

POWER FOR MINES



Lonely power

Access to reliable and cost-effective forms of energy is a strategic priority for the global industry. John Chadwick examines both traditional and renewable energy solutions

Mining has traditionally relied on conventional fossil-based fuel sources — diesel, oil, coal and natural gas — to meet its growing energy demand. The industry is expanding into new and often remote locations as a response to increasing demand from growing emerging markets. This often means having to deal with unreliable power supply from the grid and uncertain power prices. In most instances, grid-connected electricity needs to be supplemented with on-site generation, typically large-scale diesel generation, resulting in a dependency on diesel fuel. The more remote the mine, the more likely off-grid power solutions are required (*From EY's Mining: the growing role of renewable energy*).

“Many of the world's largest mining companies are evaluating greater use of renewable energy plants — a trend set to intensify rapidly — as part of a broader strategy to lock in long-term fixed electricity prices and availability while minimising exposure to regulatory changes, market pricing and external fuels.”

“In a highly volatile market”, says Majid Zahid, Group President-Energy at Zahid Group, the parent company of Altaaqa Global, a global provider of multi-megawatt temporary power solutions, “it is essential for mining companies to strike a balance between controlling costs and capitalising on growth prospects and profitable opportunities. It is, therefore, imperative for them to ensure the efficient utilisation of their working capital.”

Zahid is of the view that power generation and supply represents an area where mining

operations can make significant adjustments to their capital expenditure. “Electricity,” he says, “remains to be the life-blood of mine sites anywhere in the world. However, with the present economic situation, mine operators cannot afford to devote, rather strap, a large portion of their scarce capital to a major expenditure, like a permanent power plant. Considering this, mine operators can instead choose to hire multi-megawatt temporary power solutions.”

A consistent, dependable and sufficient supply of electricity is vital throughout the life-cycle of a mine operation. “Temporary power plants,” says Zahid, “can adequately provide for the electricity needs of a mine site. They can power camp sites during prefeasibility, feasibility and exploratory stages, and support the establishment of the mine operation after a successful exploration. They can provide power to the machinery and the processing plants, and also to the temperature-control equipment. Obviously, they can also provide the necessary power for expansion.

“Multi-megawatt temporary power plants could not be more relevant to the mining industry than in these times,” says Zahid, and adds that renting power is a logical decision for any miner looking to effectively streamline its operations.

“For instance, in this economic climate, one cannot overstate the importance of precise allocation of funds and of better management of financial resources. A key benefit of renting power is that payment schedules are fixed and regular over a contracted term. This can help

mine operators formulate accurate financial forecasts.”

“Along this line, mining companies should also be mindful of associated costs that come with building or purchasing a permanent power plant. When a mine operator goes for the rental option, all spares and ancillaries will be provided by the temporary power company.

“Mine operators will be happy to know that in hiring power plants, they will no longer need to employ new operators or allocate or re-train existing staff members to manage the plant. Temporary power providers will provide the necessary expert engineering services to ensure the faultless operation of the power station.”

Temporary power plants can also assist in reducing the energy intensity of mine operations. “Hiring power plants will preclude the chances of generators being under-utilised, because the capacity of rental power generation equipment can be increased or decreased with respect to the demand of specific mine processes.”

Zahid says that as conventional power plants are usually specified to meet the peak demand of a particular site, they are left under-utilised when the power requirement decreases. “When a power plant is running at part-load, it consumes fuel less efficiently. This will no longer be the case with rental power plants on board, thanks to their flexibility and scalability.”

Zahid says that renting power during the exploration stage of a mining operation yields myriad advantages. “By hiring temporary power plants, mining companies will have the freedom to start with a small power plant, and then grow as operations expand. When the long-term prospect of a project is still uncertain, it may not make sense to invest in permanent facilities. Renting power, therefore, protects companies from the unsecure future of mining projects at the exploration stage.

“Rental power plants are highly suitable for exploration activities in remote areas, because they are containerised and modular, so they are easily transported and installed. The latest-generation temporary power plants have state-of-the-art switching and transformation systems that give them the ability to connect to any location's grid, regardless of its age, quality or condition. This is possible even without a sub-station, as the same systems allow the power plants to assume the role of a sub-station and connect to available overhead lines or transformers.

“Temporary power plants also have cutting-edge electric power control and protection systems, which allow them to switch operational mode, from grid, to island, to base load or to standby at a push of a button in mere minutes. This is particularly useful for companies whose



With this Siguiri project, Wärtsilä will have over 6,800 MW of installed capacity on the African continent

2017-2020, thanks to mining investments, increased food production and electricity service.

