SIEMENS

In cooperation with

juwi

WHITE PAPER

Have your cake and eat it too – **microgrids for mining**

Photo: Gold Fields Ltd.

Index

PREFACE

Voices of the industry

Putting you in control of the energy transition. Small scale. Big impact.
The important change in terms of the energy mix in the mining industry is the energy transition, and namely the massive growth in renewable power generation.

First, the fact that the cost of renewable generation (solar photovoltaics and wind) and battery storage has come down tremendously and has fueled the use of renewable generation. Second, decarbonization and sustainability are driving the industry and are important to switch to renewable generation wherever possible.

The whole energy transition comes with complexity; however, energy managers should not shy away but rather embrace the challenges, to seek the opportunities and potential that it offers. Distributed energy resources (DERs) are now taking over more generation capacity, while the supply side is not as stable and predictable anymore as it was in the past. As a result, energy managers must figure out how to ensure the reliability of the energy supply, efficiency, sustainability, and compliance with strict requirements of grid codes. The hybrid solution with **Microgrid Control – a SICAM application** provides reliable control to assure carbon-reduced and efficient energy supply.

Robert Klaffus, Chief Executive Officer (CEO) Digital Grid Siemens AG

Make your power supply clean, inexpensive, and reliable: with hybrid power plants.
The mining industry accounts for 10 percent of the global energy consumption, and many minerals play a vital role in the energy transition. We are glad to support the resource industry on their decarbonization pathway with our dependable solar, wind, and battery solutions.

Data from 2020 shows that more than 80 percent of all new electricity generation capacity came from renewable energy. In line with this, the International Energy Agency (IEA) and others have updated their capacity expansion forecasts. More wind and solar power are expected to be installed every year globally than Germany's combined power capacity, because these are cheaper and faster to deploy than any other sources of power. These forecasts also highlight that solar and wind are becoming the backbone of the new carbon-free world faster than expected.

While this is good news, we realized early on that industries such as mining have very specific power requirements. The needs of mine sites differ substantially from standard wind and solar power plants. Not only are reliability and safety crucial, but hybrid power systems need to adapt to changing ore bodies, enable mine site electrification and electric- or hydrogen-powered fleets. At the same time, hybrids need to provide secure real-time data for operating mines and for the digital mines of the future. This white paper highlights the solutions that we have developed and outlines a path forward for renewable energy for mines.

Stephan Hansen, Chief Operating Officer (COO) of the juwi Group

CHAPTER 1

Developments in the mining industry and energy supply for mines

Mining has emerged from the worst of the COVID-19 pandemic in strong financial and operational conditions. The industry is developing rapidly, with environmental, social, and corporate governance (ESG) policies and carbon reductions ranking very high on the agenda of many mining executives.

In fact, companies with higher ESG ratings (from MSCI) had an average shareholder return of 34 percent over the past three years, which is 10 percent higher than the general market.

