aggreko

AN AGGREKO WHITEPAPER

MINING'S MISSION TO NET ZERO

MARCH 2022

Contents

Overview

The mining industry is undergoing a meaningful energy transition – from traditionally relying on diesel for power generation to moving towards renewable and alternative fuel solutions. Driven by the world's leading mining companies committing to net-zero emissions by 2050, there has been significant investment in the electrification of equipment, process improvements, hybrid energy systems and on-site power generation across the sector.[1]

Investors, regulators, insurers, governments, and customers have also been major drivers of the transition, as there are increasing expectations about Environmental, Social, and Governance (ESG) criteria – the set of standards for a company's operations that socially conscious investors use to screen potential investments. It is of no surprise therefore that "ESG" was listed in three of the top 10 issues miners were concerned about in Deloitte Insights' Tracking the trends 2021 report for the mining sector. In its report[2], Deloitte states miners are revising their commitments to local communities, and to society at large, by enhancing their ESG performance. Getting serious about decarbonisation would turn corporate governance frameworks into a competitive advantage – initiatives that could drive value for their broader stakeholder groups as well. Most mining companies, the report cited, were also working to link their social investments to sustainable outcomes and playing an active role in the world's transition to a clean energy future.

[1] Austmine Smart Mining. "Industry Q&A: Powering the Mines of the Future", October 2021. Accessed October 10, 2021. https://www.austmine.com.au/Web/News-Resources/Articles/2021/October/Industry-Q-A--Powering-the-Mines-of-the-Future-.aspx

[2] O'Brien, John; Stoch, Henry. Deloitte Insights (article). "Trend 3: ESG: Getting serious about decarbonization", February 1, 2021. Accessed October 10, 2021. https://www2.deloitte.com/us/en/insights/industry/mining-and-metals/tracking-the-trends/2021/decarbonization-mining-and-climate-change.html

At Aggreko we have witnessed these changes – particularly during the past few years – as greener technologies have gone from being boardroom discussions to being adopted at the coal face. Where traditionally the sector was reluctant to adopt new technologies, many mining companies are embracing the energy transformation. In fact, there are some that have become market drivers and are leading the change: they are approaching energy suppliers asking for big, bold, and creative ideas for power generation to combat climate change.

Many of the world's prominent miners such as BHP, Anglo American, Rio Tinto, Barrick, Vale and Glencore have been vocal about their "green" targets and have outlined their plans for the decades ahead. The end goal of course is for the world economy to reach net-zero by 2050, in line with the Paris Agreement targets (explained more in this document).

In further evidence of the bold changes facing mining – just recently in October 2021 – Australian miner Fortescue Metal Group (FMG) announced it would eradicate emissions across its entire global value chain, including crude steel manufacturing – by 2040 (known as Scope 3 emissions)[3]. This is bold and impressive given the vast amount of coal required to melt iron ore and consequently the resulting air pollutants[4].

---

[3]Mercer D & Borrello E. ABC Rural News (article). "FMG pledges to eradicate customer emissions by 2040", October 5, 2021. Accessed October 21, 2021. https://www.abc.net.au/news/2021-10-05/fortescue-metals-to-eradicate-customer-emissions-by-2040/100514894

[4]Gallucci, Maria. Bulletin of the Atomic Scientists (post). "How steelmaking may go carbon-free – by dropping its addition to coal", February 5, 2021. Accessed October 21, 2021. https://thebulletin.org/2021/02/how-steelmaking-may-go-carbon-free-by-dropping-its-addiction-to-coal/

We, too, are committed to a greener future and helping our customers achieve net-zero with their energy needs. We are already doing this by adapting and investing in new technology and successfully integrating renewables across our full range of power services. Proudly, we've been the world's leading provider of mobile modular power for the past 60 years, and for at least the 30 of those years, we've been servicing the mining sector. With technology advancing so rapidly and the cost of renewables becoming more affordable – never have we seen power technology developments adopted as broadly as we are right now. The mining sector is becoming truly innovative, adopting new technologies often before other industries. This is evident from projects we have undertaken in mining recently, where our renewables offerings continue to attract strong uptake from operators interested in reducing energy costs and driving sustainable operations. We have created one of the world's largest hybridised solar energy microgrids to power a mine in Western Australia and are using the world's most efficient gas engines to create virtual gas pipelines to power mine projects and reduce miners' reliance on diesel.

Renewable microgrids have become a reliable and cost-effective solution where life-of-mine contracts are typically longer and have a baseload power requirement. In mining areas too remote for utility power supply or where companies are seeking to take greater control of their power sources, microgrids have been utilised to ensure energy reliability and security.

As power generation for mining has become more complex, we have tailored our solutions to simplify and de-risk these decisions for our customers. Using a combination of diesel, gas, solar, battery storage and wind, we're able to assist miners to reduce carbon emissions while increasing overall energy efficiency. Our modular equipment – combined with our "build, own and operate" model – is allowing us to flex to suit the requirements of every mine through its entire lifecycle, or for part of it as and when needed.

Our own goal is to achieve net zero carbon dioxide emissions across our fleet and for our customers by 2050. We also aim to reduce the amount of diesel used in our customer solutions by at least 50% by 2030.

In the coming years, careful collaboration is needed between mining and energy companies to create flexible power solutions that transition mines towards cleaner power sources without compromising reliability.

In this eBook, we will explore insights from Aggreko's mining specialists and from industry analysts about what the next few years might look like in mining's energy landscape.

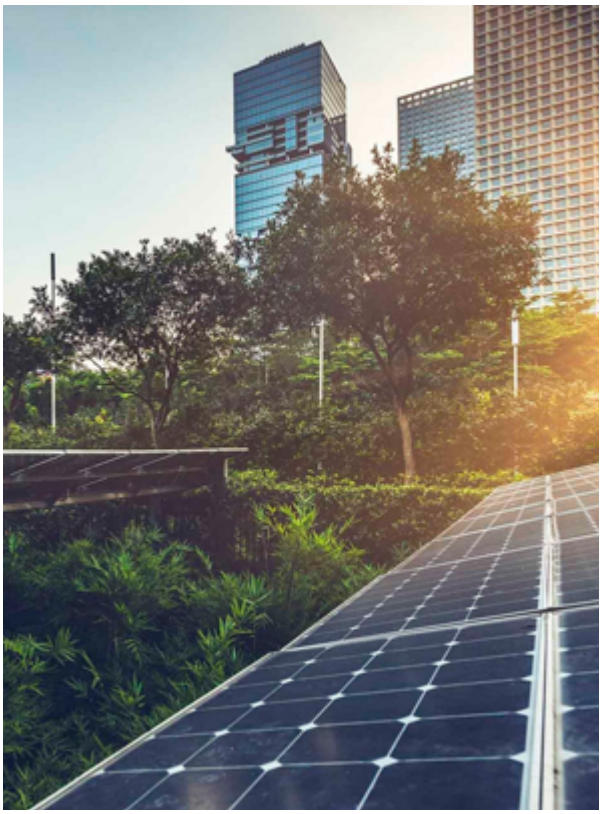
For more information, or to join the discussion about powering mining to net-zero carbon dioxide emissions, use the hashtag #AggrekoMining and follow us on LinkedIn: https://www.linkedin.com/company/aggreko.

ABOUT THE AUTHOR – AGGREKO

We help you progress your business with better and cleaner energy solutions throughout the life of your mines. As mining specialists, we understand the energy you need to operate effectively, no matter where your mine is located or how complex your need. We also understand the practical challenges of reducing your carbon emissions. That's why we'll work with you and use our deep expertise to develop the right choice of solutions and services that gives you the energy you need.