“This is a significant proof of confidence for Wärtsilä in West Africa,” comments Arnaud Guet, Regional Director, West Africa, Wärtsilä Energy Solutions. “Wärtsilä is a trusted partner to AngloGold Ashanti at

to AngloGold Ashanti's gold mine in Siguiri, Guinea. This turnkey project consists of three 20-cylinder Wärtsilä 32TS engines running on heavy fuel oil. They will be connected to the existing power plant at site, also supplied by Wärtsilä. The extension is expected to be operational during the second half of 2018 and the total power output at site will be 30.4 MW.

Siguiri, a multiple open-pit oxide gold mine and the largest gold mine in Guinea, is AngloGold Ashanti's sole operation in the country. AngloGold Ashanti holds an 85% interest in Siguiri with the balance of 15% being held by the Government of Guinea. After two difficult years, the Guinean economy is recovering, with an average projected growth of 5% over the period

Siguiri mine where we operate the power generation enabling them to focus on their mining operation.”

“We selected Wärtsilä for the new power plant at our Geita mine in Tanzania in 2016 and have again selected Wärtsilä for our Siguiri project as we have full trust in Wärtsilä's technology and in their understanding of the criticality of power generation in the operation of such a gold mine,” says Dale Bates, Project Manager, CAR Projects, AngloGold Ashanti.

Nearby, Gold Fields Ghana is switching the source of energy supply for its mining operations in the Western Region of the country from the national grid to privately generated electricity by the end of the third quarter.

The switch over is the outcome of a special arrangement between the company and independent power producer (IPP), Genser Energy Ghana, that will spare some 18 MW of power for the national grid while insulating the company's operations from the erratic power supply.

The company's Vice President and Head of Stakeholder Relations, David Johnson, explained that the new arrangement will result in the generation of 20 MW of electricity each in the Tarkwa and Damang mines within the first two years. Later, the amount of power generated could be raised depending on the growth profiles of the two mines, Johnson explained.

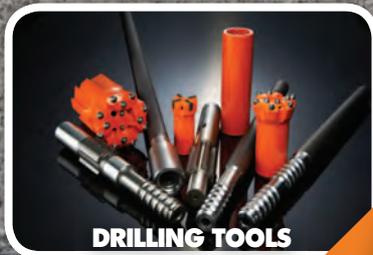
The two mines currently consume a total of 55 MW, with the Tarkwa operations, one of the biggest surface mines in West Africa, consuming 38 MW and Damang 17 MW.

The production of 20 MW each in the two mines, therefore, means that Gold Fields can spare a total of 15 MW of electricity for the national grid, which can then be redistributed among new and existing customers of the national power supplier, the Electricity Company of Ghana (ECG).

Beyond shielding the company's operations from the erratic power supply, Johnson said it would also save cost as the alternative power to the grid was comparatively less costly.

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Turbines sold five CX501-KB7 generator sets to Genser Energy Ghana. Each incorporates a Siemens 501-KB7 gas turbine. The KB7s will run on vapourised propane with fuel supply and treatment also part of the Genser contract with Gold Fields.

Genser's expertise in running turbines on propane opens up a large potential market in Africa for Centrax where pipeline natural gas is not available and liquid fuel is not economically viable. Peter Ward, Centrax's Sales and Marketing Manager commented: "this order further strengthens Centrax's position in West Africa and follows on from the sale of a CX501-KB7 to Cometstar, Nigeria."

ACTOM Turbo Machines demonstrated its ability to provide complete electro-mechanical solutions with the installation of 150 MW turbo generator sets for First Quantum Minerals' Cobre Panama new large open-pit copper mining operation in the Donoso District, Republic of Panama.

Securing what was the first international contract to have been won by ACTOM Turbo Machines can be attributed in part to the longstanding relationship between Marthinusen & Coutts, also an ACTOM division, and the customer, as well as its established track record of successes on previous projects for this mining company. It is also noteworthy that this contract was secured against tough international

competition.

ACTOM was contracted for the mechanical installation of two Skoda Doosan (Czech Republic) 150 MW turbo generator sets, which each comprised of an integrated high pressure and intermediate-pressure turbine, a low pressure turbine, a Siemens generator, a radial condenser, and auxiliaries.

Richard Botton, Marthinusen & Coutts's CEO as well as ACTOM Turbo Machines' Managing Director, Chris Bezuidenhout and eventual Site Manager John Squire, took several trips to Panama to review the scope of work, drawings and site conditions to compile the proposal, which resulted in Marthinusen & Coutts' first international installation.