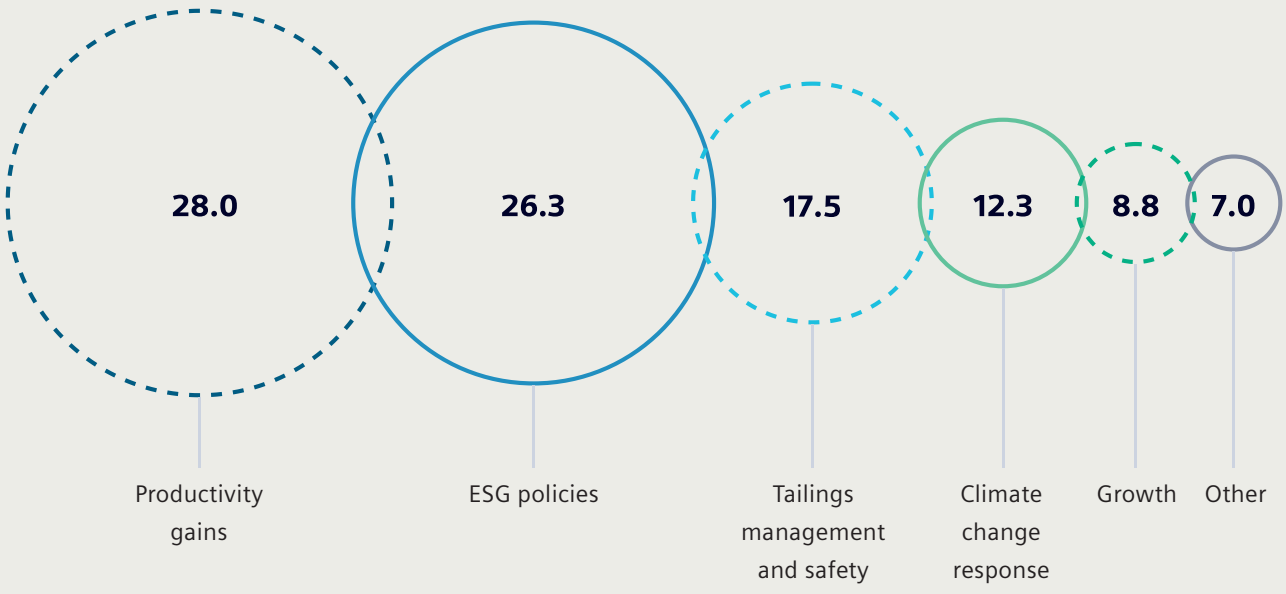
Source: PwC, Mine 2021

The year 2021 has been a watershed year for renewable energy for mines. While there were very few mines with solar or wind hybrid power just three years ago, the number of announcements and projects under construction this year has grown tremendously.

At the time of writing, juwi has seven hybrid projects in construction in Australia and Africa. Projects include the 36-megawatt solar plus 7.5-megawatt battery hybrid project at Egypt's Sukari Gold Mine, as well as two photovoltaics (PV) power plants with a combined capacity of more than 38 megawatts, and a 10-megawatt battery system for Transalta powering BHP's Nickel West Operations in Western Australia.

Outlook on what will be the main priority for the mining sector (% of responses)

Source: White & Case 2020 Mining & Metals market sentiment survey



Renewable energy developments, cash operating cost, and carbon emissions

The cost of decarbonization is a key factor and has historically prevented large-scale uptake of renewable energy at mines. However, this has changed fundamentally in the last three years. In the majority of cases, solar and wind power are now cheaper than fossil fuel, even when additional storage technologies have been implemented.

Lazard's annually released analysis on the levelized cost of electricity shows that solar PV and wind power are now the cheapest forms of electricity generation among all technologies.

Source: https://www.lazard.com/media/451419/lazards-levelized-cost-of-energy-version-140.pdf

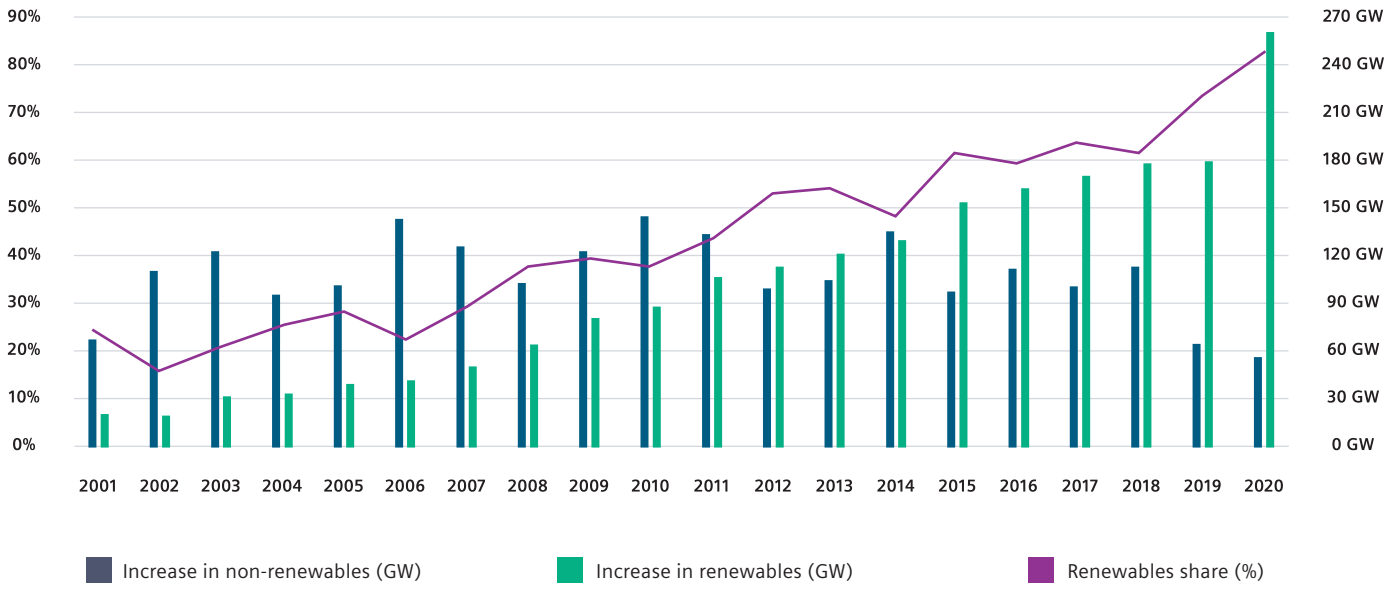
Not only are wind and solar cheaper than any other power generation options, they also remove the volatility of fossil fuel prices, are faster to deploy, and make power supply more resilient.

