Mine by design

Michael Schwartz examines whether factoring in climate change during new mine design represents an unwelcome burden, or an opportunity to boost green credentials and economics.

Simon Allen, Technical Director (Energy & Climate Change), Mining Engineer Chris Penna and Mining Analyst Beth Payne have contributed to this article on behalf of Wardell Armstrong International.

Jennifer Berger and Kevin Kammerzell, both Vice-Presidents of Mining, have contributed on behalf of Stantec.

The climate-change agenda has made mine design even more challenging. For Wardell Armstrong International (WAI), a global multi-disciplinary consultancy specialising in the environment, engineering and mining, there are two key criteria: greenhouse gas emissions – the impact of the mine on the climate; and secondly climate resilience – the impact of climate change on the mine. Both require full assessment and understanding with appropriate reduction measures and mitigation subsequently put in place.

To lower greenhouse gas emissions, energy avoidance, energy-efficiency improvements and low-carbon energy sources can all play their part, as can innovative approaches to mine design, technology improvements, and supply chain reductions and improvements.

Climate resilience, meanwhile, "requires the consideration and amelioration of potential volatile weather patterns, such as increased rainfall and flood risk, higher wind speeds, and more prolonged exposure to heat waves and risks of wildfires. Recent examples of the destabilisation of tailings dams from melting permafrost serve as a warning of some of the real-life climate change effects that need to be taken seriously by mining developers going forward".

Stantec is a global presence in sustainable design and engineering and provides consulting services throughout a mine's lifecycle. It asserts that climate-change considerations, "are critical for the mining industry. Mining is in the spotlight, as our clean energy transition relies on mined materials. The hyperawareness in general from consumers and investors on environmental, social and governance (ESG) performance means mining companies are being held to a higher standard in terms of reducing emissions and leaving less of an environmental footprint.

"Mining projects often span 30-50 years of life or more throughout operations. They then require two-five years of closure and 20-30 years of post-closure care – or more. Failure to consider the effects of climate change for nearly a century of operation could result in a significant, even catastrophic, consequence.

"We can't reach a net-zero society if the process of extracting minerals and metals is polluting our planet. Some of the largest contributors to carbon emissions in mining are diesel vehicles, ore processing and ventilation. These are the critical opportunities to reduce emissions as the industry takes active steps to become net-zero."

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Early intervention

Both Stantec and WAI draw on the expertise of government mining advisory bodies, educational establishments and equipment manufacturers.

Stantec believes that the best opportunities for positive impacts happen early in the design process. Whether Stantec is optimising an existing operation or building a new mine, establishing criteria that guide and inform the planning and design phases enables it to consider alternatives throughout the entire mining lifecycle. Designs for tailings dams, drainage infrastructure and water supply require careful consideration of design events and statistical trends in climate, regardless of whether the mine is in an arid, tropical or polar climate.

Stantec's team says, "The mining industry is evolving quickly. We believe it is imperative to be actively participating in the development and implementation of strategies, initiatives, guidelines and industry standards, as well as developing creative solutions for our clients and communities through our innovation strategy.

"We actively continue to scale our partnering ecosystem, comprising commercially available and emerging technologies, so as to better serve our clients...We're excited about ongoing collaborations...in zero-emission haulage, tailings valorisation, remote sensing for performance monitoring of earthen structures, fleet electrification, steady-state ion exchange, surgical mining and more."

WAI has undertaken due diligence works on behalf of various international finance institutions that are Equator Principle compliant, providing bespoke technical input on various projects. This has included consideration of renewable energy projects, as well as resource-efficiency studies, carbon audits and impacts assessments, and various ESG reporting.

The practice retains a close relationship with the UK's Camborne School of Mines (CSM) and its parent institution, the University of Exeter, UK. Former CSM Association and WAI Director, Haydn Scholes, was instrumental in developing the Renewable Energy degree at the University of Exeter back in 2003, and to this day WAI still fulfils guest lecturing slots on the course curriculum.

WAI has also undertaken projects with manufacturers of battery electric mining equipment to help identify the economic benefits of adopting the technology at individual mining operations.

WAI says, "One of the big opportunities for underground mines is moving to electrified underground mining fleets...One of the main benefits is that electric vehicles (EVs) do not generate exhaust fumes, meaning that ventilation requirements are often reduced with an electric fleet. Obviously, reducing ventilation requirements will mean that less energy is required to operate the mine and there will be operational cost savings as a result.