ACTOM was responsible for the installation of the centreline of the turbo generator sets, which started with the inspection of the civil works, followed by the systematic assembly of the turbo generator's in the form of transportable components and sub-assemblies. As the original equipment manufacturer (OEM) only supplied an Installation Quality Controller, ACTOM Turbo

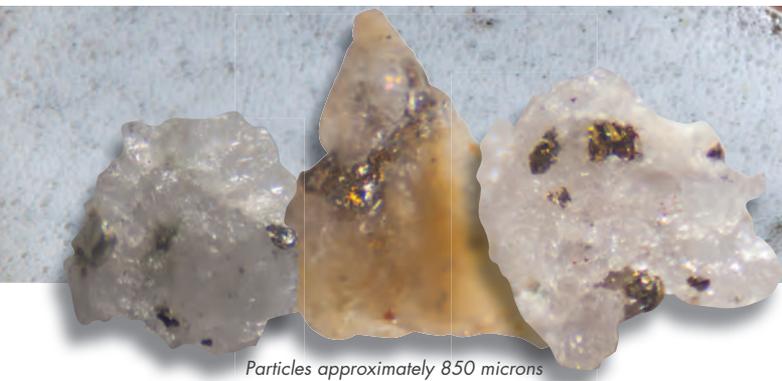


The turbine generator set for Cobre Panama showing the Siemens 150 MW generator and the low pressure and high pressure Skoda Doosan turbine set

Machines installation crew's expertise was pivotal to the successful installation of the turbo generator sets.

The tropical region's high rainfall and open building also placed extreme strain on the schedule. The turbo generators' house was largely open, and only equipped with a 40 t overhead crane, whereas the larger assemblies and components, such as the HP-IP double turbine and the LP turbine components weighed 125 and 161 t, respectively.

Weather permitting, ACTOM made use of crawler cranes to install these larger



Particles approximately 850 microns

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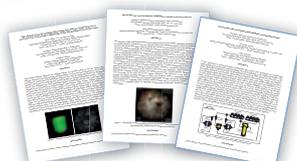


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components. To avoid fouling of the equipment due to the high humidity, ACTOM had to practice extreme caution when handling and preserving components during installation.

The remoteness of the site required ACTOM to carefully plan and supply certain essential equipment, such as highly specialised laser levelling and alignment equipment.

According to Site Manager Squire, projects like these require technical crews with in depth knowledge of rotating equipment, and the ability to perform with high-precision in remote sites. "All challenges were overcome by ensuring that we had the necessary resources available on site and on time, as well as readily having the appropriate people with the correct skill sets."

Clarke Energy, a GE distributor and service partner, will provide 11 of GE's high-efficiency Jenbacher J624 gas engines to Australia's leading energy infrastructure business, APA Group, for its new 45-MW Yamarna power station in Western Australia, which is being constructed to supply power to the Gruyere gold project. Clarke Energy will be the EPC contractor for the gas-fired power station. Gas for power generation will be transported a total of almost 1,500 km using four APA Group interconnected pipelines including its latest greenfield, 198-km Yamarna Gas Pipeline, currently also under construction.

"As an infrastructure owner, our priority is to provide safe, reliable and efficient energy to our customers," said Sam Pearce, Group Executive

Networks and Power, APA Group. "Together with Clarke Energy as the EPC and GE's demonstrated Jenbacher gas engine technology providing the power, we will be able to, once again, deliver a compelling energy solution for our customer using both our interconnected pipeline and power generation capabilities to the remote gold mine."

Gruyere is a 50/50 joint venture between ASX-listed Gold Road Resources and global miner Gold Fields Ltd. It is located in the Yamarna greenstone belt of Western Australia, 200 km northeast of Laverton and to the north of APA Group's Eastern Goldfields Pipeline.

GE's Jenbacher J624 is the world's first two-stage, turbocharged gas engine. GE says it "provides the highest levels of engineering excellence and significant advantages, particularly in the areas of operation in hot environments—such as the Gruyere project location—and in multiple engine power plants for independent power production and combined heat and power applications. It offers customers high efficiency and improved flexibility and can power up to 10,000 Australian households."

"GE's high-efficiency, high-performance and dependable gas engine technology is an excellent fit for APA Group's needs of safety, reliability and efficiency and is well-proven with an installed gas engine fleet of over 700 MW in Australia," said Greg Columbus, Managing Director, Clarke Energy. "We look forward to providing safe, on-time and on-cost project delivery for APA Group and supporting its needs at the Gruyere project well into the future."