80% of all new power generation comes from renewable energy

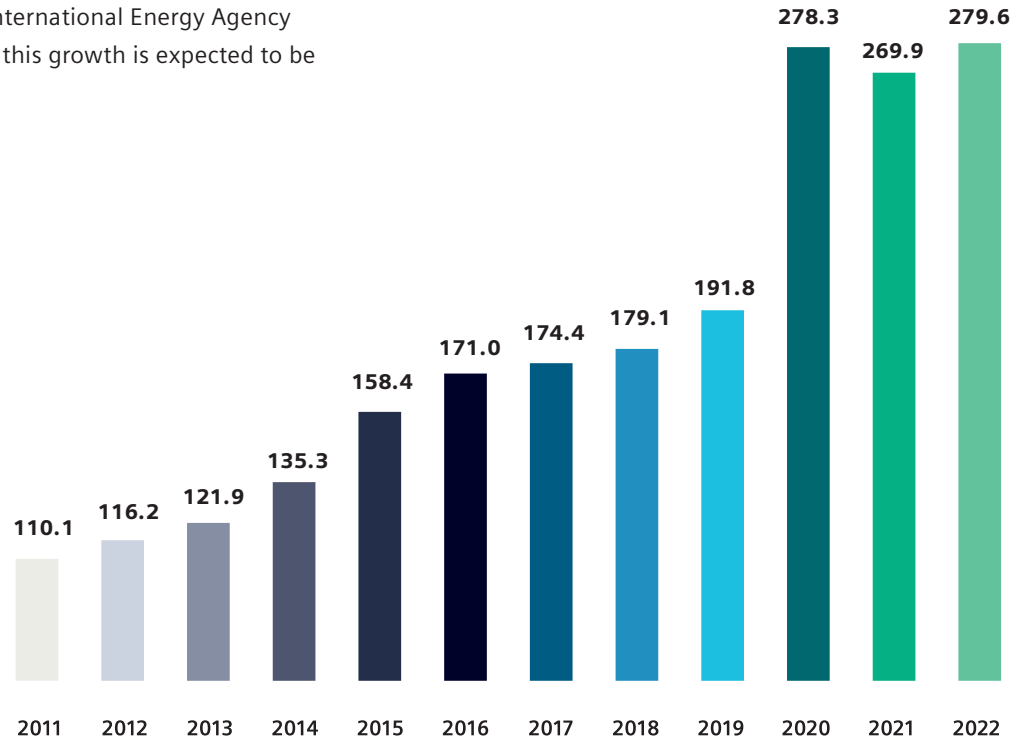
Global renewable energy capacity additions in 2020 exceeded estimates and broke previous records, despite the economic slowdown caused by the COVID-19 pandemic. According to the International Renewable Energy Agency (IRENA), more than 260 gigawatts (GW) of renewable energy capacity were added in 2020, and thus exceeded the expansion in 2019 by close to 50 percent.

