

INDUSTRY

Mining



10.1 MINING

Function	Extraction of minerals used for multiple purposes across all sectors.
GHG emissions	10 Mt CO ₂ e (2024), 1.5% of total national emissions.[61] ¹
Options for decarbonization	Decarbonization Pathways: Battery-electric and trolley-assist mining equipment. Enabling Pathways: On-site renewables and storage microgrids, transform extraction and processing, metal recycling and recovery.
Stage of transition	Emergence/diffusion boundary: Transform extraction and processing, metal recycling and recovery. Diffusion: Battery-electric and trolley-assist mining equipment, on-site renewables and storage microgrids.
Nature of the problem today	Legacy infrastructure, high up-front costs, lack of regulatory framework (metal recycling and recovery).
Other systemic issues	Pollution; worker health and safety; remediation of abandoned sites; relations with Indigenous peoples.
Strategic opportunities and concerns	Potential to reduce operational costs, improve air quality and worker health, and create new revenue streams (metal recycling and recovery). Design, build and test new electric mining technologies in Canadian labs and mines, export technology. Markets for minerals critical to a low carbon transition (eg, batteries). Indigenous land claims and opportunities for partnership. Competitiveness. Issues: Need for international collaboration.
Priorities for action	Incentivize use of electric mining equipment and on-site renewable energy production and storage; regulatory framework and funding of pilots to encourage metal recovery/recycling.
Longer-term issues	Lifecycle management of batteries, mine site reclamation, production of metallurgical coal.
Indicators of progress	Proportion of mining equipment that is electric or fuel cell; volume and value of recycled metals.

¹ All noted references can be found in the full Playbook document.

10.1.1 Current Status

Canada has a significant and well-established mining sector with over 200 active mines and 6,500 quarries.[357] The direct contribution of the mining sector to Canada's 2023 GDP was \$117 billion². [358] The sector directly employs about 213,000 people in extraction, services, and primary manufacturing.[359] These numbers do not include oil sands operations. Mining is a major source of export earnings.

Global demand for battery and defence-critical minerals means Canada's mining footprint is poised to grow quickly. Natural Resources Canada's 2024 Major Projects Inventory lists 35 new or expanded mines that are approved, 31 announced, 46 in review, and 26 under construction.[360] Capturing the economic upside while meeting net-zero and Indigenous-partnership goals will require

front-loaded deployment of low-carbon power, electric mobile equipment, and ESG safeguards.

In 2024, the total value of Canada's domestic mineral exports was \$125.0 billion. The top five mineral exports that year were gold (\$40.2 billion), iron and steel (\$20.6 billion), aluminum (\$17.4 billion), copper (\$10.7 billion), and metallurgical coal (\$10.2 billion)³. [361]

Many Canadian mining companies operate abroad. Of the sector's \$343.2 billion⁴ in assets (2023), 68.1% were located outside the country. In 2023, the Toronto Stock Exchange was the top exchange in the world for global mining equity financing. Compared to most industrial sectors, Canada's mining industry has a moderately high level of foreign ownership. In 2023, 31.9% of total mining industry assets were controlled by foreign entities, 2.2 times the private sector average.[362]

