

Sustainable solutions

With hybrid renewable systems now embedded at remote mine sites, what is next for the mine power sector? Dan Gleeson finds out

It is no longer acceptable to find any available energy solution to get new remote mines up and running; that solution needs to be cost effective, sustainable and 'green'.

Any mine or exploration site using diesel-powered generators is actively looking for a more environmentally friendly alternative, while the major miners are investing significant amounts in renewable projects to move their sites off fossil fuel-backed energy sources to more sustainable inputs.

These energy sourcing requirements are affecting mines both big and small, as Malavika Jain Bambawale, Managing Director, Sustainability Solutions (APAC) at **ENGIE Impact**, the consulting arm of electric utility company ENGIE, made clear.

"There is an increasing interest and sense of urgency for sustainability within the mining industry, driven by investor activism, as seen with recent announcements made by Australia and New Zealand Banking Group and Tesla," Bambawale told *IM*. "Miners need to go beyond low-hanging fruits to answer to the above-mentioned pressures, in addition to looking into their energy mix to avoid limited decarbonisation."

Just some of the solutions they are examining include renewable generation mixed with battery systems and a smaller diesel-powered element, partially displacing diesel use with LNG, fully renewable power projects and – more recently – the use of 'green' hydrogen.

Net zero

Many of these solutions are factored into an increasing number of mining company mission statements to get to 'net zero' by a certain date in the future.

Miners are going down different avenues to achieve these executive-led sustainability targets,

according to Bambawale.

"There are many ways to achieve a decarbonised end goal and the roadmap an organisation chooses to get there can have a major impact on factors such as cost, risk and feasibility," she said.

ENGIE Impact's understanding of decarbonisation technologies, combined with internally developed software modelling tools, has been leveraged by miners such as Vale New Caledonia to find the optimal pathway. The company sets out advanced roadmaps to hit goals and creates a "tangible action plan" to ensure a phased implementation occurs.

Some common topics coming up during ENGIE Impact's interactions with miners include 'green' electricity supply and decarbonising vehicle fleets. Depending on the type of operation, process-related emissions (due to chemical reactions) might also be a consideration.

The latter consideration is typically the most difficult to deal with as it may require a process rethink, according to Bambawale.

"So, for this category of emissions, we see an interest to deploy offsets in the short or mid-term, while the decarbonisation efforts are focused on the electricity and fuel supply," she explained. "However, to address the process-related emissions in the long term, there is a need for a holistic rethinking and co-development of solutions to better match energy consumption with renewable energy production."

For all the ESG benefits that come with employing these solutions, miners and their shareholders still want a significant return on investment from these projects.

"The main thing to consider for any solution is that competitiveness is key within the mining sector," Bambawale said. "The costs need to be recouped either through savings or through increased market differentiation and pricing for

There are more than 20,000 solar panels producing 8 MW of power at Gold Fields' Granny Smith mine (photo: Aggreko)

'green' minerals.

"However, some miners are also keen to be early adopters of new technologies with a greater risk appetite to testbed new, yet-to-be-proven technologies."

Obvious examples here are Anglo American with its 291 t FCEV haul truck project at the Mogalakwena PGM mine in South Africa, which will use 'green' hydrogen as a fuel source; Nouveau Monde Graphite's all-electric open-pit mine plan at Matawinie, in Quebec, Canada; and what was initially Goldcorp's (now Newmont) all-electric underground gold mine concept at Borden, in Ontario, Canada.

Rise of the hybrids

There have been enough hybrid power applications coming online in the mining space to prove the concept.

Tarik Sfindla, Market Development Manager, Africa, **Wärtsilä Energy**, says a hybrid setup is the most effective way to deliver reliable clean power to remote off-grid mining operations in Africa, and Wartsila has several case studies on the continent to back his opinion up.

In Mali, it is helping deliver a hybrid power solution combining solar, battery and thermal generation technologies for Resolute Mining's Syama gold mine. As part of an agreement with Aggreko – a company also working on this project – it will deliver four Wärtsilä Modular Block enclosures, with one medium-speed Wärtsilä 32 engine in each, to provide 40 MW of energy to Syama.

It is also in the process of designing and

engineering a 17 MW/15 MWh energy storage system based on the company's GEMS hybrid energy management solution for B2Gold's Fekola mine in Mali. This system will control a new 30 MW solar plant to be integrated with a heavy fuel oil component.

Wartsila also previously delivered a 15 MWp solar photovoltaic (PV) power plant to the independent power producer Essakane Solar SAS, which supplies the Essakane gold mine, in Burkina Faso (majority owned by IAMGOLD). The solar PV plant was constructed next to a 55 MW power plant running on heavy fuel oil, with the engine power plant providing backup, while the solar farm produces energy during the day.