Renewables share of new electricity generation capacity

Source: IRENA, renewable capacity highlights, March 31, 2021



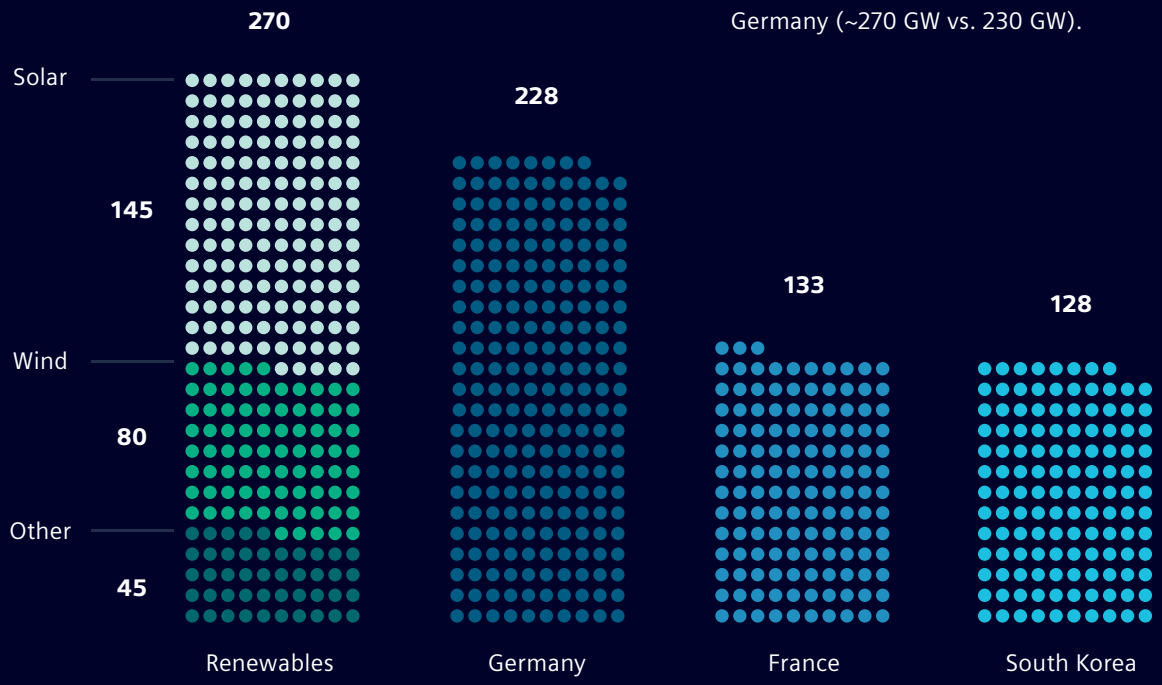
Forecasts by the International Energy Agency (IEA) confirm that this growth is expected to be the new normal.



Net renewable capacity additions, 2011–2022 (GW)

Source: Microgrid webinar (with juwi), "The future of energy systems is hybrid – Microgrids for Mining", and juwi's "Have your cake and eat it too" by Roth-Deblon A. IEA, Net renewable capacity additions, 2011-2022, IEA, Paris https://www.iea.org/data-and-statistics/charts/net-renewable-capacity-additions-2011-2022

This means the world will install more renewable energy capacity every year for the coming years than the entire power generation capacity of Germany (~270 GW vs. 230 GW).



Power generation capacity per year (GW)

Source: The Global Economy – Electricity production capacity

CHAPTER 2

What do these developments mean for the mining industry?