Whether you need flexible power, underground cooling, heating, mining services for day-to-day energy needs – or the reassurance that you can use cleaner energy without reducing your productivity – we ensure you perform efficiently and can concentrate solely on your business. Furthermore, because we are the only global provider of flexible energy solutions and services, you'll receive the same high standards wherever your mine is located.

"The Energy Transition is a pathway toward transformation of the global energy sector from fossil-based to zero-carbon by the second half of this century." – IRENA (International Renewables Energy Agency)



The global energy transition

The energy market globally is undergoing significant transition, marked by a strong shift to renewable energy.

The Global Energy Perspective 2021 report by McKinsey and Company foresees oil demand will peak in 2029 and gas in 2037, while coal will continue its downward trend: global coal demand peaked in 2014 and is expected to continue to decline by almost 40% from 2019 to 2050.[5]

Aggreko's customers are under increasing pressure to reduce their greenhouse gas emissions and currently there is no silver bullet solution to achieving net-zero. They therefore must adopt a meticulous approach to reduce emissions from power, heating and cooling applications. There is also the opportunity to prevent emissions in the first place and putting the excess heat and steam from industrial process to productive use. Nothing should be considered a waste anymore.

1. DECARBONISATION

Decarbonisation – through the adoption of renewable energy – is the lead driver in the energy transition. As renewables are adopted at scale, the costs of solar, wind and energy storage are falling. Forecasts from the International Energy Agency[6] suggests that renewables will comprise 40% of total power supply by 2040. This is changing the market in other ways too. Increasing electrification and the growing world population means global electricity demand is expected to rise dramatically. The market for temporary, distributed energy is growing and the need for flexible, reliable and integrated solutions with lower carbon and local emissions is in demand. It is also important to recognise the energy transition is happening at different paces and scales across the world and that adds to the complexity of what solutions will look like in the future.

---

[5] Mavrokefalidis, Dimitris. Energy Live News. "Global power consumption 'to almost double by 2050', January 18, 2021. Accessed October 24, 2021. https://www.energylivenews.com/2021/01/18/global-power-consumption-to-almost-double-by-2050/

[6] International Energy Agency (press release). "World Energy Outlook 2019 highlights deep disparities in the global energy system", November 13, 2019. Accessed October 24, 2021. https://www.iea.org/news/world-energy-outlook-2019-highlights-deep-disparities-in-the-global-energy-system

2. DECENTRALISATION

With the increase in the availability of renewables and storage solutions, there is a reduction in the cost to deploy and as a result a growth in localised power generation and microgrids. Once built and commissioned, the electricity generated from renewable sources is often cheaper than electricity generated by more traditional means. This localisation is encouraging customers to become less dependent from the grid. This means that the need for mass-scale thermal power plants to deliver baseload power through national grids, is decreasing. With decentralisation, more of the power is being consumed where it is being produced. What we are seeing in the US and Australia for example, is more decentralised microgrids as a result of weaker utility grid infrastructure. It also means that in some emerging economies or regions such as Africa there is a chance to bypass centralisation and jump straight to decentralised systems.

SOLAR POWER

Aggreko has worked closely with Gold Fields at their Granny Smith mine in Western Australia to successfully transition to a renewable energy system, which at the time included the installation of the biggest off-grid renewable microgrid in the world. Aggreko installed an 8MW solar farm and a 2MW battery energy storage system to work alongside the pre-existing 28MW gas-fired thermal power station. This was all engineered, procured and constructed by Aggreko and is run as independent power to Gold Fields.

Read more >>>

Aggreko has started construction of a second off-grid renewable power station for Gold Fields in Chile at Salare Norte. That station will be about 4500m above sea level and is located 190km from the nearest town. Our engineers are creating a unique and market leading off-grid hybrid power solution, comprising of solar and diesel for the harsh environmental conditions. We estimate the mine will experience $7.4 million in cost energy savings across the 10 years of our contract.

Read more >>>

VIRTUAL GAS PIPELINE

In Western Australia, Aggreko has assisted a miner to move away from diesel without capital requirements. We have built a world-class gas plant at Ora Banda Mining's Davyhurst Gold Mine, which is about 150km north of Kalgoorlie. The Liquefied Natural Gas (LNG) station helps the miner get closer to its net-zero emission targets and uses a virtual pipeline of gas trucked more than 650km. It is expected to slash the miner's carbon emissions by 25,000 tonnes in the first five years of operation. The power station is highly efficient, scalable and very suitable for transient loads and for the introduction of solar at a later stage.

HYBRID POWER PLANTS

We helped Bisha Mining Share Company / Nevsun lower their power costs to profitably convert their operations. Our containerised, mobile and modular diesel plant at the remote African location was reliable but they were looking for ways to reduce their fuel costs. Third-party solar developers offered a lower cost solar solution via a 20-year-contract. Being locked in though was unappealing, as was having two different power suppliers. Aggreko offered an integrated solar/thermal hybrid solution in a single contract. The customer did not have to find CAPEX to invest in the solar plant as they buy solar energy per kWh. The unique hybrid solution delivers more than 12% savings on fuel – with about 10,000 litres being saved every day.

Read more >>>

Mines throughout the world are becoming less dependent on mass-scale thermal plants to deliver baseload power through national grids. In Australia, Africa, and South America, for example, there is less infrastructure for mines in remote locations. Our customer Resolute Mining Limited (Resolute) needed to define a lower cost power solution relative to its existing source of power at its Syama Underground Mine in Mali, Africa. The diesel generators in use were no longer the ideal solution. Aggreko used world-leading technology to deliver cost-effective power that ultimately lowered gold production costs. The solution included a 16-year contract to build, operate and maintain a hybrid power plant comprising of Wärtsilä Modular Blocks, solar power as well as batteries. We estimate $10 million of cost savings in the first full year of operation and the reduced environmental impact will ensure longer term mine sustainability. We also have ongoing incentive to further reduce the cost for Resolute as power technology and innovation evolves.

Read more >>>

3. DIGITALISATION

Digitalisation is very much seen as the enabler to the energy transition. What gets measured gets improved. Therefore, understanding where the emissions are coming from, and having the data to measure this means that we can hold ourselves accountable and make meaningful improvements. Digitalisation also allows us to operate more complex power systems such as combining thermal with solar, wind and batteries to work in a much more optimised way. As the adoption of renewables and volume of local power generation increases, so will the complexity of keeping supply and demand in balance. Sophisticated systems and controls are needed to match an ever-wider set of energy demands with the energy supply, all while ensuring stability, reliability and maximising efficiency.

4. DEMOGRAPHIC / DEMAND GROWTH

Demand growth refers to the demand for both electricity across the world, and for cleaner power. This is happening across the world at different rates. It is all underpinned by population growth, resulting in more people needing more electricity, heating and cooling. Global consultancy firm McKinsey & Company forecasted this year that global power consumption will almost double by 2050[7] as a result of increased electrification.

The events of the last 18 months – though they have been challenging – haven't slowed down the energy transition. Much of the stimulus money that has been approved by governments across the world has gone to green initiatives.[8]

It also makes strong business sense to decarbonise when leaders in ESG have outperformed the non-ESG equivalents in the last year: Member of Chartered Institute for Securities and Investment (MSCI) Europe ESG leaders outperformed peers by 9% in 2020 through to September 2020.[9]

WHAT IS NET-ZERO?

