiatives

- establish training centres in mining regions, offering short, modular, and accessible courses adapted to local contexts.
- partner with vocational schools, technical institutes, and universities to deliver hands-on training.
- use renewable energy projects as "living labs" for practical learning and demonstration.
- training programs should also prepare local workers and service providers to operate and maintain shared systems beyond the life of the mine, reducing long-term dependence on external technicians.

Industry Partnerships and Incentives

- encourage partnerships between mining companies, energy providers, and training institutions.
- provide fiscal incentives for companies investing in local skills development and training ecosystems.
- support the emergence of local service providers and SMEs in installation, maintenance, and energy services.

TABLE 3. Key skills for the renewable energy sector

Types of skills	Examples of roles and skills requirements
Technical expertise	Professionals with a strong foundation in engineering, mathematics, and physics in solar PV, wind turbine technology, and energy storage systems. Professionals who can integrate renewable energy into all nodes of the mining value chain.
Data analysis	Interpretation and integration of data is crucial in optimizing energy efficiency, production, and consumption. Applies throughout the value chain from technical engineering roles to project management, as well as marketing and sales.
Policy and regulatory knowledge	Professionals well-versed in local and international energy policies and regulations, incentives, and compliance standards play a pivotal role in guiding companies and governments through the evolving regulatory environment.
Environmental knowledge	Innovation in improving renewable energy systems with an understanding of the responsibility to design and implement in environmentally friendly and sustainable ways.
Project management	The renewable energy industry involves complex projects requiring efficient planning and execution. Strong understanding of renewable energy technologies, regulatory requirements, and stakeholder engagement in often challenging environments.
Collaboration	Renewables workers in a multitude of sub-sectors have to collaborate across the board—with colleagues, stakeholders, technicians, engineers, sales teams, directors, and clients—teamwork is frequently required.

Source: Author, summarized from various sources.

Promoting Gender Equality and Inclusive Access to Skills

Inclusion in access to energy can significantly enhance gender equality by addressing the barriers women face in developing decent livelihoods through access to education, training, economic opportunities, and utilizing digital technologies. Mining companies, local and national-level governments, and local non-governmental organizations need to work in concert to address the multiple challenges faced by women, particularly in rural areas. Measures could include

- support for targeted training programs for women and marginalized groups, including through corporate social responsibility initiatives and public programs.
- promoting access to STEM education for girls, including scholarships, apprenticeships, and mentorship.
- delivering training in local languages and ensuring accessibility of tools and technologies.

- providing ongoing support and upskilling opportunities to adapt to evolving technologies.
- integrating gender-responsive financing mechanisms (e.g., microloans, grants) to support women-led energy enterprises.
- prioritizing access to energy and training for underserved groups within broader gender equality strategies.

Strengths of These Measures

- **build long-term local capacity:** Enable communities to install, operate, and maintain energy systems independently.
- **create employment and enterprise opportunities:** Support job creation beyond mining, including in energy services and SMEs.
- **improve sustainability of energy systems:** Locally available skills reduce reliance on external expertise and improve system reliability.
- **support inclusive development:** Targeted measures can expand opportunities for women and marginalized groups.
- **align workforce development with energy transition goals:** Prepare mining regions for future economic transformation.

Potential Implementation and Sustainability Challenges

- **skills mismatch:** Existing education and training systems may not align with renewable energy needs.
- **limited training capacity:** Rural and mining regions often lack institutions and trainers with relevant expertise.
- **retention challenges:** Skilled workers may migrate to urban areas or other sectors. This can be particularly acute where rural mining regions lack stable long-term demand, underscoring the importance of linking training to broader local economic diversification and post-mining transition strategies.
- **financing constraints:** Sustained investment is required to develop and maintain training programs.
- **social and cultural barriers:** Women and marginalized groups may face barriers to accessing training and employment opportunities.

5.1.4 Incentives and Facilitative Measures for Infrastructure Sharing

Mining companies are often best positioned to deploy renewable energy in remote and underserved regions. However, extending these systems beyond operational needs to supply surrounding communities introduces additional costs, risks, and complexities. At the same time, even where infrastructure exists, affordability constraints may prevent local households and enterprises from accessing energy.

To unlock the full potential of renewable energy for community resilience, governments can introduce targeted fiscal and non-fiscal incentives, alongside subsidies and risk mitigation tools. These measures should simultaneously

- encourage companies to invest beyond the mine site, and
- enable communities to access, use, and sustain energy services over time.