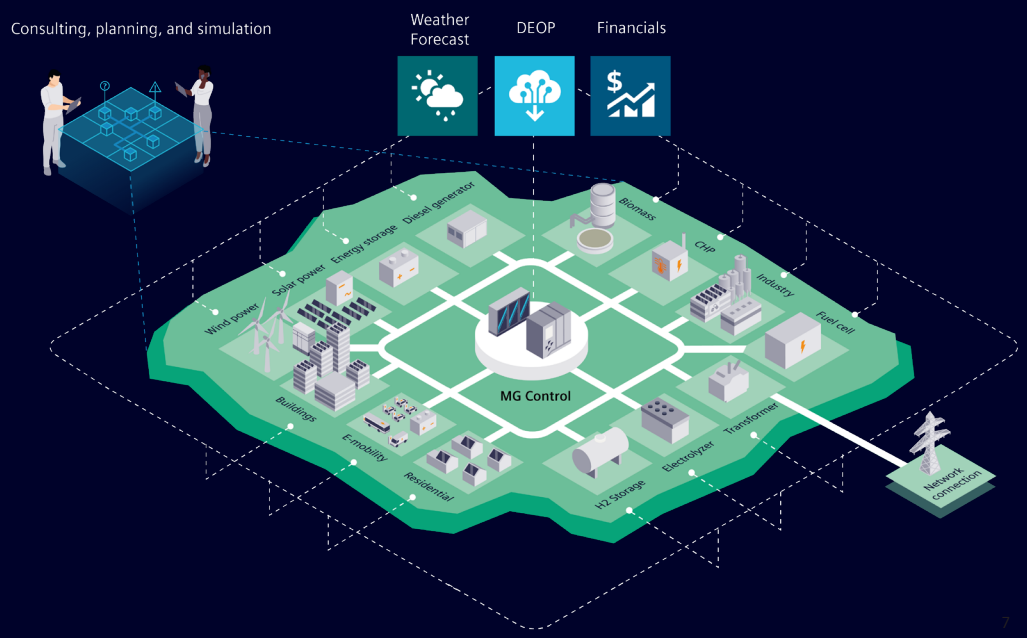
Overlaying this data with key developments in mining – such as ESG, decarbonization, and electrification – shows that renewable energy presents formerly inaccessible solutions to the mining industry.

Renewable energy hybrid systems in a nutshell

Hybrid solutions enable mines to transition from traditional thermal generation to low-cost, low-maintenance renewable energy solutions. This significantly reduces the maintenance and service costs of diesel, gas, and heavy fuel oil (HFO) assets. Second- and third-tier costs such as oil, coolants, and consumables are significantly reduced as well. Lower fuel consumption means fewer fuel truck deliveries on site, less physical maintenance work, reduced occupational health and safety (OH&S) risk, as well as a lower headcount on site. Battery storage solutions are delivering faster response capability at a lower cost, providing mine sites with improved reliability and increased performance. All of this can be achieved on brownfield sites and on mines in development.

Why are not all mines planning on wind and solar power?

One major difference between fossil power and renewables is that solar and wind are CAPEX-driven and have very low OPEX. Another one is site-specific considerations about existing infrastructure like gas pipelines, contracting structures, and contract tenors, which also play an important role in the competitiveness of hybrids. At sites with a short life of mine, for example not more than seven years, the economics can be more difficult for hybrids. Rental or lease options for hybrids can be a solution, but fossil fuels could still derive a slight, albeit diminishing, advantage, especially when there are no or low carbon-reduction targets.



CHAPTER 3

What is required to unlock **the full potential of hybrids?**

The key to achieving the full potential of hybrids is to maximize renewable energy contribution while, at the same time, minimizing times when solar or wind energy are curtailed or "spilled."

A key feature to make this happen is the ability to minimize the need for spinning reserve from thermal power stations. This can be achieved with what is called synthetic inertia. Synthetic inertia provides power system stability electronically instead of relying on physically rotating mass in generators. In practice, this means energy storage such as batteries is intelligently controlled within the microgrid, responding swiftly and reliably to changes in power generation and loads to maintain voltage and frequency. Battery or other storage thus creates synthetic inertia and, in effect, acts like a virtual synchronous machine (VSM).

This allows for more thermal generators to be turned off, while the remaining ones can be operated more efficiently, even with the intermittency of wind and solar power.

The most advanced version of juwi Hybrid IQ, with Siemens's Microgrid Control technology at its core, goes even further and provides full genset off-mode capability. This basically means that all thermal assets can be turned off at times and 100 percent of the energy can come from renewable sources.

juwi Hybrid IQ

Solar and wind power forecasting
juwi Hybrid IQ is also capable of increasing renewable energy contribution with the use of weather data, cloud cameras, and real-time wind measurements to forecast power production. This enables optimized dispatch and battery charging and discharging, while maintaining control over ramp rates of generation or loads. This increase in accuracy of solar and wind power forecasting, combined with the intelligent Microgrid Control, thus enables more renewable energy at lower cost without compromising the system's stability.

