

Remote but accessible: Powering far-flung mining operations goes green

The mining industry has historically been seen at odds with the energy transition, with HSBC noting in their 2025 [Net Zero Transition Plan](#) that the sector accounts for an estimated 4-7% of global greenhouse gas emissions, both directly from operations and indirectly from power generation.

Yet, mining operations located in remote areas present novel and unique opportunities for the mining industry and miners to decarbonise their operations, relying on new technologies and forms of financing. While remote sites come with a number of challenges, such as limited access to energy and transportation infrastructure, individual mine operators, conglomerates and governments are taking steps to turn remote mining operations 'green'.

Decarbonisation of mining is enabled by a number of different technology types

that often work in combination. While there is an overlap amongst them, a half-dozen basic tools populate the mining community's playbook. These are notably solar, wind, hydropower, electrification, gas and further down the road, nuclear. Weather, access to transport and local cost usually dictate which of these tools, alone or combined, will best serve a particular mining project or group of projects.

Many parties involved in such decarbonisation efforts point out that an added benefit is improvement in the

living standards of local communities. Access to new sources of energy, job creation and infrastructure upgrades present opportunities, not least economic ones. As the Intergovernmental Forum on Mining, Minerals, Metals and Sustainable Development (IGF) noted in 2024, "if harnessed and managed well, the [mining] sector has the potential to be transformative for current and future generations, as it can be leveraged to develop home-grown solutions, finance the energy transition, and fund climate change mitigation and adaptation."



The IGF supports 85 member countries to advance sustainability goals through mining sector regulations and policies. Its paper calls for “coordinated efforts between governments, the mining industry, and international stakeholders to ensure that the surge in mining activity for the energy transition does not aggravate other planetary crises.”

White & Case associate Raphael Papon sounded a positive note on where we are today. “There is significant activity in the field, a lot of interest coming from governments, from banks, and from miners themselves. Overall, [I see] a very promising outlook.”

White & Case partner Jared Muller, who has worked on such remote mining projects, provides important context on balancing energy transition ambition with commercial reality, “The industry is serious about decarbonising by 2050, but it won’t do so at any price. Leveraging government grants, incentives, concessional loans and other forms of innovative financings can be key to the success of a reliable green energy solution for any particular mining project.”

A [paper](#) published after an EnergyandMines conference earlier this year in Perth, said that decarbonisation requires significant investments (capex) in new technologies like electric vehicles and renewable energy sources. While these projects can reduce operating costs in the long run, the upfront costs create risk, especially in a high-interest rate environment.

Banks keen to bolster green credentials

As a potential solution to these costs, banks, amongst other parties, have jumped on the bandwagon. HSBC earlier this year set a 2050 thermal coal-mining specific target of 70% reduction of absolute financed emissions. The bank intends to support energy transitions elsewhere in the sector through strategies such as carbon capture and storage technologies, boosting alternative beneficiation and extraction, and encouraging the mining of transition metals.

In France, Caisse des Dépôts in October this year [announced](#) the launch of a €1 billion sustainable bond that will support UN climate goals in such areas as decarbonising industry. Caisse’s [framework document](#) on green investing indicates strong interest in supporting transition of energy supply and heating mechanisms.



Jared Muller

“The industry is serious about decarbonising by 2050, but it won’t do so at any price. Leveraging government grants, incentives, concessional loans and other forms of innovative financings can be key to the success of a reliable green energy solution for any particular mining project.”

Mining companies are themselves, of course, keen to explore and invest in technologies that will render remote mines more environmentally sound than they are today. The following sections discuss how mining companies are adopting alternative energy sources – such as solar, wind, and hybrid systems – to reduce their environmental footprint and drive innovation in remote operations.

Ivanhoe Mines in May 2021 [announced](#) a commitment to work with its joint-venture partners and underground mining-equipment manufacturers to ensure that Kamoa-Kakula mine in the Democratic Republic of Congo (DRC) became the first net-zero operational carbon emitter among top-tier copper producers.

Rio Tinto [signed](#) two new solar and battery hybrid services agreements this year with Edify Energy to increase the supply of reliable, competitively priced electricity to Rio Tinto’s Gladstone aluminium refinery in Queensland, Australia. Under the

agreements, Rio Tinto will purchase 90% of the power and battery storage capacity generated by the Smoky Creek & Guthrie’s Gap Solar Power Stations for 20 years. Edify Energy will build, own, and operate the projects, with construction due to begin in late 2025, targeting completion in 2028.