Aggreko also has a solid track record when it comes to integrating renewables within a hybrid power plant solution at mine sites.

It recently completed a project at the Granny Smith gold mine in Western Australia, which includes one of the world's largest renewable energy microgrids. The new hybrid power system, which has been integrated with Aggreko's existing gas-fired power station, is powered by more than 20,000 solar panels producing 8 MW of power and supported by a 2 MW/1 MWh battery system.

Once fully operational, it will reduce the mine's fuel consumption by 10-13% – the equivalent of removing 2,000 cars from the road, according to Aggreko.

George Whyte, Managing Director, Australia Pacific and Global Mining Sector Leader at Aggreko, said the Granny Smith solution was "very representative" of the type of renewable integration possible in mining, referencing the even greater 20 MW of solar PV units installed alongside the hybrid microgrid at Syama.

He expanded on this for **IM**: "When designing these solutions, our experts do of course need to take a look at the requirements and conditions at the particular site, with the location and solar irradiation at the site also playing a big role.

"However, on the whole, hybrid solutions are becoming an increasingly popular option for customers, offering both a cost reduction as well as a huge saving in emissions. The microgrid installed at Granny Smith will save approximately 9,500 t CO₂e across the project's lifetime."

One of the biggest hybrid projects currently under construction within mining is taking place in Western Australia.

Fortescue Metals Group's Pilbara Generation project will see 150 MW of gas-fired generation integrated with 150 MW of solar PV generation and large-scale battery storage to power the company's iron ore assets in the state. The hybrid energy system will be connected to a new transmission network Fortescue is building in the Pilbara, ensuring the right amount of electricity is supplied in a reliable, efficient and environmentally friendly manner.

Part of the gas-fired generation segment of the equation is being filled by **Rolls-Royce** and its agent Penske Australia, which is providing 15 medium



speed gas gensets using 20-cylinder B36.45 gas engines from Rolls-Royce's Bergen Engines brand. This will help power FMG's Iron Bridge magnetite project specifically, with Pacific Energy subsidiary, Contract Power Australia, installing the gensets.

juwi AG, which provides not only the microgrids but the full renewable energy installation on projects, also has much input to offer in this field. Its fingerprints are on both the 23 MW solar PV/gas/diesel power station at Gold Field's Agnew gold mine, in Western Australia, and the 10.6 MW solar hybrid system at Sandfire Resources DeGrussa copper mine, also in Western Australia.

The Agnew installation is part of a wider 56 MW project comprising four key components controlled by an advanced microgrid system. This includes five 110 m wind turbines, each with a rotor diameter of 140 m, delivering 18 MW; a 10,710-panel solar farm generating 4 MW; a 13 MW/4 MWh battery system; and an off-grid 23 MW gas/diesel engine power plant.

The DeGrussa installation, meanwhile, used 34,080 solar PV panels and required electrical infrastructure to be installed, including inverters, transformers and other electrical accessories and control systems.

Amiram Roth-Deblon, Head of Global Business Initiatives at the company, said its next mining project is likely to be in Africa, with several developments being finalised to move into construction in 2021.

"Our juwi Hybrid IQ micro-grid control system is going to be deployed once more to deliver best in class reliability and the lowest cash operating costs," Roth-Deblon said.

Charging up

The markets for hybrids have continued to grow in the face of COVID-19, with many participants expecting the pace of acceleration to keep increasing.

Whyte said: "More and more miners and project owners are realising the ability of hybrids to reduce emissions and costs whilst maintaining a reliable power supply for their project's operations, as well as meeting a range of local requirements on emissions and energy production in different markets."

juwi Renewable Energy, the Australia subsidiary of juwi, delivered a 4 MW Single Axis Tracking PV installation together with cloud forecasting and an advanced micro-grid control system to enable integration with the mine off-grid network at Agnew (photo: juwi)

"We expect to see an acceleration of current trends of renewable integration in the next 3-5 years and beyond as technology develops and demand increases at a rapid pace."

Miners are increasingly coming to Aggreko earlier in the process to investigate the possibility of integrating renewables into their mine plans, he said. Aggreko can employ several technological applications when performing feasibility studies, such as software-aided modelling and intelligent design features, to aid the process.

"These allow us to map the specific needs, limitations and unique considerations of each site in order to provide the most cost-effective, low emissions solution, whilst maintaining the required stability in energy generation," he said.

The hybrid take-up in mining has also been affected by changes in technology.

Aggreko has recently launched Aggreko Solar Power, a 1 MW modular solution managed by intelligent software able to integrate with battery storage products and thermal generators, which, the company says, further allows customers to incorporate renewable power into their processes with greater ease.

Roth-Deblon says there have been some fundamental changes in the power generation capabilities of renewable solutions, too.