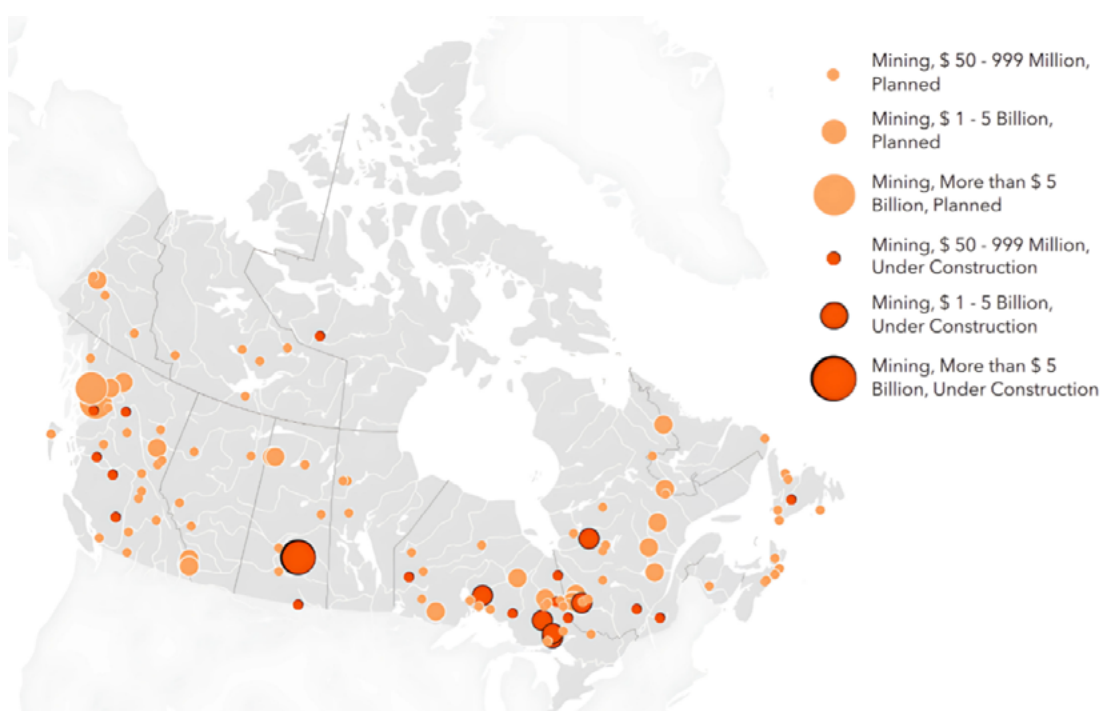


Figure 28. Canada, Major planned and under-construction mining projects

Source: Natural Resources Canada, 2025. Major Project Inventory[360]