GE's Jenbacher J624 gas engines will be built in the company's Jenbach, Austria, facility and were expected to ship during late 2017. Commissioning of both the pipeline and power station is expected to be in late 2018 to align with the Gruyere JV's expectation of first gold scheduled for early 2019.

"GE's Jenbacher J624, high-speed gas engines provide numerous benefits for customers. In

addition to high power density in hot ambient temperatures and best-in-class electrical efficiency of more than 45%, they also include the capability to operate successfully with large transient electrical loads associated with mining processing plants. We are again proud to be supplying our channel partner, Clarke Energy, for this project," said Daniel Angelo Icasiano, Sales Director Asia-Pacific, GE's Distributed Power. "GE's gas engine technology

provides a proven, cost-effective solution for powering the Gruyere mine site power station."

GE/APR commitment

APR Energy, a global leader in fast-track power solutions, and GE renewed their strategic alliance to provide mobile turbine technology into the fast-track power rental market in January 2017.

The strategic alliance grants APR Energy exclusivity around the globe as the rental provider of GE mobile gas turbines under 50 MW. As part of the agreement, APR Energy will acquire new Generation 8, GE TM2500+ mobile turbines in connection with its initiative to upgrade and standardise its fleet. In addition, GE and APR



The Jenbacher J624 gas engine is based on GE's proven Jenbacher Type 6 platform with over 4,300 units sold and delivers higher output and increased efficiency

Energy will collaborate on leads for customers looking for interim or rental power solutions as a bridge to more permanent power solutions.

The acquisition of the new mobile turbines further strengthens APR Energy's position as what it says is "the world's leading provider of mobile gas turbine power", expanding its total fleet capacity to more than 2 GW.

Jeffrey Immelt, Chairman and CEO of GE, said, "We are very pleased to continue our partnership with APR Energy. We have been impressed with their high level of customer service and ability to deliver turnkey power generation projects in remote locations all around the world. With this strategic alliance, customers will benefit from APR Energy's expertise, and can use GE technology as a bridging solution while their permanent GE power plants are under construction."



Inside view of an APR Energy mobile gas power module

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“We are very excited about the mutual benefits our renewed alliance brings, and appreciate the increased collaboration between our two companies,” said John Campion, Chairman of APR Energy. “Our partnership will provide APR Energy access to new leads and opportunities throughout the GE global network, helping to support our business growth and thereby increasing demand for GE equipment. The alliance also provides us with the latest generation of TM2500+ units, giving us the newest fleet in the industry, while benefiting customers with the latest advancements in fuel efficiency and emissions controls.”

Hybrid power

Aggreko has signed a 10-year deal to provide solar-diesel hybrid power to Nevsun in Eritrea. The company will supply 22 MW of diesel and 7.5 MW of solar-generated power for the mine's copper and zinc operations.

Aggreko's CEO, Chris Weston: “Technology never stands still, and neither does Aggreko. Our mobile, modular power enables us to make a massive difference to the communities and industries we serve, and our solar-diesel hybrid offering is an example of an innovation that brings cost-effective, reliable, uninterrupted power with additional fuel flexibility to customers.”

Aggreko's solar-diesel hybrid power package combines cost-effectiveness and green

renewable energy with the reliability of diesel-generated power to provide uninterrupted power round the clock.

The hybrid program was developed at Aggreko's state of the art manufacturing and technology centre in Dumbarton, Scotland, and uses the latest diesel generators, which are considered to be the most efficient in the world. They are monitored using Aggreko Remote Monitoring (ARM) telemetry to ensure optimum operational and fuel efficiencies.

Aggreko notes solar power is now “more affordable than ever, but it can be intermittent and unreliable. Night falls or clouds come in and power is lost. Seasons change and power capacity drops, which means that your business cannot rely on it as a sole energy source. Diesel power is reliable, so you can have electricity round the clock. But for off-grid customers diesel fuel is often a high proportion of operating costs.

“Our solar-diesel hybrid package combines seamlessly both sources of energy thanks to a state-of-the-art energy management system, minimising operating costs without compromising on reliability. This gives you

reliable power, 24/7, with cost savings of up to 20% over diesel only power all packaged into a single contract.”