Solar

One of the benefits of solar power is its movability, as the technical equipment is conveniently mobile and reusable once a project is completed. This year, African renewables developer CrossBoundary Energy signed a 17-year power purchase agreement (PPA) with Kamoa Copper to provide baseload renewable energy to the Kamoa-Kakula Copper mining complex, per [IJGlobal](#).

The Kamoa-Kakula site, in often-sunny DRC, operates as a joint venture between Ivanhoe Mines (39.6%), Zijin Mining Group (39.6%), Crystal River Global Limited (0.8%) and the Government of the DRC (20%). Ivanhoe [notes](#) that Skarn Associates estimates they have among the lowest GHG emissions intensities per tonne of metal produced globally, and the lowest of any major copper mine.

Kamoa-Kakula relies on a combination of hydropower and solar energy. Franck Alloghe, business development director at CrossBoundary, informed [IJGlobal](#), “this [PPA] agreement represents a change in energy supply for mining operations, indicating that diesel or heavy fuel-oil generators are no longer the only viable option for guaranteed baseload power generation.”

Further in Africa, ZCCM Investments Holdings (ZCCM-IH) is set to purchase a 35% stake in Maamba Solar Energy (MSEL), a wholly owned subsidiary of Zambian independent power producer Maamba Energy (MEL), [IJGlobal reported](#) in October. The remaining 65% will be held by Nava Global PTE, previously Nava Bharat Singapore, and invested in the 100MWAC solar PV power project. Amongst other outcomes, ZCCM-IH anticipates that the stake purchase will provide long-term, sustainable, and clean power supply to mitigate load-shedding challenges.

In particular in South Africa, Ivanhoe’s planned [Platreef platinum group metal/nickel mine](#) has its own 5-MW solar power facility, completed in Q1. Phase 1 production is due to commence in Q4,

followed by the Phase 2 expansion 2 years later in Q4 2027. Enpower Trading will also wheel 48.3GWh/yr from SolarAfrica's SunCentral power plant in De Aar, Northern Cape, to the mine in Limpopo as part of [a deal](#) signed earlier this year.

Solar has advantages but there are downsides. As Papon noted, "land can be scarce in some jurisdictions. [For] some developers of really large solar farms there are issues around permitting. For example, the impact on flora and fauna."

Wind

Wind has also been harnessed as a frequent power source for remote mines, especially in Africa. As Julien Bocobza has noted, wind "is more specific to certain jurisdictions such as Egypt, Morocco, Kenya, and South Africa."

Comparatively, Australia offers prospective territory for the deployment of wind power, as employed in the Agnew gold mine in Leinster, Western Australia. The [site](#) will rely on a hybrid microgrid, consisting of an 18 MW wind farm with five wind turbines, a 10,710-panel, a 4 MW solar farm, a 13 MW / 4 MWh Battery Energy Storage System (BESS) that underpins the security and reliability of the microgrid, and an 18 MW gas and diesel engine power station as back-up, all managed by an advanced control system.

Also in Australia, BHP in September this year inked a 100-MW baseload supply deal with Neoen of France to help power BHP's Olympic Dam, Carrapateena and Prominent Hill mines. The power will come from Neoen's Goyder South Stage 1 Wind Farm and Blyth BESS, IJGlobal [reported](#) in September.

And in Morocco, the Office National de l'Électricité et de l'Eau Potable [signed an agreement](#) with the Al Baidaa Desalination consortium for the flagship Casablanca Desalination Project public private partnership (PPP) in May 2025. The desalination process will use reverse osmosis technology entirely powered by the It Bir Anzarane wind farm. It is the first in a national pipeline of desalination PPPs aimed at strengthening Morocco's water security and climate resilience through sustainable, large-scale infrastructure. "This landmark financing represents a defining step for infrastructure development in the region, and we were proud to play a lead



Julien Bocobza

"This landmark financing represents a defining step for infrastructure development in the region, and we were proud to play a lead role in structuring this complex transaction."

role in structuring this complex transaction. Delivered through a PPP and powered by renewable energy, it demonstrates how innovative financing models can deliver meaningful, sustainable and long-term benefits for millions of people. Contributing to a project of this significance underscores our commitment to transformative infrastructure projects," Bocobza said.

While wind and solar generated power offer significant benefits, they are intermittent energy sources requiring "firming" capacity when the wind isn't blowing or the sun

isn't shining. As a result, many mining companies adopt hybrid systems to deliver reliable energy for their operations. Various options - such as hydro, batteries or gas-fired generation - can be used individually or in combination to strengthen firming capacity at remote locations.

As Muller put it, "reliable electricity supply from intermittent green energy sources depends on adequate firming capacity."