Essentially when a company or country announces they want to achieve net-zero emissions, they're talking about reducing their carbon footprint to the lowest level possible and making sure any emissions that can't be avoided are balanced out by those they take out of the atmosphere.[10]

THE PARIS CLIMATE CHANGE AGREEMENT

Goals for companies and countries to reach "net-zero" became more significant after December 12, 2015, when most countries throughout the world committed to the Paris Climate Change Agreement (or Paris Agreement) – an ambitious global action plan to fight climate change. As of March 2021, 194 states and the European Union had signed the agreement, though there are still some major emitting countries to formally join the agreement (as of October, 14, 2021).

The agreement aims to substantially reduce global greenhouse gas emissions to limit the global temperature increase in this century to two degrees Celsius above preindustrial levels, while pursuing the means to limit the increase to 1.5 degrees Celsius. Ever since, civic, government and business leaders have been ramping up efforts to drive the clean energy advances needed to meet the goals of the agreement and slow down dangerous climate change. Leaders from around the world collectively agreed that climate change is driven by human behaviour, and it's a threat to the environment and all of humanity, and that global action is needed to stop it.[11] The meeting of the United Nations Framework Convention on Climate Change, where the accord was made, was held in Paris – hence the name "Paris Climate Change Agreement", which is often shortened to "Paris Agreement".

---

[7] Grundy, Alice. Current. McKinsey: Power consumption to double by 2050 as COVID-19 helps pull back fossil fuel peak", January 14, 2021. Accessed November 23, 2021. https://www.current-news.co.uk/news/mckinsey-power-consumption-to-double-by-2050-as-covid-19-helps-pull-back-fossil-fuel-peak

[8, 9] Howat, Noreeen. Aggreko. From webinar presentation: "Fitch Solutions & Aggreko's How to Bridge the Gap to Netzero", October 14, 2021.

[10] ABC News Video Lab, (video): "Is green hydrogen the fuel of the future?", April 17, 2021 & updated April 23, 2021. Accessed October 19, 2021. https://www.abc.net.au/news/2021-04-17/is-green-hyrdogen-the-fuel-of-the-future/13306412

[11] Denchak, Melissa. National Resources Defence Council (NRDC) (article). "Paris Climate Agreement: Everything You Need to Know," February 19, 2021. Accessed October 21, 2021. https://www.nrdc.org/stories/paris-climate-agreement-everything-you-need-know#sec-whatis

MINING'S CONTRIBUTION

Mining is responsible for 4% to 7% of global greenhouse gas emissions in terms of the sector's Scope 1 and Scope 2 emissions, according to January 2020 estimates from McKinsey & Company. Including Scope 3 emissions it links the sector to about 28% of global emissions.[12] As a large contributor, the sector will play a massive role in emissions reduction.

To achieve the Paris Agreement's 1.5°C climate-change target by 2050, the mining industry will need to reduce direct carbon dioxide (CO2) emissions to zero. Many of the largest miners in the world are committing to achieving net-zero carbon dioxide emissions by 2050 and they have set earlier targets to achieve other significant milestones on this journey. Governments throughout the world have made similar commitments to work with industries to achieve this, with varying levels of caution or enthusiasm.

"What is the future of fuel? It's a broad question, comprising a myriad of fuel types and applications, including some that make efficient use of by-products from industrial processes."

– Carsten Reincke-Collon, Aggreko Director of Future Technologies

EMISSIONS SCOPES

Emissions in mining are broken down into three broad types.[13] These are Scope 1, Scope 2 and Scope 3 which measure an organisation's overall carbon footprint:

Scope 1 – includes all direct emissions from the activities of an organisation or those under their control (e.g. diesel consumed by haul trucks at mine sites).

Scope 2 – emissions from electricity generation. Includes indirect emissions from electricity purchased and used by the organisation, such as gas-powered electricity bought from the gird and used at mine sites.

Scope 3 – emissions from the supply chain and transport. Includes emissions from customers using products sold by a mining company, such as coal burned at a power station, or processing iron ore into steel.

Many of the world's largest miners have been acting by setting ambitious targets to lower their CO2 emissions, with goals for Scope 1 and 2 emissions often an earlier target (for example by 2030).

---

[12] Delevingne, Lindsay; Glazener, Will; Grégoir, Liesbet; Henderson, Kimberly. McKinsey & Company. "Climate risk and decarbonization: What every mining CEO needs to know", January 28, 2020. Accessed October 26, 2021. https://www.mckinsey.com/business-functions/sustainability/our-insights/climate-risk-and-decarbonization-what-every-mining-ceo-needs-to-know

[13] Scopes are listed in full in the World Resources Institute (WRI) and World Business Council for Sustainable Development (WBCSD), Greenhouse Gas (GHG) Protocol: A Corporate Accounting and Reporting Standard (Revised Edition) (2015), available at https://ghgprotocol.org/

Achieving a Net-Zero mine

As the world shifts to an economy with reduced emissions, mining companies are thinking strategically and operationally to address this challenge. While it's currently unknown what the energy sector will look like in 2050 as the technology may not be developed yet – it will likely include green energy solutions created from biogas, hydrogen, energy storage, wind, solar and hydropower, plus future fuels.

Consultancy S&P Global Platts reported in July 2020: "Many [miners] are dropping exposure to commodities with a substantial carbon footprint and increasing exposure to commodities used in batteries or other renewable energy sectors. They are also looking at things like reducing water usage or swapping diesel trucks for electric vehicles." [14]

McKinsey & Company listed possible routes to achieving zero-carbon mines sometime between 2030 and 2040, including battery electric vehicles (BEV) and hydrogen pathways. These will require significant mine-level investments: typically, $100 million to $130 million for a 25 million metric ton run-of-mine (ROM) facility — as well as an accelerated technology push and commercialisation of the technology.[15]

Decarbonisation therefore presents significant opportunities for forward-thinking companies to stand out and become leaders on the journey toward zero-carbon mining. To achieve decarbonisation at scale, stakeholders such as miners, original equipment manufacturers (OEM), suppliers, oil and gas players, customers, governments and others need to continue to work together to explore and develop technologies that are currently not viable.

---

[14] Kuykendall, Taylor; Bouckley, Katya; Warwick, Filip; Tsao, Stephanie; Dholakia, Guarang. S&B Global Platts (blog). "NetZero: Mining faces pressure for net-zero targets as demand rises for clean energy raw materials", July 27, 2020. Accessed October 10, 2021. https://www.spglobal.com/platts/en/market-insights/latest-news/coal/072720-mining-faces-pressure-for-net-zero-targets-as-demand-rises-for-clean-energy-raw-materials