"More generally, electric motor efficiency is significantly greater than that of a diesel engine meaning the overall energy demand is reduced for the same mechanical work output. Modern electric engines also include regenerative braking capability, thus converting expelled mechanical energy back into usable electrical energy for battery recharge.

"For all this, the current challenge remains the comparatively large capital outlay often required to adopt an electrified fleet – an attractive business case cannot be made for every operation. Challenges also exist in adapting established mines to a condition ready and able to accept an electric fleet. Realisation of the full economic benefit may only be possible if their implementation is considered at the initial mine design phase."

Stantec echoes that ventilation needs are being reduced in underground mining. Mines are using battery EVs underground to reduce diesel particulates or are exploring ventilation-on-demand options. Still others are looking to use more natural cooling or heating methods and even cleaning and recycling air when possible.

Stantec says, "Confidence in emerging technologies remains a primary concern. We work closely with industry partners to explore and understand the most viable solutions for each unique challenge."

WAI continues, "On the flip side, climate change is generating more extreme weather events and, as a result, mines need to be designed to be more resilient to the potential changes that will be experienced during the life of a mine. This could mean building in better contingencies against flood events, or installing firebreaks to prevent wildfires, or even accounting for melting permafrost in the design of tailings dams.

"Provided such considerations are accounted for from the outset and form part of the overall holistic design process, there shouldn't be any issues, but failing to account for this due to naivety, ignorance or any lingering climate change denial (see box-out on p43), could prove to be a very costly mistake."

Meanwhile, "like many other aspects relating to climate, [water supply] depends on geographic location", says WAI. "Most mines have large water demands and developing a successful water balance will be an integral part of any mine design...and critical for the acceptance of a mine and its social licence to operate.

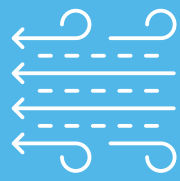
"The correct disposal of surplus and potentially contaminated water is equally important, and difficulties in achieving this can be compounded massively by flood events overwhelming existing infrastructure and facilities. Appropriate design and proper prior preparation is critical, with adaptation to address any future climate volatility a pressing concern".

WAI adds, "Any opportunities to improve the supply of potable water to the local community will be massively beneficial, especially at a time when water scarcity (for many) is likely to become a much more pressing concern."

Stantec notes, "Integration with legacy or existing infrastructure [of all these technologies] can be a challenge. Integrity management can be combined with digital solutions to understand and optimise integration. Comprehensive modelling, digital twins and simulation, as well as virtual reality and augmented reality solutions, can be implemented to understand and manage the interfaces.

"Capital investment is another challenge. Economic pressures, including escalation, pose one of the largest threats to the advancement of projects. Leveraging professional funding specialists can help navigate and prioritise opportunities to secure alternative funding, thus propelling projects forward."

Ventilation is typically responsible for 40% of a mine's electrical power consumption. The efficient distribution of airflow is critical in reducing mine-wide energy demand.



Push and pull

Stantec points out that "climate-change considerations drive the social licence to operate. Communities are demanding improved management practices that do not compromise the future of our natural environments. This ultimately drives the response by regulators".

They highlight, however, the varied form governmental regulations can take and stressed the need for mining-specific international frameworks, such as the Global Industry Standard on Tailings Management or the specific standards within which members of the International Council on Mining and Metals operate (see box-out below).

WAI acknowledges that "government regulations are providing the incentive for change". As an example, it cited a strong motivation for mines in EU countries to replace diesel machines with an electrified fleet due to an EU objective to enforce very low threshold limit value/time weighted averages for nitrogen dioxide and diesel particulate matter at 0.5ppm and 0.05mg/m^3 of elemental carbon, respectively.

Mining leaders commit to support 'nature positive future'

The International Council on Mining and Metals has released a *Nature: Position Statement* and a five-point plan for halting and reversing biodiversity loss by 2030:

1. **Protect and conserve natural environment** – No exploration in World Heritage Sites and respect all legally designated protected areas.
2. **Halt biodiversity loss** – No net loss of biodiversity at all mine sites by closure, against a 2020 baseline.
3. **Collaborate** – Develop initiatives throughout supply and distribution chains to achieve this.
4. **Restore and enhance landscapes** – Around operations through local partnerships, including with Indigenous Peoples, land-connected peoples and local communities.
5. **Catalyse wider change** – Acting to change the fundamental systems that contribute to nature loss and fostering opportunities for nature's recovery.