² In chained (2017) Canadian dollars

³ In 2024 Canadian dollars

⁴ In 2023 Canadian dollars

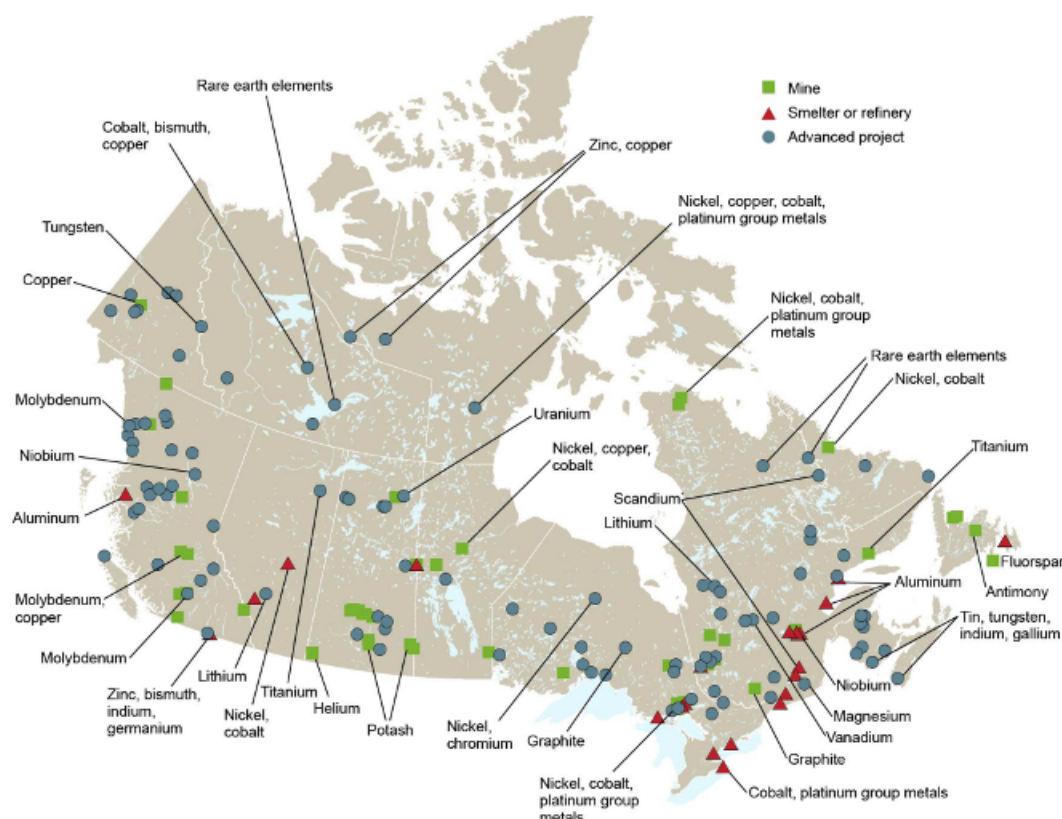


Figure 29. Canada, Critical mineral project locations (2022)

Source: Natural Resources Canada, 2023. *The Canadian Critical Minerals Strategy*[363]

10.1.2 Nature of the Problem

The main challenge to decarbonizing this sector is the remote location of most mines, sunk investments in existing mining infrastructure, high capital costs for new equipment (for example, electric vehicles, processing equipment, net-zero energy supplies) and competitiveness concerns in this globally integrated industry. Mobile equipment is a key source of emissions in mining; however, because this equipment is routinely replaced every 10 to 15 years, these regular procurement cycles provide cost-effective opportunities to transition to electrified alternatives, mitigating some of the challenges posed by high initial capital costs. In 2022, Canada's mining sector emitted 10 Mt of CO₂e or approximately 1.5% of Canada's

total emissions. At the mine site, stationary emissions come from electricity generation (needed for ventilation, lighting, ore processing, etc.).[186] Diesel trucks are the largest source of mobile emissions. Since 1990, emissions have remained flat while the sector has grown significantly. Many remote mines rely on expensive and polluting diesel generators to power operations. Mining companies face increasing environmental and economic pressures from local and Indigenous communities and are subject to more stringent regulation. Unsettled Indigenous land claims in some regions complicate mine development. Some decarbonization activities, such as renewable power generation, can provide helpful partnership opportunities with Indigenous and local communities.

The mining sector in Canada has begun to re-position itself as a supplier of metals and minerals that are critical not only to a low-carbon economy but also to national sovereignty and defence. Reflecting this broader priority, the federal government now lists 34 critical minerals that it considers essential for economic security and the energy transition[364] such as lithium, cobalt, nickel, and copper, as well as for rare-earth elements used in permanent magnets, copper for grid and transportation electrification, and specialized metals required for wind turbines, semiconductors and defence systems. On the other hand, demand for thermal coal will fall as Canada phases out coal-fired generation. Metallurgical coal (which makes up 97% of Canada's coal exports) will continue to be needed by the steel industry until alternative foundry technologies are developed and diffuse internationally over coming decades.[365]

10.1.3 Net-Zero Pathways

The fundamental approach to achieving net-zero emissions in mining is electrification of mine operations, supply of renewable electricity, and the modernization of extraction and processing techniques—for example for comminution (crushing and grinding of ore). Promotion of resource efficiency in mineral-consuming industries, reuse, and recycling (embracing the circular economy) provides a complementary track. Given the established global leadership of Canada's mining sector, and existing public and private sector activities currently underway, Canada is well-positioned to lead on both paths.