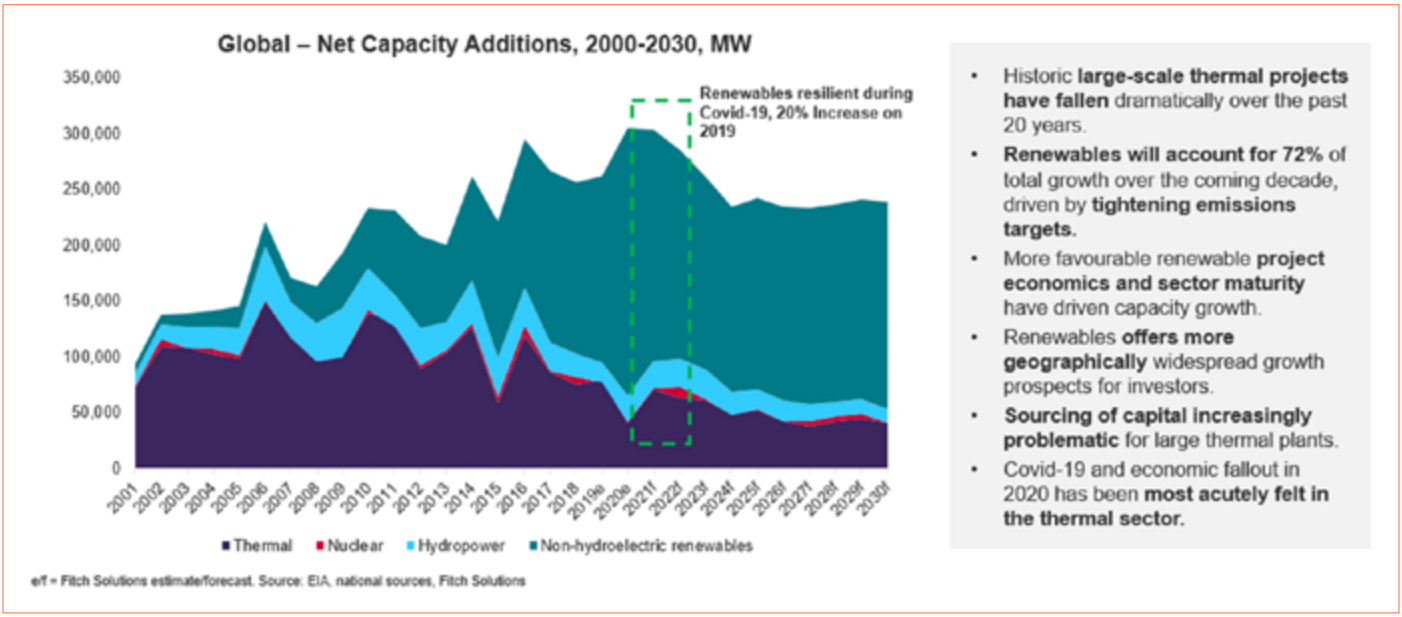
[15] Legge, Henry; Müller-Falcke, Clemens; Nauclér, Tomas; Östgren, Erik. McKinsey & Company (article). "Creating the zero-carbon mine", June 29, 2021. Accessed November 16, 2021. https://www.mckinsey.com/industries/metals-and-mining/our-insights/creating-the-zero-carbon-mine

The power sector's energy transition

In October 2021[16] an analyst from Fitch Solutions indicated historic large-scale thermal projects had fallen dramatically in the past 20 years, and renewables would account for 72% of total growth over the coming decade. From 2010-15 and towards today [2021] there was a rapid ballooning of the renewables sector driven primarily by the falling prices in technology and the maturing of the industry. The report states, the new dominance moving forward over the next 10 years will largely be driven by the tightening of emission standards on a global level, the ease of deployment, and the greater access to capital for a lot of developers.

Exhibit C: Global Power Sector Overview

Source: Fitch Solutions[17]



[16,17] Van Lanschot, Thomas. Fitch Solutions Country Risk & Industry Research. Adapted from webinar presentation: "Fitch Solutions & Aggreko's How to Bridge the Gap to Netzero", October 14, 2021.

SHORT-TERM DECARBONISATION ACTIONS IN MINING

In their June 2021 report, McKinsey & Company forecast that "solutions to decarbonise the majority of emissions will become economic within this decade, addressing both Scope 1 and Scope 2 emissions."[18] Short-term decarbonisation actions included focussing on cost-positive alternatives with technology available today to ensure no-regret moves. Some of the advice provided for miners was to improve and take operations to top-quartile levels; search for green energy alternatives; and switch to existing drop-in sustainable fuels. During this first stage, up to 60 percent of emissions could be reduced over the next three to five years. Miners can step away from diesel currently by utilising gas and hybrid power until renewables and future fuels become more viable, both in terms of affordability and availability.

MID AND LONG-TERM OPPORTUNITIES IN MINING

McKinsey & Company found that mid and long-term opportunities to achieving zero carbon all needed technological development not yet commercially available yet. The following three options all offered routes to sustainable mining, though the precise selection depended on operational characteristics and some forthcoming industry developments:

- BEV pathway (battery electric vehicles). Move to a fully electric mobile equipment fleet, with haulage trucks charged on pantograph and others charged using a battery-swap approach.
- Hydrogen pathway. Use a Fuel Cell Electric Vehicle (FCEV) mobile fleet, combined with a build-up of green hydrogen capacity derived from wind or solar.
- Synthetic fuel pathway. Keep existing equipment, but use drop-in synthetic fuels created from green hydrogen and carbon capture, utilisation, and storage (carbon capture, utilisation and storage, otherwise known as CCUS).

---

[18] Legge, Henry; Müller-Falcke, Clemens; Nauclér, Tomas; Östgren, Erik. McKinsey & Company (article). "Creating the zero-carbon mine", June 29, 2021. Accessed October 10, 2021. https://www.mckinsey.com/industries/metals-and-mining/our-insights/creating-the-zero-carbon-mine

A HYPOTHETICAL EXAMPLE OF A ZERO-CARBON MINE

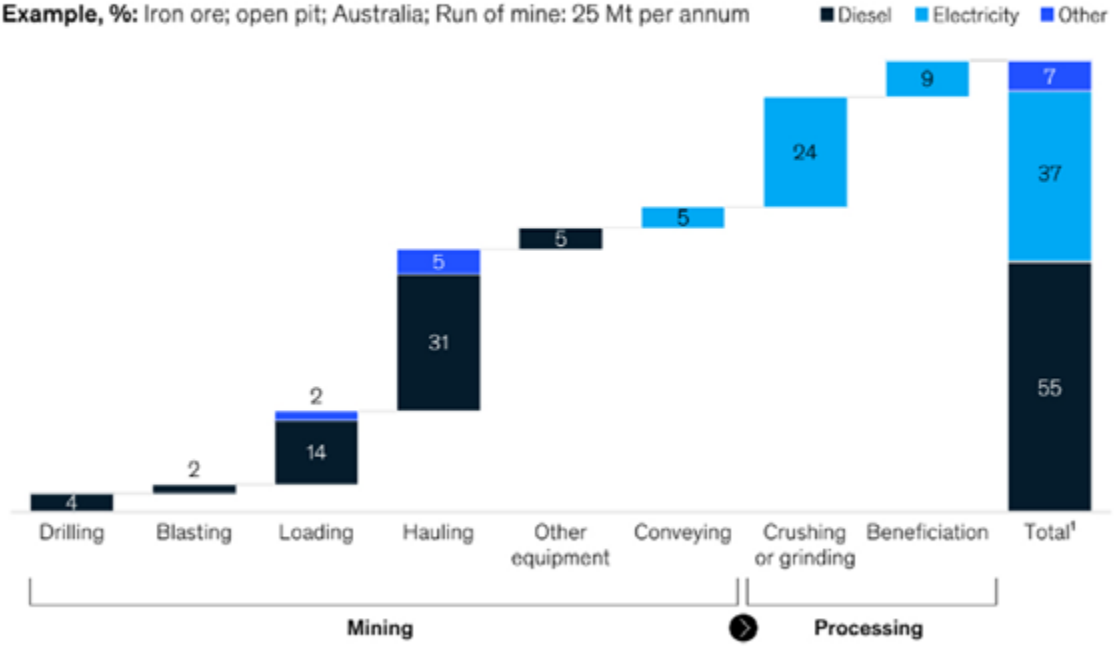
So what could a zero-carbon mine look like? This is an extract from McKinsey & Company's report, "Creating the zero-carbon mine"[19], published on June 29, 2021.