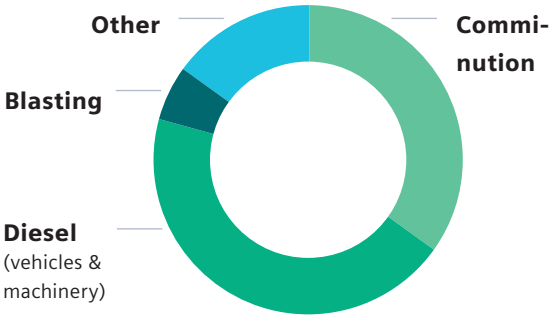
Why are hybrid's growing faster with certain metals?
When one analyzes the energy needs of different mines, it becomes clearer why juwi's earliest projects took place at copper and gold mines, rather than at iron ore operations. Copper's and gold's energy demands are dominated by electricity due to their high level of on-site beneficiation, while iron ore or bauxite with their low beneficiation on site need much less electricity and much more fuels to power their fleets.

Mining operations with a large share of electricity like gold or copper mines are the first to replace fossil fuel with solar and wind power, because the mine can simply add wind and solar power generation capacity without changing the mining process or introducing electric or hydrogen fleets. However, what we have seen so far is just the very first step on the mining industry's decarbonization journey.

Estimated energy intensity and usage from metals mining

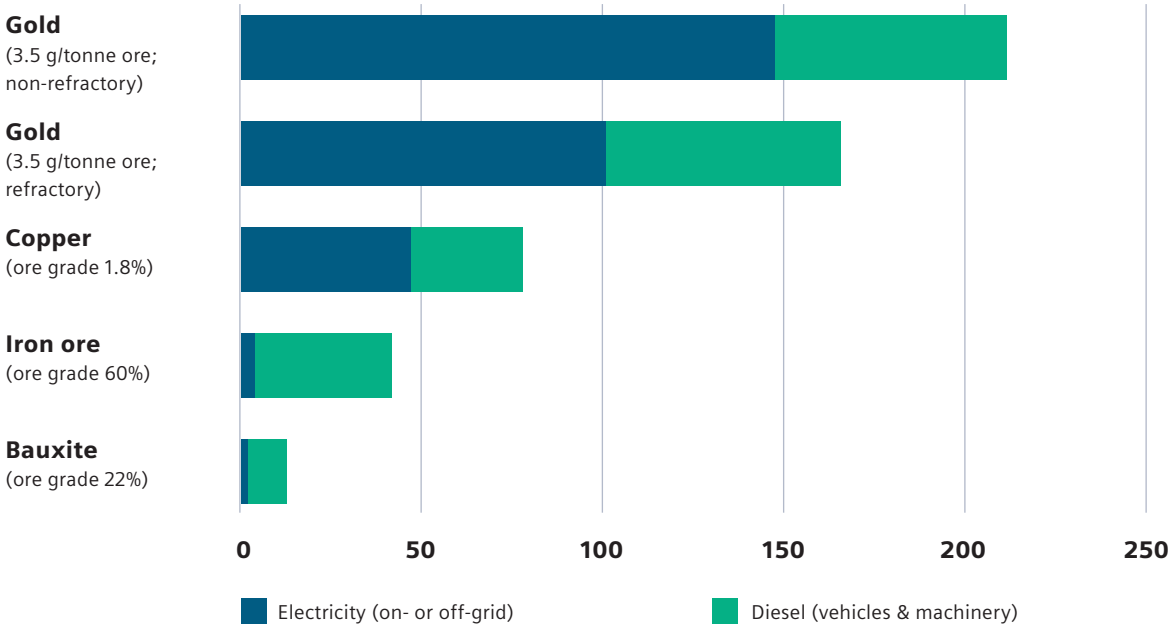
Source: https://arena.gov.au/assets/2017/11/renewable-energy-in-the-australian-mining-sector.pdf

Metals
54.5 kWh/tonne



Energy intensity of different metals (kWh/tonne)

Source: https://arena.gov.au/assets/2017/11/renewable-energy-in-the-australian-mining-sector.pdf



Variable and scalable mining

The natural next step after adding solar and wind to the generation side is to expand the view to when and how the energy is used. Mining experts invest a lot of expertise and time into engineering and optimizing the way material is extracted, moved around, and processed. We help our clients to take this one step further by analyzing what it could mean to operate differently to take advantage of abundant and low-cost electricity from solar or wind. Questions like "Would it make sense to increase crusher, grinder, or mill capacities and stockpile some portion during the day?" or "Should we run a larger processing facility during the night when there is abundant wind energy?" are just two examples of variable mining considerations.