Importantly, incentives should be applied selectively, based on clear criteria (e.g., proximity to communities, availability of surplus power, mine lifespan, and local demand), to ensure that public support targets viable and high-impact projects. These criteria should also take into account the availability and capacity of utilities or other service providers to manage interconnection, long-term service delivery, and eventual post-closure transition.

Cross-Cutting Design Principles

Across all incentive mechanisms, governments should ensure

- **long-term service delivery:** Incentives should be conditional on operation, maintenance, and service quality over time.
- **prioritization of high-impact uses:** Where supply is constrained, incentives may prioritize connections that strengthen community resilience, such as health centres, schools, water systems, cold storage, and local enterprises.
- **conflict-sensitive deployment:** Incentive frameworks should avoid creating or exacerbating tensions over land, water, or unequal access to infrastructure benefits.
- **affordability and tariff design:** Energy pricing frameworks should balance cost recovery with affordability, including lifeline tariffs or targeted support for low-income users.
- **integration with utilities:** Where relevant, utilities should be involved to support system integration, scaling, and long-term service provision.
- **transparency and accountability:** Incentives should be linked to measurable outcomes (e.g., number of connections, service reliability).
- **time-bound and performance-based design:** Incentives should avoid permanent fiscal burdens and be tied to results.

Recommendation 11: Provide targeted fiscal incentives for infrastructure sharing

Fiscal incentives can help offset the additional costs of extending renewable energy infrastructure to communities and improve the commercial viability of shared systems.

Types of Measures

Governments Can Deploy Tax-Based Instruments

- tax credits or deductions linked to verified investments in community-facing renewable infrastructure
- accelerated depreciation for renewable energy assets used for shared systems
- VAT exemptions on renewable energy equipment, particularly for last-mile connections
- import duty rebates for equipment dedicated to community access (e.g., solar panels, battery energy storage systems, transformers)
- royalty reductions or rebates tied to delivery of energy access outcomes

Support Communities

- link incentives to affordability conditions (e.g., capped tariffs, service to priority users such as schools and clinics).
- governments may also condition eligibility on transparent reporting of access outcomes, service reliability, and compliance with agreed tariff or affordability provisions.
- require minimum thresholds of connections or service coverage to qualify for benefits.

Strengths of These Measures

- improve project viability by reducing upfront and operational costs.
- encourage scale beyond mine site needs.
- leverage private investment for public development outcomes.
- can be performance-based, ensuring delivery of tangible benefits.
- support affordability when linked to pricing conditions.

Potential Implementation and Sustainability Challenges

- revenue trade-offs for governments, particularly in resource-constrained contexts.
- risk of misuse or over-subsidization if not well targeted and monitored.
- administrative complexity in verifying compliance and outcomes.
- need for time-bound design to avoid long-term fiscal burden.

Recommendation 12: Introduce non-fiscal incentives to reduce barriers and transaction costs

Beyond fiscal tools, non-fiscal incentives are critical to reducing administrative, regulatory, and operational barriers that can delay or discourage renewable energy sharing initiatives.

Types of Measures

Governments Can Streamline Processes and Improve Enabling Conditions

- accelerate permitting processes for renewable energy projects with community access components, while maintaining environmental and social safeguards.
- provide priority access to land or grid connections for shared infrastructure projects, with appropriate consultation and safeguards.
- develop standardized contracts and templates (e.g., PPAs, community agreements) to reduce legal uncertainty.
- enable government-backed offtake arrangements for surplus electricity, including for public services.
- where applicable, clarify the roles of utilities and regulators in approving interconnection, wheeling, tariff setting, and the future absorption of shared systems into broader public energy networks.
- provide technical assistance and advisory support for project structuring.

To Benefit Communities

- simplify procedures for community-level connections and licensing.
- provide regulatory clarity for mini-grids, local distribution, and service provision.

Strengths of These Measures

- reduce delays and transaction costs.
- improve investor certainty and ease of doing business.
- facilitate faster deployment of renewable energy systems.
- enhance accessibility by lowering regulatory barriers for community connections.
- encourage innovation through flexible and enabling frameworks.

Potential Implementation and Sustainability Challenges

- institutional capacity constraints to implement streamlined processes effectively
- risk of uneven application across regions or projects
- potential governance risks if fast-tracking reduces oversight quality
- coordination requirements across agencies to deliver integrated support
- potential conflict over land use for other economic activities, such as agriculture and for environmental protection and conservation purposes.

Recommendation 13: Use targeted subsidies to ensure affordability and sustainability

While incentives can stimulate investment, subsidies are often necessary to ensure that renewable energy remains affordable for low-income communities and that systems remain operational over time.