This applies to all 'four realms' – land, freshwater, oceans and atmosphere – and is supported by transparent disclosures on performance outcomes, including publishing the results of nature-related impact and dependency assessments, and setting targets to address these.

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EVs are being seen by many mine operators within the EU as the most feasible way to address the challenge of complying with these new concentration limits. Some operators perceive difficulty in meeting the guidelines with diesel equipment, even if fitted with a Euro VI compliant engine. Euro VI is the cleanest emission standard for heavy vehicle diesel engines sold within the EU and the European Economic Area.

WAI points out that, "more often than not, it is the guidelines of the financial institutions that provide the real driving force. The Equator Principles, International Finance Corporation Performance Standards, and European Bank for Reconstruction and Development Performance Requirements have brought about specific thresholds and demands that must be met to qualify for finance.

"Initiatives like the Taskforce for Climate-related Financial Disclosure are forcing investors to consider embodied carbon and upstream and downstream supply chain emissions on top of direct emissions from the mining activities. This more holistic approach means that a far greater level of transparency is afforded, which not only allows investors to make more informed and conscientious decisions, but also makes it much clearer the projects that are more likely to carry reputational risks and bad PR."

Stantec claims climate change has impacted costs as investors are looking for confidence and return on investment. "Solutions need to drive value and be fit for purpose, while reducing greenhouse gas emissions to build more sustainable operations. Prioritising strategies is essential for managing costs while optimising mitigations. On the other hand, when done properly, sustainability is not an added cost – it is a collection of practices and solutions that reduce waste and drive profitability."

To sum up, "Planning for climate change is not optional. Consumers and investors are pushing for it. For greenfield mines, the CapEx is not sufficiently higher than traditional mines. For brownfield or already operating sites, investing in new equipment may be a bigger hurdle but having a payback period of even a few years is great",

WAI believes that cost implications are invariable when examining new or alternative ways to reduce carbon emissions and to adapt to climate changes. However, the firm points out that focusing on the cost of an additional study is to miss the bigger picture – there are huge potentials for savings from moving to lower-cost renewable energy options, particularly where these avoid (or at least reduce) the requirements for fuel supply.

> *A modern approach to mine closure is to appreciate that the mine has given everything it can to us and now it is entering its next chapter."*

Renewable energy (wind and solar in particular) is now seen by WAI as one of the cheapest forms of power generation, outperforming coal, oil and gas. That is not to ignore their limitations – the wind is not always blowing, the sun is not always shining and, in most cases, there will be a need for either some form of energy storage or some back-up power supply. However, the ability of these technologies to reduce costs as well as carbon mean that they deserve serious consideration.

WAI also points to various studies, from the *Stern Review* back in 2006 and to many more since, which have noted that the cost of doing nothing will be higher than the cost of taking action now. This applies at national level but can also apply at project level. Some pragmatic investment at the start may help avoid a lot of headaches further down the line.

Can automated software help?

Although artificial intelligence (AI) is rapidly advancing, there is no single automated piece of software that will design, specify and fully calculate all the necessary parameters relating to a low-carbon mine. There are various software tools that can be employed to help with the process, but ultimately mine design, climate resilience and low-carbon optioneering all require dedicated specialists and human input.

WAI notes that it has access to various specialist forms of software to assess climate impacts and renewable energy feasibility. They include Life Cycle Analysis software tools for whole-life carbon impacts, although the company would generally approach carbon auditing for mines using its own bespoke models.

Windfarm and PV Sol feature among the software used to help design wind and solar installations, while in-house hydrogeologists use Modflow to help simulate and predict groundwater conditions and groundwater/surface-water interactions.

More specifically, WAI's mining engineers use Datamine and Deswik to aid mine design, mine planning and scheduling. The software enables multiple iterations to focus on key issues such as reducing mine waste production or optimising the operating fleet. While Ventsim software helps model mine ventilation.

Stantec notes that automation advances in technology and simulations can assist, however, "we need to make sure we properly set up the technology to make sure it is measuring, or simulating, the right things. For example, anyone could use AI, but if you do not adjust it to what you need, it might not be helpful for you. So, as we grow and adapt technology, we also need to confirm that the technology is being applied in a way that makes sense. We need to go through a robust validation process to ensure it is adding value".