Table 6. Decarbonization opportunities by mine type and grid connectivity mine area

	Grid-Connected Opportunities	Additional Off-Grid Considerations
Site-wide Power and Storage	Stationary batteries can help overcome grid peak-demand limitations as operations electrify. Greening the grid is generally more practical than adding on-site renewable generation, unless supply reliability is a concern.	On-site renewable generation (wind, solar) can displace diesel, though energy storage is needed to smooth intermittent supply. Large-scale storage may be required to bridge extended periods of low renewable availability. Establishing a grid connection should be evaluated where feasible.
Underground Mining (material movement and ventilation)	Hoisting and conveyance systems are typically already electrified; further gains come from optimizing these systems. Battery-electric or trolley-assisted mobile equipment (loaders, haul trucks) can replace diesel fleets, also reducing ventilation energy requirements. Electrification and optimization of ventilation air heating offer additional energy savings.	Expansion of local generating capacity (renewables, diesel, or hybrid systems) is needed to support the additional electrical load from fleet and ventilation electrification.

	Grid-Connected Opportunities	Additional Off-Grid Considerations
Open Pit Mining (haulage and conveying)	Diesel haul trucks are the dominant source of emissions; trolley-assist systems augmented by on-board batteries, or fully battery-electric trucks, can substantially reduce fuel use. In-pit crushing and conveying (IPCC) systems can replace truck haulage on suitable haul profiles. Hydrogen-powered haul trucks are an emerging alternative for long-haul routes.	Significant expansion of local generating capacity is required to support trolley, battery, or conveyor electrification. Hydrogen-powered trucks may be better suited than trolley-assist in remote settings where electrical infrastructure is limited.
Mineral Processing (comminution and concentration)	Energy efficiency improvements through ore-sorting and grade-control technologies can reduce the volume of material processed. Optimizing comminution and processing parameters (i.e., grinding circuits) lowers energy intensity per tonne.	Higher cost of locally generated electricity can shorten payback periods for efficiency investments. Reducing energy intensity per tonne is especially valuable where power supply is constrained.
Metallurgical Processing (smelting, hydrometallurgy, refining)	Most mines do not operate their own smelters or refineries. Concentrate is typically shipped to centralized metallurgical facilities located near low-cost power, water, and transport infrastructure, often operated by separate companies. Where on-site hydrometallurgy exists (i.e., solvent extraction-electrowinning for copper), process electrification and efficiency gains can be pursued directly.	On-site metallurgical processing at off-grid mines is rare. Gold operations are the main exception, with leaching and smelting of doré bars routinely carried out at remote sites. SX-EW circuits, which produce finished metal at the mine, are generally feasible only at grid-connected operations due to their high electricity demand.

Electrify all that is possible. Energy is one of the largest and most volatile operating costs for mines—typically around a quarter to a third of total operating costs—and in some deep or remote operations it can be the single largest.[366,367] Many of Canada's remote mines are off-grid and rely on diesel for power generation and operational equipment. For underground mines, this means additional costs for ventilation and increased health risks for workers from air and noise pollution. Mine electrification can reduce operational costs. Electric (or hydrogen fuel-cell) mining

equipment eliminates the need for diesel, improves air quality in underground mines, eliminates tailpipe emissions, and reduces ventilation costs and noise. Newmont Goldcorp's Borden gold mine in Ontario, which opened in 2018, is the first all-electric underground mine in Canada.[368]

Major equipment manufacturers like Sandvik, Epiroc, Komatsu, Hitachi, and Caterpillar as well as several Canadian firms (e.g., Maclean Engineering) already sell battery electric mining equipment. Hydrogen fuel cell electric

technology is currently under development for mining applications, providing torque, size and weight advantages over batteries. But this equipment is not yet in commercial production. In March 2020, the federal government introduced a temporary 100% first-year capital cost allowance (CCA) for eligible zero-emission vehicles and automotive equipment (under new CCA Class 56), with a full write-off available if put into use by 2023, phasing down to 75% in 2024–25 and 55% in 2026–27. However, industry stakeholders have pointed out that the write-off under Class 56 only applies to fully electric or hydrogen-powered self-propelled equipment (i.e., battery or fuel-cell vehicles). The inclusion of tethered or trolley-powered equipment is unclear as these retain a diesel engine. This has led to calls for extending eligibility to these systems.