"Costs of wind and solar have fallen further and the commercial benefits for mines have become even more attractive," he said. "We are progressing towards higher contribution from wind and solar with each project that we design and build, and our experts continue to push the limits towards 100% renewable energy."

This landmark milestone looks like being achieved in South America with grid-based projects through a combination of solar, wind and other renewable

IM reported on the latest developments with **247 Solar's** modular, scalable concentrated solar power technology in this same issue last year.

Using heliostats as opposed to PV cells and not requiring battery back-up for power storage, the technology could soon make a debut in California, USA; a development the off-grid mining industry is watching intently.

The company recently reported that it, along with microturbine supplier Capstone Turbine Corporation, had successfully tested a revolutionary commercial turbine that can generate electricity using hot air at atmospheric pressure without combustion.

This significant breakthrough is made possible by an ultra-high temperature heat exchanger with technology that has its origins at the Massachusetts Institute of Technology (MIT). The 247Solar Heat Exchanger™ uses a proprietary nickel-chromium-aluminium-iron alloy engineered for sustained operation at very high temperatures, 247 Solar said.

This turbine is the heart of the first operational 247Solar Plant™ being built in California. The plant includes a system that concentrates sunlight to heat ambient-pressure air to 970°C, a high-enough temperature to drive the turbine to produce electricity without burning fuel.

The plant also includes the 247Solar Thermal Storage System™, which stores sunlight as heat instead of electricity at a fraction of the cost of batteries, according to the company. The stored heat powers the turbine up to 20 hours at night and on cloudy days, reducing fuel consumption by up to 90% – far more than PV and batteries, 247 Solar says.

To guarantee electricity 24/7, even when there is no solar-heated air available, the turbine includes an optional combustor. The combustor is external to the turbine and can be engineered to burn most liquid and gaseous fuels, including hydrogen and biogas.

energy inputs, yet hitting that benchmark off-the-grid is a different proposition altogether.

Reaching this target might not be that far away with the progress being made with solar power technology, according to Roth-Deblon.

“When we built the DeGrussa hybrid system in 2016, the solar modules had 310 Wp capacity,” he said. “We are now deploying 450 Wp modules and it does not stop there. Our experts already design systems that will have modules that deliver more than 500 watts each.”

He added: “Hybrids for mines have moved from bolt-on solutions for existing electricity generation to become integrated energy solutions. Future systems will not only provide power to stationary equipment but include electric fleets, variable mining and further optimised mine designs.”

Energyising for electrification

The electrification of the wider mining sector – especially the mobile fleet – is acting as a major enabler for accelerating decarbonisation strategies, according to ENGIE Impact's Bambawale.

“Once the machines are electrified, either through battery-electric, permanently grid-connected, or green hydrogen, it becomes a lot easier to transition toward zero carbon over time, as the cost of renewables keeps decreasing and the direct and external cost of fossil fuels goes up,” she said.

But what should come first: electrification of the fleet or decarbonisation of the grid?

“The commercial availability of electrified equipment by established OEMs is a major enabler to implement decarbonisation strategies,” Bambawale said. “It creates a whole set of realistic options, which we assess in our decarbonisation roadmaps.”

But these equipment solutions need to be mine-

ready otherwise they will affect productivity, whereas Bambawale says the switch to decarbonised energy inputs at site would be a lot smoother.

“Even if the electric grid is fuelled partly by fossil fuels, it is a lot easier to decarbonise the electricity supply without continuously having to interrupt the mining process itself, once it is already electrified,” she said.

Siemens knows a thing or two about this.

Its mining-specific power solutions have recently benefitted from a strategic technology partnership with juwi to focus on microgrids for the mining industry.

It has also looked to leverage its power solutions



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expertise within the expanding mine electrification space.

Siemens Australia, in November, announced it had teamed up with Murray Engineering to develop a ground-breaking high-powered electric vehicle charging station for use at mines both below and above ground.

The vehicle-agnostic charging stations will first be used to power a new light electric vehicle being designed and manufactured by Murray Engineering. It will provide a fully-enclosed solution specifically designed to handle the toughest underground mining conditions in Australia, according to the companies.

Siemens will provide its Sicharge UC high power DC chargers, which boast a flexible output range from 125-600 kW with five frontends on each station as well as pantograph charging. One of Siemens' Sicharge UC200 chargers, which can deliver 200 kW of power, is already on site at Murray Engineering headquarters in Pinjarra, Western Australia.

The flexible, high power range of Siemens' Sicharge UC portfolio enables the charging stations to scale to light, medium and heavy vehicles, it said.

Aggreko's Whyte says smart power management is key in this type of electrified mining environment to ensure a mine's electricity supply is more efficient, resilient and environmentally friendly than ever.