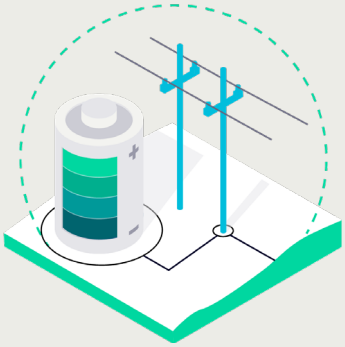
These topics are especially relevant if the mine site's design is still flexible or nearing an upgrade or expansion.

Electric or hydrogen-powered fleets

Step three toward lower cash costs and lower emissions includes electric and possibly hydrgen(H2)-powered fleets. Electric fleets bring several additional advantages especially to underground mining:

1. **Higher performance**
2. **Improved work environment**
3. **Lower cooling requirements**
4. **Reduced ventilation needs**
5. **Much lower carbon emissions**
6. **Decreased risk of fire associated with diesel and heat**

Even if the decision today is only about adding a first-phase solar plant, the microgrid is ready to adapt or expand at a later stage.



Underground mines such as Newmont GoldCorp's Borden Mine in Ontario, Canada are leading the way, but even mega operations like the Pilbara iron ore mines in Australia by BHP, FMG, and Rio Tinto are working on solutions to decarbonize and electrify their fleets.

However, there are reasons why electric or hydrogen-powered fleets have not been adopted yet. Electric and H2 fleets require replacement or retrofit of equipment or site infrastructure, and might even mean a change in the mining processes. This applies to both brownfield and greenfield sites.

Despite these additional hurdles, the convergence of low-cost and abundant wind and solar power with zero-carbon emission targets is driving innovation for the mines of the future.

In such a dynamic environment, decision-makers are especially hard-pressed to identify what is viable today, while ensuring they are future-proofing their solutions.

The good news is that juwi Hybrid IQ offers this future readiness. Even if the decision today is only about adding a first-phase solar plant to an existing brownfield site, the microgrid is ready to expand at a later stage. So, whenever site managers and electrical superintendents have to adapt to changing ore bodies and processing methods, or decide to electrify their fleets, they can simply change parameters or add features and infrastructure to the existing system.

juwi Hybrid IQ can not only provide resilient, lowest-cost renewable power to stationary loads, it can also manage charging points or hydrogen electrolyzers, while enabling variable mining with real-time KPIs that are customized for mine sites.

All of this provides our clients with a head start on their decarbonization journey.

CHAPTER 4

Microgrid Control as a proven product for a faster implementation of microgrids

The core of Hybrid IQ, Microgrid Control is a modular and flexible solution for microgrids. Based on the well-known **Siemens SICAM A8000** product family, it benefits from long-term experience on this platform in applications worldwide.

Siemens has sold this platform more than 85,000 times, which is used in various applications and different, challenging environments. The use of the platform began in digital substations and has progressed over the years to be used in over 600 systems in the growing field of renewable generation; in other words, wind parks, photovoltaic plants, battery storage systems, and, not to forget, microgrids. The customer base includes utilities, private grid operators, railways, infrastructure, and the oil and gas, and mining industries. More than 60 customers with close to 100 sites benefit from Microgrid Control on campuses, remote sites, critical infrastructure, and industry controlling over 600 megawatts.

It provides flexible communication, seamless continuity and maximum security.
Microgrid Control allows for quick and easy integration, combining various conventional and renewable generation and energy storage devices. Thus, the intelligently controlled energy mix enables a robust, safe, and economical operation of the microgrid.

Scalable, flexible, and expandable

Microgrid Control is a flexible system – with the hardware, you can add I/O modules ranging from discrete connectivity to redundant features or systems. All the functions such as black-start, diesel offsetting, and more are simulated, tested, and proven before being compiled into the application, which then just needs to be applied to the site. This means that the function can be replicated for other projects, enabling economies of scale and allowing the system to start up operations quicker and thus enabling full flexibility while fulfilling the respective requirements for microgrids from IEC and IEEE (e.g. IEEE 2030.7 or IEC TS 62898-2).