Renewable diesel would offer a drop-in and bridge decarbonization pathway for remote-site generators and legacy diesel fleets, cutting a portion of lifecycle emissions without engine modifications while electrification builds out.

On-site wind and solar-PV power generation, when combined with energy storage technologies, can reduce carbon emissions for off-grid mine sites or those connected to emission-intensive electricity grids. Glencore's Raglan mine in Quebec has two wind turbines and an energy storage system, which includes a small hydrogen generator. [369] Between 2014 and 2019, the mine's new power system displaced 10 million litres of diesel fuel. Small modular nuclear reactors have also been proposed as a longer-term option for power generation at mines, but the technology remains far from market, and it is uncertain how cost, safety, and security concerns will be overcome.

Transform extraction and processing technologies. Achieving full electrification will require major advances in mining and mineral processing systems for upgrading, integrating

continuous mining with already-continuous processing circuits, reducing material brought to the surface, and increasing sorting efficiency. Such platform improvements could dramatically increase energy efficiency and reduce water use and tailing discharges, raising operational efficiencies. Modernizing mining processes (which in some respects have remained remarkably stable) to eliminate inherent energy inefficiencies can also help address the long-standing problem of declining ore quality, where more material must be processed to extract a given quantity of mineral. It will require continued research and development and significant capital expenditures.

Block caving. This is an emerging option for deep or mature deposits and a gravity-assisted underground method that lets ore break and flow to draw-points, slashing waste-rock movement and diesel haulage. Canada's only operating block-cave mine is New Afton (B.C.), but several projects, including KSM (B.C.), Red Chris extension (B.C.), and Galore Creek (B.C./YT), have advanced block-cave designs. Studies by WSP and recent case reviews link the technique to smaller surface disturbance, potential reductions in GHG emissions, and improved worker safety, making it a credible component of Canada's critical-minerals strategy.[370,371]

Recycle and reduce usage. Greater demand for metals and minerals needed to decarbonize the economy could increase the cumulative environmental impacts of mining. Encouraging materials efficiencies in industries that consume mine products and promoting recycling (keeping materials in circulation and postponing final waste disposal) can limit primary extraction. This potentially decouples economic growth from increasing natural resource consumption and complements electrification. Re-processing legacy mine tailings—which often contain economically

recoverable critical minerals—presents an additional source of supply while turning an environmental liability into value. Action Canada's Waste Not report (2025) estimates that re-mining Canadian tailings could unlock substantial volumes of copper, nickel and rare-earth elements.[372] Recycling is well developed for some metals (steel, aluminum) but immature for others. The global e-waste recycling market is expected to increase six-fold by 2050, providing a valuable source of metals such as gold, copper, and aluminum. This could create new economic opportunities.

Some ultramafic-hosted nickel deposits go a step further, using their magnesium-rich tailings to mineralize and permanently store CO₂. Pilot initiatives at Canada Nickel's Crawford project in Ontario, Giga Metals' Turnagain deposit, and FPX Nickel's Baptiste project in British Columbia suggest such sites could sequester hundreds of thousands of tonnes of CO₂ each year, creating opportunities for genuinely net-negative mining operations.

These approaches to net-zero emissions face significant obstacles. While high up-front

capital costs for non-diesel power generation and for electric- or fuel-cell-powered trucks and equipment can deter investment, mobile equipment is normally replaced on roughly a 10-year cycle. This creates recurring, lower-cost opportunities to adopt these technologies as part of the regular capital-replacement program. Even so, the sunk costs of existing infrastructure and the substantial upgrades it may require continue to make full decarbonization financially challenging for many mining companies. Recycling initiatives can appear to threaten primary producers. Canada currently lacks a policy and regulatory framework to incentivize metal recovery and recycling.

Although absolute production emissions are not high, coal mining poses a distinct challenge. While thermal coal extraction is expected to decline as coal is eliminated from the power sector, demand for metallurgical coal will remain for some time. Fugitive methane emissions will therefore require offset provisions, and policies to ease the burden for impacted workers and communities will be required.