This is where software tied to microgrids able to react automatically within milliseconds to meet changes in generation demand is vital, allowing operations to switch to a back-up power source should an interruption occur with an energy input.

“Another increasingly important element for mines is battery storage systems,” he said. “A battery can provide peak power for large demand spikes like shovel walks in milliseconds – without the need to bring additional generation online. A battery can also buffer intermittencies in renewable generation, effectively becoming a ‘Swiss army knife’, providing practical solutions to a broad range of issues.”

Ready for hydrogen?

The introduction of hydrogen into the sector may change the dynamic somewhat.

Many government-backed industry collaborations are going on across the globe to create ‘green hydrogen’ blueprints that could then be translated for the mining industry.

As has been well documented, ENGIE is helping Anglo American on its hydrogen haul truck project at Mogalakwena, which could see first movement next year in a display the industry is watching with interest.

Anglo has also mooted that hydrogen could play a bigger role in its power mix across its operations.

On the topic of hydrogen developments, Bambawale drew on her experience of the solar market to outline the fuel's expected trajectory in the mining sector.

“Hydrogen is at the dawn of its era, maybe similar to solar PV in the early 90s,” she said. “This means

their sustainability goals.” 

TUGLIQ has been pushing forward on its Arctic re-motorisation project, despite COVID-19 delays. The company is in the process of converting diesel utility vehicles to “fully-electrified” versions, as well as developing the necessary charging infrastructure for Arctic conditions.

TUGLIQ’s President and Chief Executive Officer, Laurent Abbatiello, said the company hopes to make headway on the project in early 2021.

“We lost three to four months of work because of COVID-19,” he told *IM*. “We had to stop the electrification project, but it’s now back on.”

This is a timely resumption considering the challenges TUGLIQ faces in deploying such a solution at a remote Arctic mine.

“It is essential for us to test the equipment during winter,” he said. “The R&D involved in the project is primarily about preparing an electric truck for the Great North.”

Studies using conventional battery-powered solutions in Arctic conditions have shown batteries lose power when extreme cold creeps in, but the technology TUGLIQ and its partners are developing overcomes this issue, according to Abbatiello.

Still, the company faces a small window of opportunity to not only deliver the battery retrofit solution to the intended site, but also calibrate it for winter operation.

“The sea road to the mine is closed between February and June, so it is crucial that the equipment can get to site and be available for testing during the winter months,” Abbatiello said.

Looking to another season, TUGLIQ is working on upping the renewable energy contribution at one of its flagship installations.

TUGLIQ already operates 6 MW of wind power capacity at Raglan Mine in Nunavik, Canada. Clean electricity from wind energy allows the mine to displace more than 4 million litres of diesel every year, but TUGLIQ is looking to increase this further still: this time with solar technologies.



A Saft Energy Storage System installed at the Raglan Mine is helping the integration of Tugliq’s 6 MW wind farm into the mine’s diesel grid, displacing more than 4 million litres of diesel per year

“In the summer, there are 23 daily hours of sun in this region, so it makes sense to utilise it,” Abbatiello said. “We now have a solar farm being constructed at Raglan Mine to increase the share of renewable energy being generated at the mine.”

The project, supported by the Quebec government, will demonstrate the concept for replication at future sites, including local communities, according to Abbatiello.

He concluded: “Raglan is always looking at its renewable share of energy. It has an aim to constantly improve the credentials of the mine.”

that it is currently a solution that can make sense in some situations, but not necessarily across all types of mining.

“However, while this technology is in an early phase, we should not underestimate the massive cost reductions that will happen for hydrogen applications once the solutions scale up.”

Wärtsilä is already investing in hydrogen, having developed a combustion process in its gas engines to enable them to burn 100% hydrogen fuel. This followed more than 20 years of research on the fuel and testing its engines with blends of up to 60% hydrogen and 40% natural gas.

Fortescue is also backing hydrogen, with numerous projects including the conversion of a fleet of hydrogen coaches at its Western Australia site.

ABB and Hydrogen Optimized have also signed a Memorandum of Understanding to explore the development of large-scale green hydrogen

production systems connected to the electrical grid to offer a clean, sustainable and affordable energy source for industries such as mining.

There is clearly momentum behind this energy source and, while White says Aggreko is not expecting broad commercial implementation of hydrogen power solutions in the mine power space in the next five years, he did say the fuel plays an important role in the company’s future decarbonisation strategy: “particularly green hydrogen, where electrolysis is powered by renewable energy”.

He added: “We are currently investing in pilot projects to understand its potential and limitations as a fuel for our customers. We are also exploring how we can integrate green hydrogen into our fleet, and how we can combine it with renewables and battery storage to build efficient and resilient hybrid systems, which simultaneously help our customers to achieve