Hydropower

The Republic of Guinea a year ago [secured funding](#) for the Amaria hydropower project with support from China's TBEA. The government of Guinea noted that the project will support industry and improve living conditions for the local population. It has also linked Amaria to its [Simandou 2040](#) program, which aims to align mining sector goals with state sustainable development goals.

Earlier this year, the [World Bank](#) provided an update on the DRC's Inga hydropower site on the Congo River between Kinshasa and the Atlantic Ocean, which it committed \$250m to, after pulling its support for the project in 2016. The power from Inga "is expected to benefit approximately 100 communities (1.2 million people) through improved access to clean water, electricity, and roads. Approximately 10,000 people are also expected to benefit from skills and higher education training."

Likewise in Rwanda, the [Ruzizi III Regional Hydroelectric Project](#) is one of the largest infrastructure projects in the region comprising Burundi, DRC, and Rwanda. It is the first privately financed project in sub-Saharan Africa that will utilize a common regional water resource to generate power that will be shared between the three countries.

While neither Inga nor Ruzizi is specifically geared toward supporting mining, the three nations all house mining projects that will likely benefit from the improved energy security in the region. The DRC, for instance is home to the Kamoakakula facility referenced above and a trove of other mining projects.

Gas

While referring to gas as a decarbonisation option may seem counter-intuitive the element can play a key role in the energy transition. Natural gas produces significantly less carbon dioxide per unit of energy



In partnership with

WHITE & CASE



EDMOND
DE ROTHSCHILD



North Africa boasts some of the highest solar irradiation levels globally, making it an ideal location for solar-powered hydrogen production

generated compared to coal and oil. Also, natural gas infrastructure can be adapted for future decarbonisation technologies, such as carbon capture and storage via the capture of emissions from the plants for storage underground.

In January this year, the [African Energy Chamber](#) said that Senegal and Mauritania started operations at the Greater Tortue Ahmeyim (GTA) development 10 kilometres offshore from Mauritania. Project developers BP and Kosmos Energy, alongside Senegal's national oil company Petrosen and Mauritania's NOC *Société Mauritanienne des Hydrocarbures* (SMH), have officially opened the first well of the GTA project, signalling the start of technical operations and a new era of gas-driven development and energy security in West Africa.

In a paper on the use of natural gas in Africa, the Atlantic Council [stated](#) such efforts are essential in a continent in which 42% of the people have no access to reliable electricity supply. And there needs to be openness to all options. Each country's energy transition must be feasible within the context of its economy, geography, and natural resources. Rather than offer "unhelpful generalisations," the international community must "embrace and support nuance and country-specific analysis," as Youba Sokona, author and vice chair of the Intergovernmental Panel on Climate Change, said in 2022.

The [US Department of Energy](#) (DOE), amongst other entities, has indicated that reforming low-cost natural gas can provide hydrogen today for fuel cell electric vehicles (FCEVs), as well as other applications. Over the long term, the DOE expects that

hydrogen production from natural gas will be augmented with production from renewables, nuclear, coal (with carbon capture and storage), and other low-carbon, domestic energy resources.

In another [paper](#) the African Energy Chamber noted that "North Africa already has the requisite abundant natural resources and developing infrastructure to support a massive expansion in green hydrogen production. The region boasts some of the highest solar irradiation levels globally, making it an ideal location for solar-powered hydrogen production. Countries like Morocco and Egypt have already initiated projects like the Noor Ouarzazate Solar Thermal Complex and the Benban Solar Complex, respectively, which could serve as the backbone for the industry."

Electrification

Electrification also plays a major role in the route to decarbonisation as it applies to many aspects of the operating environment. For instance, electric vehicles produce fewer emissions, particularly when renewably charged. Electric heat pumps can replace gas boilers for heating and electrically powered industrial processes are cleaner than those relying on coal or gas.

Other examples include the Western Australian Government's recent announcement supporting the development of priority electricity transmission corridors in the Pilbara, proposed to link prospective renewable energy hubs to the major load centres in the region. One of the advanced transmission corridors, includes the proposed construction of approximately 550 kilometres of 330-kilovolt transmission lines,

and associated infrastructure, to connect the proposed renewable energy hub to existing iron ore mines in the Pilbara region to help facilitate decarbonisation of the sector.

In Angola, Trafigura and engineering company ProMarks signed a memorandum of understanding ([MOU](#)) with the Angolan government last year to develop a PPP model for a major regional power transmission and supply project. The project involves building and operating a 2-GW high-voltage electricity to take surplus green electricity produced by hydroelectric dams in the north of Angola to the Democratic Republic of the Congo's Copperbelt and Zambia, integrating with the Southern African Power Pool.