Competitiveness Implications

Mine electrification in Canada is not solely a decarbonization play; it is a trade-competitiveness investment. The EU's Carbon Border Adjustment Mechanism already covers aluminum, iron, and steel, worth over \$38 billion of Canada's \$125 billion in annual mineral exports, and the trajectory is clear: embedded production emissions are becoming a direct input to the landed cost of traded minerals through border adjustments, procurement screening, and ESG-conditioned financing. Canada's clean hydroelectric grids in Quebec, British Columbia, Manitoba, and Ontario make mine electrification structurally cheaper here than in most competing jurisdictions, where mining runs on coal-fired or diesel-generated power, a cost-formation advantage few mineral-exporting nations can replicate at comparable speed. But the advantage only materializes if mines electrify during the current round of new and expanded mine development. With 138 new or expanded projects underway and equipment replacement cycles of roughly 10 years, every procurement round that defaults to diesel locks in a decade of competitive exposure across export markets that increasingly price embedded carbon.

10.1.4 Priorities for Action

Transition in this sector can be accelerated by incentives to lower capital costs for electric mining equipment and on-site renewable production and storage, and measures to promote retirement of diesel generators and mining equipment. These could be linked to industrial policy measures to (a) support Canadian companies that can provide net-zero mining technologies and power supplies, and (b) expand mining of materials required for society-wide electrification. A regulatory framework for metal recycling and recovery would lower uncertainty and speed market development. Some mining companies have already begun to process recycled materials

at their smelters and refineries, and government support for pilot or demonstration projects could help.

Several longer-term issues await attention. The increased use of batteries and fuel cells, both at the mine site and by consumers, creates concerns about end-of-life disposal. Improved lifecycle management will be needed to minimize the potentially toxic legacy of these zero-GHG emission technologies. Increased demand for metals and minerals may exacerbate existing reclamation liabilities for the sector. Measures to address remaining metallurgical coal production will ultimately be required.



Criteria Status

- Fails to meet criteria
- Meets in some respect
- Not promising
- Potentially meets criteria
- Meets criteria

10.1.5 Mining Pathways Table

			ALIGNMENT WITH CARBON NEUTRALITY	Economic		Technical			Social		
PATHWAY ELEMENTS	ROLE IN NET-ZERO SYSTEM	SIGNAL TO DECISION- MAKERS		ECONOMIC VIABILITY	ECONOMIC DEVELOPMENT OPPORTUNITY	MATURITY	OPERATIONAL FIT	INFRA- STRUCTURE AND SUPPLY CHAIN SUITABILITY	SOCIAL ACCEPTABILITY	RELEVANCE TO STAKEHOLDERS	RELATED BENEFITS AND COSTS
 Mining Equipment and Processes											
Battery Electric & Trolley Assist Mining Equipment	Priority Decarbonization Pathway Can fully displace mobile diesel, which is the largest source of mine site emissions.	Deploy Invest in site electrification, charging infrastructure, and workforce training.	 Zero tailpipe emissions. Enables net-zero operations when powered by clean electricity.	 Higher capital costs offset by lower fuel and ventilation reducing operating costs. Tax incentives can improve payback.	 Canada can design, test, and assemble equipment. Exportable know-how from labs and operating mines. Could be combined with autonomous and connected vehicle technology.	 Commercial for many underground loaders/trucks. Open-pit ultra-class battery electric haulage still emerging.	 Strong fit, especially underground. Needs charging/trolley integration and upskilled maintenance and labour.	 Requires site charging power, batteries and/or trolley. Off grid mines need microgrid upgrades.	 Cleaner air and lower noise improve worker health/safety.	 Seen as a solution to reduce emissions and costs where appropriate, less relevant to open pit or legacy operations.	 Air quality and safety gains. Less heat/ventilation energy. Lower local pollution.
Hydrogen Fuel-Cell Mobile Equipment (haul & utility)	Potential Niche Pathway Useful where long duty cycles, heavy haul or fast refuelling challenge batteries.	Incubate Fund demonstrations for heavy-haul and long-cycle mining applications where batteries face limitations. Develop on-site hydrogen production	 Zero tailpipe emissions when supplied with low-carbon H ₂ .	 Vehicle and fuel costs are high. Viability hinges on H ₂ price and on site production/ logistics.	 Targeted opportunities across H ₂ value chains (electrolyzers, storage, service), but unclear near-term scale.	 Demonstrations only. Not in commercial production for mining fleets.	 Operationally attractive for long blocks/quick refuelling. Requires new fuelling protocols and training.	 New H ₂ production, storage, and dispensing must be built at remote sites.	 Generally positive where safety is robustly managed. Air quality benefits valued.	 OEMs and a few miners are piloting. Interest is real but not universal.	 Air quality and ventilation reductions in underground settings.
Transform Extraction & Processing	Enabling Pathway Cuts energy use and diesel haulage. Complementary to clean power and offsets declining ore grades. Block caving reduces surface disturbance and GHGs in suitable deposits.	Enable Invest in process redesign and electrified material movement where productivity and emissions benefits align.	 Significant energy reductions from efficiency gains.	 Often attractive on operational savings and throughput. Capital costs vary by site/process.	 Canadian engineering/R&D has global export potential.	 Mixed maturity: some technologies proven. Others at pre-scale.	 Broadly applicable with process redesign. May require stoppages or staged retrofits.	 Uses/optimizes existing plants with targeted upgrades.	 Fewer tailings/water impacts and safer operations raise acceptance.	 Strong operator interest when productivity improves.	 Less water use/tailings and noise. Smaller surface footprint in some methods.