McKinsey & Company: We have created a comprehensive mine-decarbonization model. This breaks down mining emissions at an equipment level and assesses more than 20 decarbonisation options (Exhibit 2). We have used an iron ore mine in Australia as an example to see what the world's first zero-carbon mine could look like. In this example, haulage trucks are the single biggest source of emissions from the mine (accounting for 20 to 25% of the total), followed by comminution or crushing equipment (approximately 20% of emissions), bulldozers (7%), and excavators (5%). Addressing carbon emissions from these four types of equipment offers a substantial opportunity to make a step change in reducing overall mining emissions.

Exhibit 2

Addressing emissions from multiple sources is key to the decarbonization of mining.

Example, %: Iron ore; open pit; Australia; Run of mine: 25 Mt per annum



[1]Figures may not sum to 100%, because of rounding.
Source: McKinsey Mine Decarbonization Model

"The stone age did not end for lack of stone. The oil age will end long before the world runs out of oil."

– Ahmed Zaki Yamani, Saudi Minister of Petroleum & Mineral Resources from 1962-1986.

[19] Legge, Henry; Müller-Falcke, Clemens; Nauclér, Tomas; Östgren, Erik. McKinsey & Company (article). "Creating the zero-carbon mine", June 29, 2021. Accessed November 16, 2021. https://www.mckinsey.com/industries/metals-and-mining/our-insights/creating-the-zero-carbon-mine

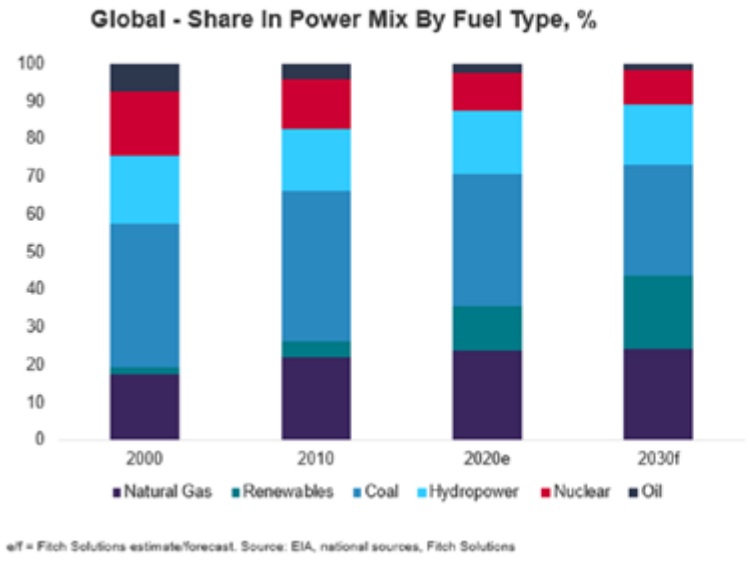
EXPLORING THE DECARBONISATION OPTIONS

Mine sites require a significant amount of energy to operate, and mining is vital to the world's future as the metal needed to reduce the population's reliance on fossil fuels and move towards renewable energy are still in the ground. Metals like nickel and lithium are needed to produce technologies like solar cells and batteries, while copper and aluminium are critical for transmission and distribution.[20] Understanding what options are available can help miners plan, take action, and incorporate renewables into their operations.

Fitch Solutions[21] suggested that they expected power from renewables across the world to account for 22% by 2030 (see Exhibit D). Gas now played a role in smoothing intermittency of renewables output, satisfying peak demand and generally improving stability of the power grid.

Exhibit D: The Global Power Mix

Source: Fitch Solutions[22]



- Non-hydropower renewables will rise from **12% in 2021** to **22% by 2030.**
- Gas saw **rapid growth between 2000-2010,** but this will **level out over the coming decade**.
- Gas now plays a **role in smoothing intermittency** of renewables output, satisfying peak demand and generally improving the stability of the power grid.
- **93 markets** are set to see **renewables gain ground** in the power mix over 2021-2030. Of these, only **41 markets** will see **growth in the share of natural gas**.
- This casts some doubt on the view that renewables will create positive spillovers for natural gas.

Overall, it is expected solar growth will surge over the coming decade, becoming the largest segment by the end of 2021, just etching ahead of wind. It will grow at an average annual rate of 9.1% against 7.4% for wind.

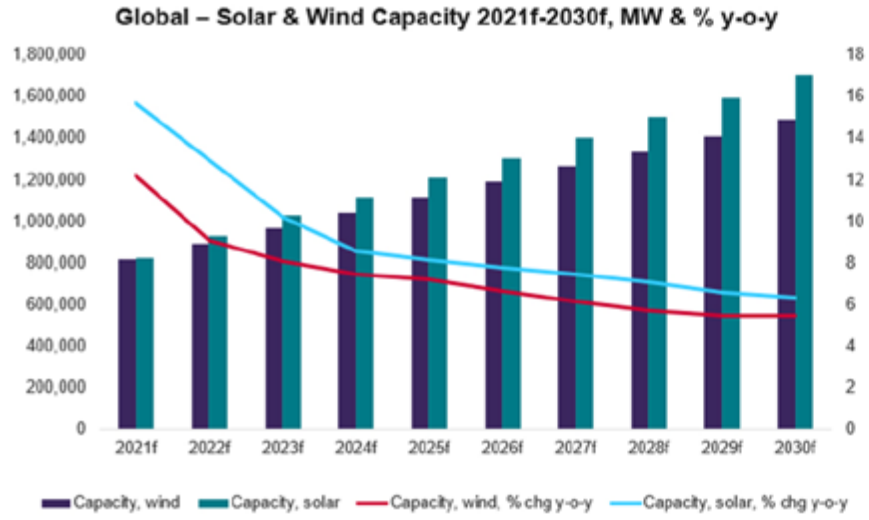
---

[20] Treen, Jon. Stantec. (Article) "Powering our mines: Transitioning from hydrocarbons to renewables", June 28, 2021. Accessed: October 24, 2021. https://www.stantec.com/en/ideas/content/blog/2021/powering-our-mines-transitioning-from-hydrocarbon-to-renewables

[21, 22] Van Lanschot, Thomas. Fitch Solutions Country Risk & Industry Research. Adapted from webinar presentation: "Fitch Solutions & Aggreko's How to Bridge the Gap to Netzero", October 14, 2021.

Exhibit E: Global Solar Power Growth to Accelerate

Source: Fitch Solutions[23]



- **Solar sector capacity will overtake wind over 2021**, growing at an average annual rate of 9.1% against 7.4% for wind.
  - Widespread scope for deployment
  - Greater variety of installations ranging from small distributed systems to large-scale utilities
  - Shorter lead times for developments and rising efficiencies have driven further cost declines
- **Wind will retain its dominant share** of total non-hydropower renewables **generation, 51.5%** by 2030 compared to **32.8% for solar**.

THE MINING ENERGY MIX

One of the best ways to power mine sites of the future is to reinvent the way it is done. Traditionally mine operators would use diesel for power or use purchased power from utilities which relied heavily on hydrocarbon fuels such as coal, oil and natural gas. Without a form of carbon capture, those fossil fuels release gases upon combustion.