A power purchase agreement has been signed between IAMGOLD Essakane, EREN Renewable Energy, AREN ENERGY and Essakane Solar to begin the development of a 15 MWp solar power plant for IAMGOLD's Essakane mine in Burkina Faso. The agreement is for an initial period of up to 15 years. The mine is located about 330 km northeast of the Burkinabe capital city, Ouagadougou. Jointly owned by IAMGOLD (90%) and the Government of Burkina Faso (10%), IAMGOLD Essakane, which owns and operates the mine,



Working with miners to develop clean, cost-effective and reliable power sources is not a new concept for Aggreko. It developed an innovative approach to such a problem in partnership with Sibanye Gold at its Beatrix gold mining operation in South Africa. The infrastructure allowed Aggreko to capture naturally occurring methane gas intersected during underground mining operations to create a self-sufficient, free source of fuel that would otherwise have been wasted as flare gas

produces over 400,000 oz/y of gold. Essakane Solar, a local entity created by the project developers, will operate the solar power plant that sells the energy to the Essakane mine.

“Hybrid power systems enable energy intensive industries, such as mines, to reduce fuel consumption, decrease energy costs, protect against fuel price volatility, as well as improve their social and environmental footprint by cutting greenhouse gas emissions and boosting local employment,” commented President and CEO of IAMGOLD Steve Letwin. “This 15 MWp solar project may only be the beginning for our Essakane mine, but IAMGOLD is already well on its way to increase the proportion of renewables to 15% of its total energy needs within three to five years. Switching power generation to renewables has been on IAMGOLD's agenda for several years as evidenced by the 5 MW solar power plant that was installed in 2014 at the company's Rosebel gold mine in Suriname.”

With the transition to processing harder ore, energy consumption at the Essakane mine has increased from about 14 GWh/month in 2013 to 26 GWh/month in 2015. In light of this, IAMGOLD Essakane decided to partner with EREN Renewable Energy (EREN RE), a global renewable energy independent power producer (IPP), and AEMP, a South-African based developer and independent power producer, to push the frontier of innovation in power solutions to mines. Together they are constructing solar capacity to complement the existing 57 MW heavy fuel oil (HFO) power plant. In the project's first phase, 15 MWp of solar capacity would be built and the hybridisation of IAMGOLD Essakane's HFO power plant will allow savings of approximately 6 million litres of fuel and a reduction of 18,500 t/y of CO₂.

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Biohydrometallurgy '18

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EREN says it is “the largest solar farm connected to a thermal-based power plant.” The fixed-tilt 15 MWp solar power plant is comprised of close to 130,000 photovoltaic (PV) panels, deployed over an area of nearly 22 ha.

“The solar power plant project engages our Essakane mine in energy transition, sparks real local sustainable development and is an honour for Burkina Faso. It’s worth noting that this hybrid diesel-solar power plant will be the first of its kind in this country,” declared Bruno Lemelin, CEO of IAMGOLD Essakane at the inauguration.

The IPP solution obviates the mining company from deploying significant upfront capital and adding the power asset to its balance sheet. It is also a way of handing down the development, financing, permitting, construction and operation to an expert, therefore freeing some time to focus on the core business. The power purchase agreement signed between the independent power producer and the off-taker sets an electricity price which is applicable over the long-term – renewable power serves as a solid hedge against fuel price volatility.

Christophe Fleurence, Vice President Business Development – Africa of EREN Renewable Energy: “The project started with a site visit two years ago where we assessed the best terrain for a solar project, meaning relatively flat land and the closest possible to the diesel power plant, and

analysed our client’s load curve and specific needs. From there, we conducted fuel simulation and grid stability studies to come up with an optimal size of the PV plant while ensuring stable and non-disruptive power supply.

“Renewable energy for mining companies can be competitive and reliable today. The business rationale is really simple: maximise the savings for our customers. EREN RE thrives to lead the energy transition of mining companies in Africa, but also globally. The Essakane solar project truly highlights our expertise in actually delivering large scale sustainable and economical energy solutions that are adapted to the needs of the extractive industry.”

Wärtsilä signed its first Asset Management Agreement for a PV power plant in April 2017 and will assume full responsibility for the operation and maintenance of the Essakane solar plant. The solar plant shares a control system with a thermal power plant. Operative co-ordination to maximise the production of the two plants is key in the new agreement.

The seven year agreement includes the daily operation of the solar plant, preventive, scheduled and corrective maintenance, cleaning of the modules and coordination of operations with those of a thermal power plant using the same control system. The new Asset Management Agreement seamlessly

complements the EPC agreement Wärtsilä signed in March 2017 for the solar power plant.

Wärtsilä’s task is to optimise the production of the PV plant and make sure that the thermal plant delivers effective, efficient and stable power with unsurpassed performance. In parallel, the thermal plant, which operates on 11 Wärtsilä 32 engines, retains a sufficient number of engines in stand-by mode to cover potential fluctuations in the PV solar energy production.

Maximising the PV plant’s production means that less heavy fuel oil is needed for the thermal plant, reducing both fuel costs and environmental impacts.