PATHWAY ELEMENTS	ROLE IN NET-ZERO SYSTEM	SIGNAL TO DECISION-MAKERS	ALIGNMENT WITH CARBON NEUTRALITY	Economic		Technical			Social		
				ECONOMIC VIABILITY	ECONOMIC DEVELOPMENT OPPORTUNITY	MATURITY	OPERATIONAL FIT	INFRA-STRUCTURE AND SUPPLY CHAIN SUITABILITY	SOCIAL ACCEPTABILITY	RELEVANCE TO STAKEHOLDERS	RELATED BENEFITS AND COSTS
Renewable Diesel (RD)	Bridge Pathway Can help reduce emissions from diesel equipment while electric options are being commercialized.	Deploy Maximize drop-in renewable diesel use across existing fleets while electrification scales.	Drop-in fuel, with some lifecycle CO ₂ cuts. Combustion emissions persist and sustainable feedstocks are finite.	Higher production cost than diesel. Viable where policy support offsets fuel premiums.	Supports refinery jobs, rural economies, and feedstock markets. Growth is limited by feedstock constraints.	Fully commercial, drop-in fuel. Dominant production processes (i.e. hydrotreated vegetable oil) mature, with several large-scale facilities operating globally. Established technology licensors.	Drop-in fuel ideal for near-term fleet decarbonization without new equipment or operational changes.	Existing fuel storage, pipelines, and retail networks work for RD. Main gaps are upstream (sustainable feedstock availability and refining capacity scale-up).	Accepted when made from sustainable waste feedstocks and used as a bridge. Concerns over land-use competition.	Fleets seeking fast GHG cuts. Fuel producers and farmers benefiting from new markets. Policymakers aiming for near-term climate progress and rural investment.	Delivers reduced particulate matter and NO _x emissions in existing fleets. Benefits are tempered by feedstock limits and land-use change concerns.
On-Site Energy Generation											
On-site Renewables & Storage Microgrids (Solar, Wind, and Battery Storage)	Priority Enabling Pathway Off-grid mines rely on diesel. Hybrid microgrids cut fuel, cost, and GHGs.	Deploy Support hybrid microgrid deployment at off-grid and remote mine sites. Build enabling frameworks for grid interconnection.	Enables low carbon electricity for mine loads and electric fleets. Key to decarbonizing remote sites.	Site specific economics. High upfront costs. Some operational offsets with avoided diesel and reliability gains but today largely reliant on subsidies.	Room for Canadian suppliers/ integrators.	Commercial components with multi-year field results in Canada. Current deployments custom designed, widespread deployment is challenging.	Works across various geographies with adequate storage/controls. Adds microgrid complexity and requires upskilling.	Integrates with existing diesel systems. Grid connection added where feasible.	Strong community support when it reduces noise, spills and local pollution.	High priority for miners seeking cost stability, power resilience and sustainability outcomes.	Health/air quality gains and energy security benefits for nearby communities. Improves reliability of power supplies.
Small Modular Reactors (SMRs) for Mine Power	Potential Niche Pathway Zero-carbon heat/power is attractive for remote sites, but SMRs are pre-commercial with cost and waste concerns. High potential if delivered.	Don't Prioritize Track SMR development timelines and costs but do not anchor plans to this technology. Prioritize proven electrification and renewable alternatives.	Enables net-zero electricity for mine loads and electric fleets.	Costs and financing are uncertain. Decommissioning and waste obligations weigh on viability.	Could leverage Canada's nuclear ecosystem, but near-term market is unclear.	Pre-commercial. No mine deployments.	Conditionally applicable. Matching unit size to load and siting is complex.	New fuel, logistics, and regulatory systems required.	Public concerns about safety and waste reduce acceptance.	Emerging interest from nuclear fuel suppliers. No clear interest from mining.	Potential community co-benefits such as reliable power and use of waste heat in buildings, but long-term waste and decommissioning challenges. Improved air quality.