A way mining companies are operating more sustainably is by supplementing their power supplies with in-house energy solutions, in a way to reduce energy consumption and carbon emissions. Utilising gas is a way to move away from diesel and start on the decarbonisation journey, while hydrogen, and other future and renewable power sources become more viable.

Consultancy Stantec also listed combined heat and power plants (CHP) – a plant that generated electricity and thermal energy (heat) at the same time, which can be used for other purposes, as a great self-generation solution for mine sites. Steam could be used to generate electricity, heat buildings, or run steam chillers for cooling and gives mine operators more control of their Scope 1 and Scope 2 emissions.

They said creating a microgrid and distributed energy resources (DER) on site, made mines less reliant on power providers, affording them more flexibility and high efficiency rates. DER brings together many forms of power generation. For example, energy produced at a gas power plant can be supplemented with renewable energy sources like wind, solar, or hydropower.[24] With DER and microgrids, mines can send any excess electricity back to nearby power grids to service communities in need.

---

[24] Treen, Jon. Stantec. (Article) "Powering our mines: Transitioning from hydrocarbons to renewables", June 28, 2021. Accessed: October 24, 2021. https://www.stantec.com/en/ideas/powering-our-mines-transitioning-from-hydrocarbon-to-renewables

ELECTRIFICATION IN THE MINING INDUSTRY

If the mining industry gets ready in time, electrification could herald a new age. Research by global consultancy firm McKinsey & Company[25] forecasts electricity consumption to grow from 19 to 30 TWh by 2030.

Environmental, health concerns and increasing financial pressures have already led mining companies to begin electrifying their equipment. Investments in technology, also forced by the challenges of deeper shafts, are giving mine owners alternatives to diesel. Electric equipment is helping miners move away from fossil fuels, improve safety, lowering their costs and reducing emissions.

Electric haul trucks are already being implemented at various mine sites around the globe and over time they can be further optimised using innovative technology for added efficiency. For example, gravitational force could be used to charge trucks automatically by utilising energy that is used to prevent trucks speeding when going down ramps and converting it back to electrical energy. Even changing a battery on a mining truck could become automated.[26] It could also not be too long before vehicles and other mining equipment send back data on their energy consumption automatically to analysts on the surface, or AI programs are able to recommend where best to send certain miners.[27]

> *"It feels that hydrogen is at the same place that wind and solar were 10 to 15 years ago – it's a matter of time."*
>
> *– Rod Saffy, Aggreko Global Head of Mining*

The Borden mine – a Newmount Goldcorp gold mine in Canada – has been hailed as one of the first all-electric mines on earth. It uses electrification such as battery-powered trucking technology and technology that can help miners squeeze equipment though narrow passages. Even though it is yet to electrify its haul trucks, Newmount has cut greenhouse emissions by 70%.[28] With mining electrification increasing, the industry will need workers educated and trained in the field of automation, particularly as it becomes more common.

HYDROGEN'S ROLE IN MINING DECARBONISATION

Investment in hydrogen as a fuel is increasing due to its role in supporting a global transition to net-zero. Its versatility and compatibility with existing furnaces, engines and generators make it especially appropriate for energy-intensive industries seeking to decarbonise. Hydrogen is seen as a potentially zero-emission fuel though getting it in a pure and useable form currently involves processes that can produce lots of emissions.

---

[25] McKinsey & Company. (Report) "The Global Energy Perspective 2021", January 2021. Accessed October 24, 2021. https://www.mckinsey.com/industries/oil-and-gas/our-insights/global-energy-perspective-2021

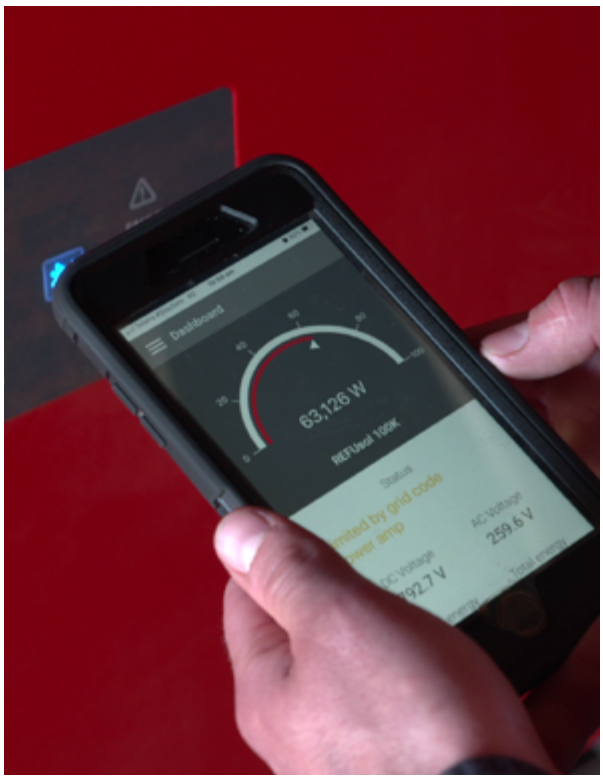
[26, 27, 28] Valentino, Andrea. "How the mining industry is embracing the benefits of electrification", June 26, 2021. Accessed October 24, 2021. https://www.nsenergybusiness.com/features/mining-industry-electrification/

Hydrogen can be created through the methods of black, brown, grey, blue, turquoise, pink and green hydrogen. Green hydrogen is hydrogen produced through electrolysis powered by renewable energy, such as wind, solar and hydropower. This is the cleanest way possible to produce hydrogen. That's because there are no carbon emissions in the value chain when it is produced the right way.

Until recently though, using hydrogen was thought to be too tricky, risky and expensive for it to really take off as it was a headache to transport and store. That's all starting to change now, with large-scale investment and growing interest meaning hydrogen is finally on the cusp of becoming truly viable. It's important not to look at hydrogen as a direct replacement for oil, coal or gas, or a direct competitor to wind and solar, but to find applications where the unique properties of hydrogen give it a technical and commercial fit.[29]

Companies are striving to make it available for power generation. In 2020, Japan and Saudi Arabia unveiled the two largest green hydrogen plants in the world, using solar and wind to power the electrolysis process used to create hydrogen.[30] [31] Meanwhile, at the start of 2021, plans for installation of the UK's largest electrolyser was announced, enabling the production of up to eight tonnes of green hydrogen daily.[32] Looking within the mining industry, Fortescue Future Industries (FFI) has also announced it will build the world's largest green energy hydrogen manufacturing facility in Central Queensland, Australia.[33]

OUR ENERGY MIX:
At Aggreko, our hybrid power plants are created using a green energy mix, offering clients reliable power 24/7, as well as net savings up to 15% compared to 100% diesel power grid. It's fast to deliver and set up – and it's all bundled into a single contract.