Nuclear

Finally, there are isolated moves afoot to consider nuclear power, notably small modular reactors (SMRs), as sources of energy to remote mines. The Asian Development Bank has been [reviewing](#) a longstanding policy of not financing any nuclear-based projects. This follows on from the World Bank that recently ended its own ban on nuclear energy financing.

Muller noted that "nuclear could play a key role in achieving net zero commitments by 2050 – it offers firm capacity and is able to generate low carbon electricity – and the policy settings in a number of jurisdictions are changing with nuclear playing a substantial role in the energy mix". Noting, however "it does have its challenges, including concerns over waste disposal, security, public safety and cost - historically nuclear projects have encountered substantial cost overruns and schedule delays."



The World Bank that recently ended its own ban on nuclear energy financing

The International Atomic Energy Agency (IAEA) earlier this year issued a [report](#) urging exploration of the technology to power Africa. The IAEA noted in its report that “SMRs are generally designed to be more flexible and could serve remote areas with no grid infrastructure or serve mining operations while also providing process heat or cooling, in addition to power generation.”

The World Bank and the IAEA in June this year [agreed](#) to work together to “support the safe, secure and responsible use of nuclear energy in developing countries.” One strategic priority the two entities identified is accelerating “the development of small modular reactors, which offer flexible deployment, lower upfront costs, and potential for wide adoption in developing economies.”

Russia, with its mining-sector heavy industry, has been testing out nuclear applications for local mines. The World Nuclear Association in a [study](#) published in May 2025 noted that beneficiaries of Russia’s steps at introducing nuclear power to industrial processes include Rosatom. The mining major is planning four optimised floating power units hosting at Cape Nagloynyn to supply 440 MWe to the

Baimskaya copper mining project south of Bilibino and Pevek.

Nuclear is obviously far from risk-free. As recently as this year, the [World Nuclear Association](#) noted “strong awareness of the potential hazard of both nuclear criticality and release of radioactive materials from generating electricity with nuclear power.” And in a [more recent paper](#) the same group noted that small modular reactors (SMRs) “offer additional flexibility in operation and wider deployment opportunities, allowing for nuclear to be used in more locations and for a greater range of applications.”

Some key risks for remote power solutions for the mining sector

Cleaner greener power-supply efforts are not necessarily risk-free. Early in 2024, Sandfire Resources decommissioned their DeGrussa copper-gold mine, 900 km north of Perth, Australia. The site, powered by a solar hybrid power system, had been operational for seven years before being depleted. Power provider Neoen has indicated it is looking into ways of repurposing DeGrussa’s 34,080 solar panels as well as inverters, transformers and battery pack.

Operator Neoen told [Energy Source & Distribution](#) early in 2024 the group was hoping to find further use for DeGrussa’s solar panels and items such as inverters, transformers and battery pack.

As Muller pointed out this speaks directly to one of the key considerations for renewable energy developers working with miners. “For developers that provide energy solutions for remote mining projects, the stranded asset risk is a key risk requiring careful consideration.”

He added, “Unlike traditional, fixed power generation plant and infrastructure, renewable and hybrid energy assets can be modular and redeployable. That flexibility allows equipment to be reused across multiple sites as mines close, change ownership or adjust production profiles, thus mitigating the stranded asset risk.”

There are other concerns being raised, with cost being at the top of the list. While extolling the availability and capacity of solar power in Africa, it is important to note consumers and governments alike must deal with the financial constraints that can jeopardize solar project profitability. Barriers include upfront capital requirements, grid integration challenges, and weak incentives for private investment as the [World Economic Forum](#) noted in May 2025. However, WEF suggested that “renewables offer a way forward, though the journey will be challenging. Africa possesses abundant solar, wind, hydro and geothermal resources, but they remain largely untapped.”

In a paper about the positive elements of green mining practices (GMPs), Swiss think tank Frontiers in a [December 2024 paper](#) concluded that “those mining companies that actively pursue green practices enhance environmental performance while making reasonably significant contributions to broader sustainability objectives.”

Summing up the bigger picture for cleaning up remote mining, Bocobza was upbeat, “the transition is not going to be done overnight but it is happening.”

Overall, there seems to be substantial global momentum where stakeholders across regions and industries are collectively advancing toward decarbonisation. With this widespread alignment, the transition to lower-carbon solutions in remote mines appears not only inevitable but also poised to accelerate as market forces and policy objectives converge ■