The local operations of the PV plant in Burkina Faso are remotely supported by Wärtsilä Expertise Centres which continuously monitor the plant parameters and alert for potential problem situations that may arise in the day-to-day operation of the facility.

“This agreement is significant to Wärtsilä in many ways. It is our very first operation and maintenance agreement for a solar plant, beginning an entirely new chapter in the story of Wärtsilä. In co-ordinating production of the two power plants, we will be able to combine our strong background in engine-based power production with our solar offering. We look forward to many years of successful cooperation with EREN RE,” says Serge Begue, Vice

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Solar, the rising energy star

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Total has combined its solar offer with its mining expertise to develop a sustainable and reliable energy solution. It says that “besides being environmentally sustainable, solar energy represents several advantages for the mining industry. Often located in remote areas, mining companies can boost their operational reliability with this off-grid energy solution. The highly reliable PV panels can also be used as a back up power supply.

Through its SunPower division, one of the world's leading suppliers of solar panels, Total is also a supplier of the innovative option of a hybrid solar-diesel energy solution, combining sustainability with cost-effectiveness.

With the addition of Tenesol, SunPower has acquired the expertise to design and tailor-make off-grid solutions. With nearly 30 years of experience working in tough geographical areas it can meet energy consumption needs.



SunPower offers standard and back up PV solutions, fully solar and hybrid solutions (solar/diesel). Building on this, SunPower has excellent experience in deploying and maintaining off grid systems in all types of challenging conditions.

Harness the Namibian sun

B2Gold Corp has selected Caterpillar and Cat® dealer Barloworld to supply 7 MW of solar power at the Otjikoto mine in Namibia. The full system, including Cat PV solar modules and the Cat microgrid master controller (MMC), will be used to reduce reliance on a heavy fuel oil (HFO) power plant currently used to power the mining facility.

Barloworld is supplying EPC services for the project. Installation of the system is underway, with the completion of the project expected in early 2018. “At B2Gold, we embrace

Total has combined its solar offering with its mining expertise

environmental stewardship and social responsibility as key corporate priorities in doing business,” said Mark Dawe, Managing Director and Country Manager for B2Gold Namibia. “As one of the largest solar installations in Namibia, the facility at the Otjikoto mine will help us to leverage a plentiful, renewable resource while improving the quality of life for nearby communities.”

Caterpillar’s solar PV system is powered by advanced thin-film solar modules that are setting the industry benchmark with improved performance over conventional silicon solar panels. Fully scalable and pre-engineered for quick and easy installation, the system offers reliable and predictable energy in all climates and applications with modules that are



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Caterpillar's solar PV offering is a key component of the Cat Microgrid technology suite, an innovative lineup of power systems that adds environmentally friendly solar panels, state-of-the-art energy storage, and advanced monitoring and control systems to Caterpillar's traditional line of reliable power generation equipment, including HFO, natural gas and diesel generator sets, switchgear and automatic transfer switches. The Cat Microgrid technology suite is designed to reduce fuel expenses, lower utility bills, decrease emissions, and reduce the total cost of ownership while increasing energy efficiency in even the most challenging environments.

"A key differentiator in Caterpillar's offering is the Cat MMC, which keeps loads continuously energised with high-quality power at the lowest cost. It manages the flow of power from every source in the system, including the main grid when connected. The Cat MMC determines optimum recharge times for the energy storage systems while managing power during times when solar energy is not available."

The MMC also uses Cat Connect technology for real-time collection and communication of on-site performance data that can be monitored and analysed remotely. "The economic viability of remote mining operations depends on the cost-efficient generation of power," said Tom Frake, Vice President of the Global Power Solutions Division for Caterpillar. "Caterpillar's solar technologies provide a scalable, sustainable power solution that significantly reduces fuel consumption while delivering the reliable power needed to support mining sites."

Renewable and storage technologies

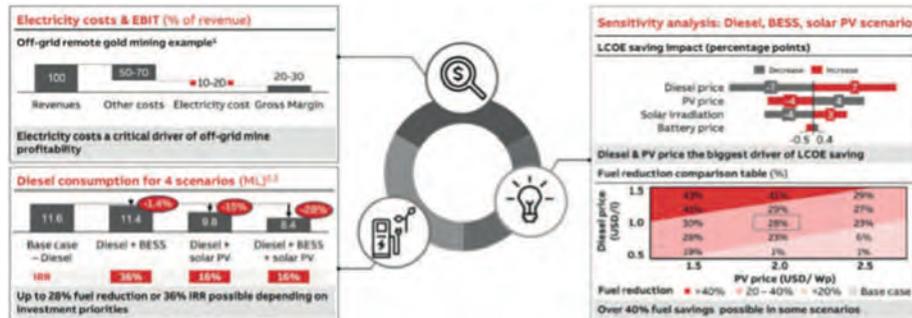
ABB says "for off-grid mining in particular, renewable and storage technologies present an ideal opportunity not only to improve the mine's environmental footprint, but also to reduce energy costs while improving power quality.