[29] Aggreko. "Hydrogen: Your Guide to the Carbon-Free Super Power in Energy", May 2021. Accessed October 26, 2021. https://www.aggreko.com/en-au/aggreko-perspectives/harnessing-hydrogen

[30] As read about in Green Tech Media article: https://www.greentechmedia.com/articles/read/us-firm-unveils-worlds-largest-green-hydrogen-project

[31] As read about in Nikkei Asia: https://asia.nikkei.com/Spotlight/Environment/Japanese-tech-to-slash-green-hydrogen-costs-by-two-thirds

[32] Ellis, Dominic. Energy.digital.com. "ScottishPower submits plans for UK's largest electrolyser", April 12, 2021. Accessed: October 26, 2021. https://energydigital.com/renewable-energy/scottishpower-submits-plans-uks-largest-electrolyser

[33] Hosier, Phoebe. ABC News (article). "New $1billion-plus project in Queensland to double world's green hydrogen production capacity", October 10, 2021 & updated October 13, 2021. Accessed October 21, 2021. https://www.abc.net.au/news/2021-10-10/qld-palaszczuk-andrew-forrest-hydrogen-gladstone/100527670

HYDROGEN POWER BENEFITS

Hydrogen can be used for power generation across a wide variety of industries and sectors. Benefits include:

- The most obvious upside of using hydrogen is that it doesn't cause any local carbon emissions when you use it to generate electricity (providing you use blue, turquoise, pink or green hydrogen). For companies that have access to hydrogen and are looking for reliable, effective, large-scale ways to cut their power generation emissions, that's a huge plus.
- Its energy density makes it attractive to industries like long-haul trucking and long-duration energy storage compared to conventional lithium-ion.
- Hydrogen can also be used as a fuel source in heavy industry. In this industry, applications are difficult to decarbonise, so switching to hydrogen offers a handy solution.
- Hydrogen is highly versatile. You can transform it into electricity, synthetic gas, synthetic diesel, or even "hydrogen carriers" such as methanol or ammonia. This opens up a range of fuel options that you can adapt to the needs of your project and site.
- A major benefit for using hydrogen as a clean-burning, synthetic fuel is that it can be used as a drop-in fuel for temporary equipment, without making expensive modifications.

HYDROGEN LIMITATIONS

To make hydrogen practical to use, you must either compress it to extremely high pressures or liquefy it, which means cooling it to -250°C. This creates challenges for hydrogen storage and transportation, which can get very expensive.

- It's not yet possible to simply tap into a hydrogen pipeline the way you might with natural gas.
- Since hydrogen is a tiny molecule, it's leak-prone. This means you really do need to invest in special provisions to ensure existing pipelines and other infrastructure are compatible with hydrogen service.
- Hydrogen has a very wide flammability range in air and low ignition energy. It burns with a colourless flame that makes it hard to detect until you get close. In short, you need to be extremely careful when handling hydrogen.
- Production costs vary widely. While it's possible to produce hydrogen for as low as $0.90 per kg through generation from natural gas, this doesn't fix the carbon emissions problem. Green hydrogen production, which does fix the problem, costs significantly more. More investment and innovation is needed to bring these costs down and make green hydrogen feasible because it needs to be produced from electricity from renewable sources alone.

In October 2021, The International Energy Agency (IEA) said governments needed to step up investment in hydrogen production and storage chains to help cut net emissions to zero. States and private investors had so far only come up with about a quarter of the $1,200 billion needed by 2030 to develop and deploy hydrogen and make it part of global net zero strategies.[34] Although there are limitations, these can be overcome as miners and suppliers collaborate and hydrogen's full potential can be realised.

---

[34] Reuters. "States must raise hydrogen investment to help reach net zero – IEA", October 4, 2021. Accessed October 26, 2021. https://www.reuters.com/business/energy/states-must-raise-hydrogen-investment-help-reach-net-zero-iea-2021-10-04/

STEEL PRODUCTION AND HYDROGEN

Globally steel production is still needed, which relies on coal. A barrier currently, is the cost of decarbonising steel production. Steel companies however have started placing their bets on hydrogen to curb emissions, according to the Bulletin of the Atomic Scientists[35]. In steelmaking, hydrogen sets off a chemical reaction that removes oxygen from iron ore, eliminating the need for purified coal in the blast furnace.

HYDROGEN IN MINING MICROGRIDS

Demand for off grid energy has increased in recent years due to growth in the remote mining sector.[36]

Hydrogen offers a useful alternative source of electricity; one that isn't subject to the availability of weather-dependent renewables like solar and wind. Hydrogen production and refuelling can happen around the clock. Fuel cells provide a constant power supply for generators and other equipment. It can also be fed as raw fuel into large-scale furnaces and engines, creating a way to supply temporary, off-grid power. As the technology improves, powering stackable generator units with hydrogen power could allow off-grid users to scale up their local power production into entirely clean, on-site, temporary power plants. All of these suggest exciting possibilities for decentralised power not reliant on the grid. A lot more investment in infrastructure will be needed before hydrogen is fully viable for substantial off-grid applications.

HYDROGEN INVESTMENTS: *Aggreko is accelerating its investments in hydrogen technology. Our first hydrogen power generation units, developed in conjunction with our clean technology partners, have been piloted in field trials in the Netherlands.*

HYDROGEN IN MINING VEHICLES

Some mining companies are already exploring ways to incorporate hydrogen into their fuel mix for use in remote areas. This includes using green hydrogen to create cleaner drop-in fuels to replace diesel. These are already proving to be a practical choice for ultra-class trucks, as well as generators and other equipment.

To learn more about hydrogen and how it is produced download our e-Perspectives white paper.

[35] Gallucci, Maria. Bulletin of the Atomic Scientists. "How steelmaking may go carbon-free – by dropping its addiction to coal", February 5, 2021. Accessed: October 24, 2021. https://thebulletin.org/2021/02/how-steelmaking-may-go-carbon-free-by-dropping-its-addiction-to-coal/

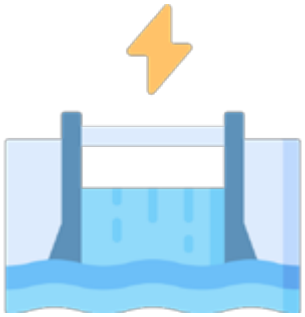
OTHER POWER SOURCES

BIOFUELS

Biofuels, including ethanol blended fuels and biodiesel, are made from vegetable and animal products whereas petrol and diesel are made from non-renewable resources like crude oil. While using biofuels is not new, as technology advances, biofuels are expected to become less expensive and provide a sustainable alternative to fossil fuels.

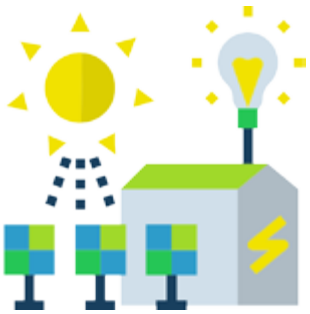
WIND POWER

Electricity generated from wind turbines is already a source of renewable energy on mine sites. Wind power takes advantage of unused land on mine sites and is used to augment the energy supply when the wind is blowing.



HYDROPOWER

Miners already generate a substantial amount of their energy from hydropower. Further developments in microturbine technologies are likely to provide opportunities to recover energy from gravity flow liquid systems within a mine. This will generate more renewable energy.



SOLAR ENERGY

Energy generated by the sun is an effective way of integrating renewable energy at mine sites, particularly at mines with large amounts of unused land.