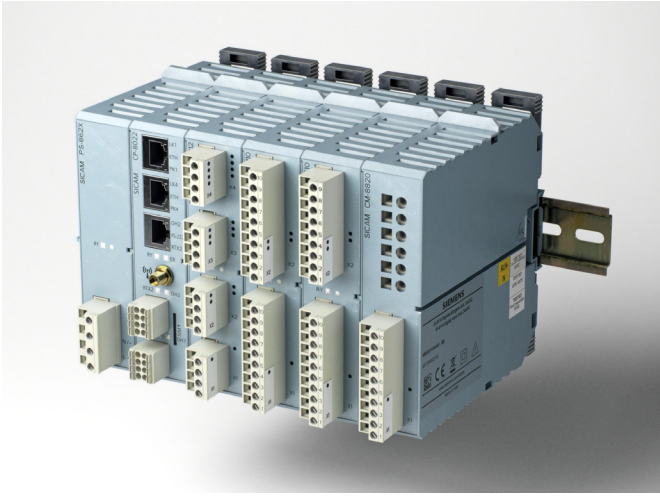
Replication of standardized functions reduces risk and has a positive effect on project delivery times.

Microgrid Control - a SICAM application is a scalable system that can adapt to changing ore bodies and processing methods and which increases the contribution from renewable energy or hydrogen.

One should also take note that Microgrid Control and the underlying SICAM A8000 controllers require minimum maintenance and can be installed in extreme environments. Due to an automation-system-specific, hardened operation system, no periodic updates are required. It is meant to be installed, commissioned, and perform the task without interference of maintenance cycles.

Redundancy

If system availability is to be increased, one can opt for a redundant configuration. Microgrid Control is set up with two independent CPUs, each equipped with an own power supply and Ethernet communication module. If one of the CPUs malfunctions, this is detected automatically and the process is taken over by the non-active CPU, thus ensuring a smooth switchover process. The non-active CPU can be placed in a separate rack or in the same rack of the controller. Using these features Microgrid Control provides an availability over 99.9 percent.



Cybersecurity

Microgrid Control also includes built-in cybersecurity, a fundamental requirement in today's IT landscape. The password-protected Microgrid Control has an integrated crypto chip, which protects data in a secure environment, and IPSec encryption to facilitate secure communication over IP networks.

The SICAM product platform, the basis for Microgrid Control, is certified to be compliant with the IEC 62443-3-3 and 62443-2-4 standards respectively and fulfills the German Association of Energy and Water Industries' (BDEW) white paper recommendations for secure control and communication systems. Furthermore, the TÜV NORD CERT GmbH certification body confirms that the Siemens Digital Grid (i.e. SICAM product) complies with the information security management system standard IEC 27001:2013.

Product advantages

Modular platform for versatile application options and a reduction of spares

Extended temperature range of –40°C to +70°C for rough ambient conditions

Highest EMC stability of up to 5 kV (IEC 60255) for direct use in substations

Multitude of interfaces for simple adaptation to existing communication infrastructures

Integrated crypto chip and IPSec encryption to fulfill high cyber security requirements

Plug-and-play functionality of the modules for time and cost savings

Integrated Web Server for simple engineering, parameterization, monitoring, and control

Modular redundant controllers and redundant I/O

Flexible to integrate various DERs: Agnostic and vendor neutral

Open to custom functions and various grid requirements

CONCLUSION

Key takeaways

Lower your mine site's cash operating cost and carbon emissions at the same time – with solar, wind, and battery hybrids.

Flexible and scalable juwi Hybrid IQ, based on Microgrid Control – a SICAM application, adapts to changing ore bodies and processing methods.

Reduce risk and future-proof your operations with expandable, cyber secure, and redundant system architecture.

Siemens AG
Smart Infrastructure
Digital Grid
Humboldtstrasse 59
90459 Nuremberg, Germany

For the U.S. published by
Siemens Industry Inc.
100 Technology Drive
Alpharetta, GA 30005
United States

juwi AG
Energie-Allee 1
55286 Wörrstadt
Germany
info@juwi.de