"For off-grid mines operating in remote locations, the cost of electricity can reach \$300/MWh and consume up to 15% of mining revenues. Lowering energy costs will not only increase viability of mining operations today but also help future proof them against rising fuel costs.

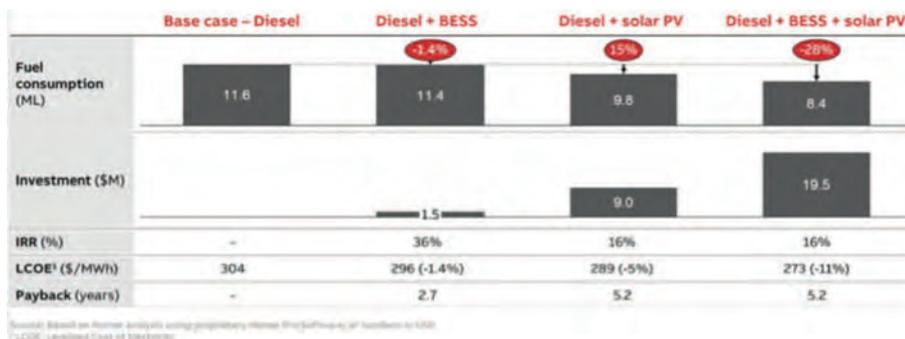
"To test the viability of storage plus renewables for brownfield mining sites, ABB considered four scenarios that were optimised using HOMER Pro2 microgrid modelling software. The benefits compared include:

- Fuel saving (and associated reduction in CO₂ emissions & maintenance costs)
- Reduced Levelised Cost of Electricity (LCOE) with an attractive IRR
- Improved power quality.

"The results showed that the highest



BESS + solar PV benefits for an off-grid remote brown-field mine (~5 MW demand example)



investment IRR of 36% was possible by installing a Battery Energy Storage System (BESS) where the main benefit comes from improved generator operational efficiency that results in a reduction in maintenance costs. Alternatively, by combining this with solar PV generation we can additionally substitute expensive diesel fuel with cost competitive solar PV thereby delivering the largest reduction in fuel consumption (28%) and LCOE (11%), while maintaining a healthy IRR (16%). Additional power quality benefits provided by a BESS such as reduced stress on the electrical installations across the mine site and associated reduction in maintenance cost and down-time have not been modelled in this study."

Finally, ABB's analysis shows that the most important factor impacting system design is the price of delivered diesel followed by the cost of the installed solar PV system.

Two conclusions can be drawn from the business case:

- Mining companies have the opportunity to start transforming their mines today as solar PV now delivers a lower LCOE than diesel
- Deployment of solar PV + BESS is an excellent hedging solution against diesel price increases and/or future carbon costs.

ABB concludes that "powering remote mines with diesel generators provides a proven and reliable energy source, but leaves the mine operator vulnerable to diesel price fluctuations, fuel supply risk as well as uncertainty around future carbon taxes. It also fails to capitalise on the economic and operating benefits that BESS and solar PV offers today and potential cost savings from carbon taxes in the future. The figure presents an overview of the economic

Up to 28% reduction in fuel and CO₂ possible when combining diesel with BESS and solar PV

benefits and capital requirements of the four scenarios tested.

"In some cases, mine operators may prefer the incremental hybridisation route as it allows more gradual changes to the operating system and strategy. This analysis shows that it makes sense to consider BESS in the first step without additional renewable energy capacity as this offers the highest IRR. Ideally, the use of a flexible BESS, such as the ABB PowerStore, would allow the storage capacity to be increased if renewable energy systems are later added.

"In terms of renewable options, wind has also proven itself to be effective in the mining sector, particularly in those areas with high wind resource and low solar resource. Due to historically lower costs, high scalability and relative ease to gain approvals in remote locations, wind has accounted for 59% of installed renewables in mining to date. Where mine lives are shorter than 10 years new business models allowing for relocatable solar PV to be installed could be considered. Once you have found the right renewable choice for your location, combining with a BESS can provide additional cost-savings that mining operators can benefit from today."