			ALIGNMENT WITH CARBON NEUTRALITY	Economic		Technical			Social		
PATHWAY ELEMENTS	ROLE IN NET-ZERO SYSTEM	SIGNAL TO DECISION-MAKERS		ECONOMIC VIABILITY	ECONOMIC DEVELOPMENT OPPORTUNITY	MATURITY	OPERATIONAL FIT	INFRA-STRUCTURE AND SUPPLY CHAIN SUITABILITY	SOCIAL ACCEPTABILITY	RELEVANCE TO STAKEHOLDERS	RELATED BENEFITS AND COSTS
 Waste and Recycling											
CO₂ Mineralization in Ultramafic Tailings	<i>Potential Niche Pathway</i> Potential storage solution for CO ₂ . Permanently captures and stores CO ₂ in magnesium rich tailings. Optional in sector-wide pathways.	Incubate Fund pilot, monitoring, and process optimization at sites with suitable geology.	 Could be a direct CO ₂ capture and storage method or negative emissions option.	 Business case depends on process cost and carbon credit revenue.	 Emerging niche service or carbon credit production method. Domestic IP and technology development. Potential branding as “net negative” metals.	 Pilots underway. Sustained field data still developing.	 Integrates with tailings management. Process control and monitoring needed.	 May need grid connection or another source of renewable energy. Equipment supply chain is nascent as technology is maturing.	 Converts tailings ponds into environmental assets.	 Growing interest from government and academia with ongoing studies and pilots.	 Stabilizes tailings, reduces dust and long term risks while sequestering CO ₂ .
Metal Recycling & Recovery	<i>Enabling Pathway</i> Limits primary extraction needs and creates new revenue streams. Complements—not replaces—primary mining.	Enable Strengthen regulatory frameworks for recycled content and e-waste recovery. Invest in collection, sorting, and quality assurance infrastructure.	 Net-zero metal production when powered by clean energy.	 Economics vary by metal and collection/ sorting costs. Mature for some streams, nascent for others.	 Expanding e-waste and tailings re processing can grow domestic jobs and IP.	 Many processes already commercial. Others emerging.	 Uses existing smelters/ refineries. Requires new feedstock logistics.	 Collection and quality assurance systems are the constraint, not technology.	 Public support for waste reduction and circularity.	 Miners and smelters are beginning to integrate recycled inputs.	 Cuts land/water impacts and community exposures. Reduces biodiversity pressure.