Types of Measures

Governments can design targeted subsidies for both supply and demand:

- subsidized transmission or wheeling charges when electricity is allocated to communities or priority services.
- output-based subsidies tied to verified delivery of electricity to underserved users.
- capital subsidies or co-financing for shared infrastructure components.
- leasing support for renewable energy systems (e.g., solar PV, battery energy storage system) linked to community access commitments.

For Communities

- lifeline tariffs or targeted subsidies for low-income households. These should be designed within a broader tariff architecture that balances affordability for vulnerable users with sufficient cost recovery to maintain reliable service over time.
- subsidies for productive uses of energy (e.g., for small businesses, for rural agriculture and agro-businesses).

Strengths of These Measures

- improve affordability and inclusion, particularly for vulnerable populations.
- support long-term system viability by covering operational gaps.
- enable productive use of energy, strengthening local economies.
- can be targeted and conditional, improving efficiency.

Potential Implementation and Sustainability Challenges

- budgetary constraints and fiscal sustainability concerns, especially in low-income countries.
- targeting difficulties, with risks of leakage or exclusion.
- dependency risks if subsidies are not gradually phased out or well designed.
- administrative complexity in managing and monitoring subsidy schemes.

Recommendation 14: Deploy risk financing instruments and guarantees to de-risk investments

Extending renewable energy infrastructure into remote or low-income areas often involves higher perceived risks, including uncertain demand, payment risks, and long payback periods. Risk mitigation instruments are therefore essential to unlock private investment.

Types of Measures

Governments, often in partnership with development finance institutions, can provide

- partial risk guarantees to cover payment defaults or regulatory risks.
- credit guarantees to facilitate access to finance for projects involving community components.
- concessional loans or blended finance mechanisms to improve project bankability.
- insurance instruments (e.g., political risk insurance) for investors.
- viability gap funding for projects that are socially beneficial but not fully commercially viable.

For Communities

- support microfinance and credit schemes to enable connection and productive energy use. This can include financing for community enterprises, local economic activities, digital services, and other uses that strengthen livelihoods.
- de-risk community-owned or cooperative energy models.

Strengths of These Measures

- unlocks private capital by reducing perceived and actual risks.
- improves bankability of complex or marginal projects.
- enables investment in underserved areas where commercial returns are uncertain.
- supports innovation and new business models.
- facilitates inclusion by enabling financing for community participation.

Potential Implementation and Sustainability Challenges

- such instruments may not be feasible for low-income countries, with limited financial resources, high budget deficits and debt levels.
- dependence on external partners (e.g., development finance institutions) in many contexts.
- contingent liabilities for governments if guarantees are triggered.
- complex structuring requirements requiring strong financial and legal expertise.
- risk of moral hazard if risks are excessively transferred to the public sector.

6.0 Conclusions

The integration of renewable energy into mining operations is both a major decarbonization opportunity and a catalyst for socio-economic transformation in surrounding communities. Mining operations can incorporate renewables across the value chain through electrification of mining equipment and by replacing fossil feedstocks, often operating within hybrid systems in tandem with backup fossil fuel capacity, and with the support of storage options in off grid sites. At the same time, technical and operational constraints, high upfront investment costs, skills shortages and a risk averse industry culture pose obstacles to a widespread uptake, particularly for high temperature processes and large scale storage applications. Technological solutions alone are therefore not sufficient and will require targeted policy support alongside careful operational planning.

This report shows that renewable energy deployment in mining is deeply intertwined with community resilience, operating across multiple dimensions: emissions reduction and improved energy management, the development of human, physical, natural, and financial capital, improvement in air quality, and the creation of new economic activities. However, if poorly designed, renewable energy systems may compete with nature based solutions for land, increase pressure on ecosystems through unsustainable biomass use or large hydropower projects, and increase social inequalities in mining regions.

Governments thus have a decisive role to play in ensuring that renewable energy investments in mining deliver benefits both from a climate and a social/development perspective. Policy and regulatory frameworks need to go beyond technology to provide specific incentives that should foster grid integration and innovation. More importantly, they should align with national energy and development strategies. This means imagining mining projects as reliable energy off-takers to enable the electrification of off-grid areas, developing extensive skills development programs to maintain the viability of renewable energy projects and to benefit the community at large, and embedding local content requirements. Such efforts would also need to extend beyond the operation of mining sites, given that some renewable energy technologies can easily adapt to the topography of closed mining terrains, serving the community beyond the mine's lifespan. With such an alignment, renewable projects in mining can not only alleviate the climate impact of these operations but can also extend their reach beyond isolated corporate endeavours and advance local development and resilience.

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