For more detail, see <http://register.e.abb.com/ABBMicrogridBusinessCaseforMining>

Hydro power

In 2016, Gilkes Hydro won a contract to supply its Compact Turgo turbine to AngloGold Ashanti in Mali, where it will generate in the region of 150 kW. At the time, the company said "we are



The 12" Compact Turgo unit to be supplied by Gilkes Hydro to AngloGold Ashanti in Mali is very similar to the one pictured

very excited about this new opportunity of re-entering the mining sector, where we have a long history worldwide, and to expand our presence in Africa.

“We believe that there is huge opportunity for our Turgo to be installed on the tailings of mines due to their superior resistance to abrasion.”

The Turgo Impulse turbine was developed by Gilkes to be a simple impulse type machine with a higher specific speed than a Pelton. The design therefore allows a larger jet of water to be directed at an angle onto the runner.

Covering the boundary between a Pelton and Francis machine, Turgo turbines have proved themselves to deal extremely well with ‘dirty’ water without any detriment to performance.

Originally designed and patented by Gilkes, the first ever Turgo turbine was installed in Scotland in 1919. Since then, turbines of Gilkes originated design have been operating in over 80 countries worldwide and many of the original units are still in operation.

ClearPower North America has expanded the market for its patented, Straflo design Industrial Turbine Generator (ITG) with the launch of its new ITG-M Series for the mining industry. The ITG-M Series allows mining companies to use their existing gravity-fed pipelines or outfalls to convert water and selective water slurry flows into a source of sustainable, renewable, low-cost electricity. By harnessing sufficient water flow and head, mining companies that install the ITG-M Series can produce over 30 MW of economical off-grid power, significantly reducing their electricity costs. The ITG-M is capable of producing up to 3 MW of electricity per 46 m of head.

ClearPower says that “mines that currently use

expensive diesel fuels and inefficient generators spend approximately \$212 to \$281 per MW for electricity according to data provided by the Rocky Mountain Institute. At these rates, mines are spending approximately \$65 to \$100 million annually on energy for the 30 to 50 MW of electricity they need for operations.”

“Our Industrial Turbine Generator-M Series is a perfect fit for mining companies,” said Michael Prendergast, Managing Partner at ClearPower North America. “Mines utilise millions of gallons of water every day. This water can be economically converted into an inexpensive and sustainable source of clean energy. ClearPower’s in-conduit ITG-M platform provides a robust bolt-on solution that can dramatically cut the cost of power for a fraction of the investment of other renewable sources, while reducing their carbon footprint.”



ClearPower North America’s ITG-M Series is a bolt-on platform that can be installed quickly with potentially no downtime or disruption to operations. It also offers a small footprint that easily becomes part of an existing infrastructure that removes pressure while not affecting flow

The ITG-M Series features a unique direct-drive, synchronous, permanent magnetised generator (PMG) that harvests the energy of moving water from gravity-fed pipelines. The unique all-in-one rim design of the generator removes the need for a central shaft and couplings, resulting in a simplified, compact and efficient generating system that improves efficiency, limits noise, and prevents vibration.

Power storage

One way to overcome the problems of intermittent power from renewable sources is to store some of the power when it is available. A huge amount of R&D dollars is being poured into battery research.

Aggreko has spent £40 million to acquire Younicos, a global market leader in the development and deployment of integrated energy systems, based on battery storage. Aggreko stated: “This acquisition strengthens our position as global energy markets continue to evolve and is in line with our strategy to invest in technology in order to reduce the cost of energy for our customers.”

Younicos delivers smart energy solutions integrating battery storage, which are modular and scalable. “Its knowledge of batteries combined with proprietary control systems, enables the seamless integration and management of all forms of power, including thermal, renewable and battery energy resources; this is becoming critical in an increasingly distributed energy market.”

Global energy markets are changing: decarbonising and becoming more decentralised and digital. As renewables penetration increases, intermittency becomes a more difficult issue to manage across grid systems. Integration and control of thermal, renewable and battery systems will be increasingly required to ensure power stability and reliability are maintained. Off grid and microgrid energy solutions are ever more integrating renewable generation, whilst industrial and commercial customers are also taking advantage of opportunities for renewable integration and demand-side management.

“The capabilities brought by Younicos, leveraged through our global footprint and experience in distributed power generation, are compelling. The Younicos integration and control systems, combined with batteries, can be deployed across our existing business to lower the cost of energy, ensure reliability and reduce carbon emissions for our customers around the world. Younicos has invested heavily in R&D since it was founded in 2005. It is based in Germany and the USA and has over 200 MW of installed storage systems, with a strong pipeline across both developed and emerging markets.” **IM**