ENERGY STORAGE

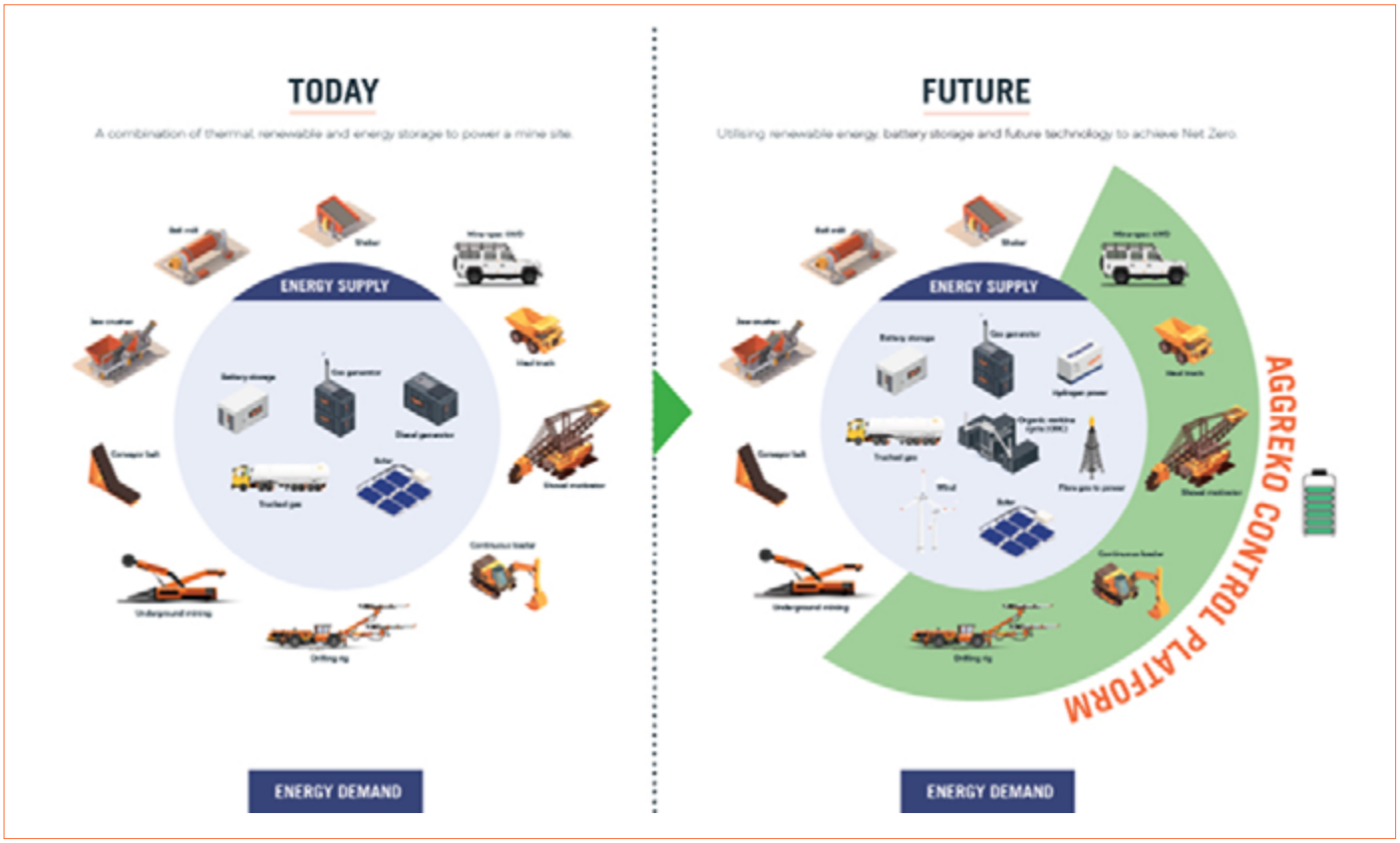
Battery energy storage systems (BESS), pumped storage, and electro-mechanical flywheel energy storage have the potential of being incorporated into a mine's microgrid. The technologies help to level demand by reducing peak loading and storing excess energy generated from renewables.

GAS

There is an increasing trend for miners running on diesel to convert to gas which produces less emissions. There is also no reason why mines cannot add a solar power system, battery storage and wind power, or any other renewable you might find, to the arrangement.

OTHER FUTURE TECHNOLOGY FOR RENEWABLE POWER

Other new technologies Aggreko's team are currently experimenting with include green hydrogen, mobile wind solution using kites, re-deployable solar panels, and tidal wave power. In mining specifically, the team are running demonstration projects with modular and containerised solutions, after securing four major solar contracts to power mines throughout their lifecycle. While bringing the benefits of solar integration, the units will be highly mobile, and provide solar power to mines for a shorter contract duration of below five years. This innovation has the potential to open the door to more renewable power for the mining industry and in locations that previously seemed out of scope. The Aggreko Control Platform is a bespoke software developed for managing the integration between energy supply and energy demand. With a significant shift to Battery Electric Vehicles (BEVs) as highlighted in the graphic below, the way mining customers are using their power is shifting. The Aggreko Control Platform is designed to manage this shift.



A quick look at energy demand vs energy supply at a typical mine site powered by Aggreko now and into the future.

The final word (for now...)

The world's reliance on power – particularly renewables – will grow significantly in the next 10 years. As well as being healthier for the planet, the energy transition is making good business sense for mining companies to become cleaner and greener. We've seen traditional fossil fuel-based organisations reposition themselves to become more integrated energy companies moving into the lower emission sectors. While it's unknown exactly what technologies will be in place by 2050, a key to reaching net-zero relies on miners moving away from diesel to gas and renewable energy in the short term.

Aggreko's offerings such as virtual gas power plants and hybrid power plants incorporating wind, solar, battery will certainly continue to assist miners on their decarbonisation journey. Investing in fixed, long-term power stations will be considered higher risk for mining companies when technology is evolving so rapidly. We expect we will form more partnerships with miners, as the move de-risks the threat of future innovation and technology for their projects and frees up their working capital for profitable uses.

A move to hybrid power offerings is a sentiment echoed across our global networks. In October 2021, we conducted an industry-wide survey with 859 participants to understand what others thought the energy market would look like in the next decade. Some 83% of respondents believed that in the next decade fossil fuels would work alongside renewable solutions, such as biofuels, wind and solar. The majority (69%) believed hybrids would be the number one choice, offering a way for businesses to bridge between fuel sources, ensuring both reliability and emissions reductions.

A full shift to renewable solutions was not a reflection of a lack of appetite. Three in five (65%) viewed the energy transition as an opportunity for their business. Other important considerations were cost, outdated infrastructure and lack of clarity on government commitments and incentives.

Longer term, hydrogen will have an enormous impact on power generation as the logistical challenges are worked out and more can be made. To seriously reshape the future of energy, the industry will need to step up its production, storage and distribution game. At the same time, it's up to tech innovators – including temporary power providers like us at Aggreko – to invest and innovate in hydrogen power conversion technology, so that these producers have a market to sell to. End consumers also need to play their part, by increasing demand for green hydrogen and renewable energy in the first place. Hydrogen is a future energy carrier, but with the right innovation and investment, the potential can start to be realised.

In the next few years we anticipate even greater collaboration between the power sector and mining companies as the world transitions to a greener future. It will be exciting to see the innovations presented as some of the industries' best minds continue to collaborate, invent, and create. If you'd like to contribute to the conversation about powering miners to net-zero, follow us on LinkedIn: https://www.linkedin.com/company/aggreko and use the hashtag **#AggrekoMining**.

aggreko

Aggreko is proud to be guiding miners to net-zero.

By 2030 we will reduce customer diesel use by over 50%, by offering customers cleaner technologies and fuels that guarantee the same or better level of reliability and competitiveness.

By 2030 we will reduce local air quality emissions of our solutions by 50% (this includes all emissions from diesel, gas and other fuels) and achieve net-zero across all our own business operations.

By 2050 we will be a net-zero business across all services we provide.

We are constantly adapting to make sure our focus on a sustainable future is at the forefront of our strategy. We are committed to ensuring that our success also brings long-term social and economic benefits to the communities and countries where we operate.

We'd be delighted to speak to you about your future energy needs.