Mine restoration

For WAI, mine closure presents an additional opportunity for mines to leave a lasting legacy within their host community. Remediation and restoration are now seen as important parts of a mine's lifecycle. And renewable energy systems installed to serve the mine may have operational life left at the time of closure – promising to gift such a valuable resource to the local community may be a great way to engender support for the mine and help gain its social licence to operate.

Other important opportunities that could be developed through a mine closure include activities to improve climate resilience in the local area, such as by installing attenuation features and/or other flood defences to help prevent localised flooding, or producing enhanced opportunities for ecosystem services for the betterment of resilience to drought or starvation.

Finally, rehabilitation may involve planting trees and plants that will help sequester carbon for years to come, putting back into the ground some of the greenhouse gases that have been released by the mining activities.

Stantec makes its view clear. "Yes, proper mine planning requires a progressive closure and rehabilitation plan before the mines are even built. Unfortunately, the truth is there are still legacy abandoned mines that require extensive environmental remediation. Closure needs to be considered at every stage of mine development, design and operation. It is complex and involves a multi-disciplinary and integrated approach to planning."

And the future?

WAI notes that more and more mining operations are looking at options for installing onsite renewable energy to help supply their needs. Wind and solar photovoltaic are the primary technologies, but hydropower, geothermal power and solar concentrators are contenders as well, albeit highly dependent on local topography, catchment areas, geology and insolation levels. Energy storage is another big growth area. Battery storage is leading the way, but flywheel storage, compressed air and hydrogen storage are all emerging onto the scene.

Stantec sets out its own observations. "It is exciting to see more nature-based solutions enter into the picture. In general, reducing waste and energy use is going to be more of a theme in the coming years, and that is exciting too. In addition, the future of mining is knowing how you are going to close a mine. That wasn't always the case. In the past, many mines were abandoned. Today, mines must have a closure plan in place before they even begin. A modern approach to mine closure is to appreciate that the mine has given everything it can to us and now it is entering its next chapter."

Climate change has brought yet another highly important consideration to mining. It is up to the industry to welcome climate change as an asset during mine design and not a burden.

Combatting climate change denial

Wardell Armstrong International (WAI) acknowledges that there are still undoubtedly some climate deniers in the mining industry, but acceptance of the reality of climate change is definitely becoming more mainstream. There is a greater understanding now of the opportunities afforded by the innovations designed to help address climate change.

Additionally, "the adoption by some of the majors of various renewable technologies has seen them become more credible against denial, and therefore influential over the rest of the industry. But really the tipping point has been the understanding of the economic benefits that some of these technologies can deliver," notes WAI.

"The best way to deal with climate denial when it arises is to demonstrate how, irrespective of the environmental benefits that can be delivered, there are cost benefits that make adopting a proactive stance the only smart option. It is amazing how quickly sceptics can be turned into believers when it benefits their bottom line..."

Engineering consultants, Stantec, adds, "In mining, risk management is a mature and well-understood process. We identify and assess risks and implement controls on a daily basis. Applying this principle to climate change simplifies the discussion and allows for informed decision-making.

"The nice thing about operating more sustainably is that often reducing waste and requiring less energy are also less expensive. So even if someone is not 'sold' on why it's good for the environment, it also has appealing financial savings.

"In one example, we designed a model that increased throughput and reduced delays at a site in Western Australia. US$2mln was required to adjust chutes, add screens, replace motors and replace other minor equipment within the plant. These improvements resulted in an additional 2Mt/y flowing through the plant. Being more efficient means less wasted energy."

The capital outlay required to adopt an electrified mining fleet can be prohibitive to many operations. Individual equipment items may cost more than 30% more than the diesel engine equivalent with additional outlay required for the battery supply, maintenance and charging infrastructure. Operators that adopt the technology expect the outlay to be paid back in:

- Operating cost savings, i.e reduced energy demand and equipment maintenance costs.
- Improved equipment productivity from high-powered electric drivetrains, leading to greater acceleration, traction control, breakout/lifting capacity and ramp speed.
- Reduced capital cost in other areas such as ventilation raise excavation or air conditioning requirements.

Such cost trade-offs will invariably be specific to the individual operation and so must be conducted on that basis.

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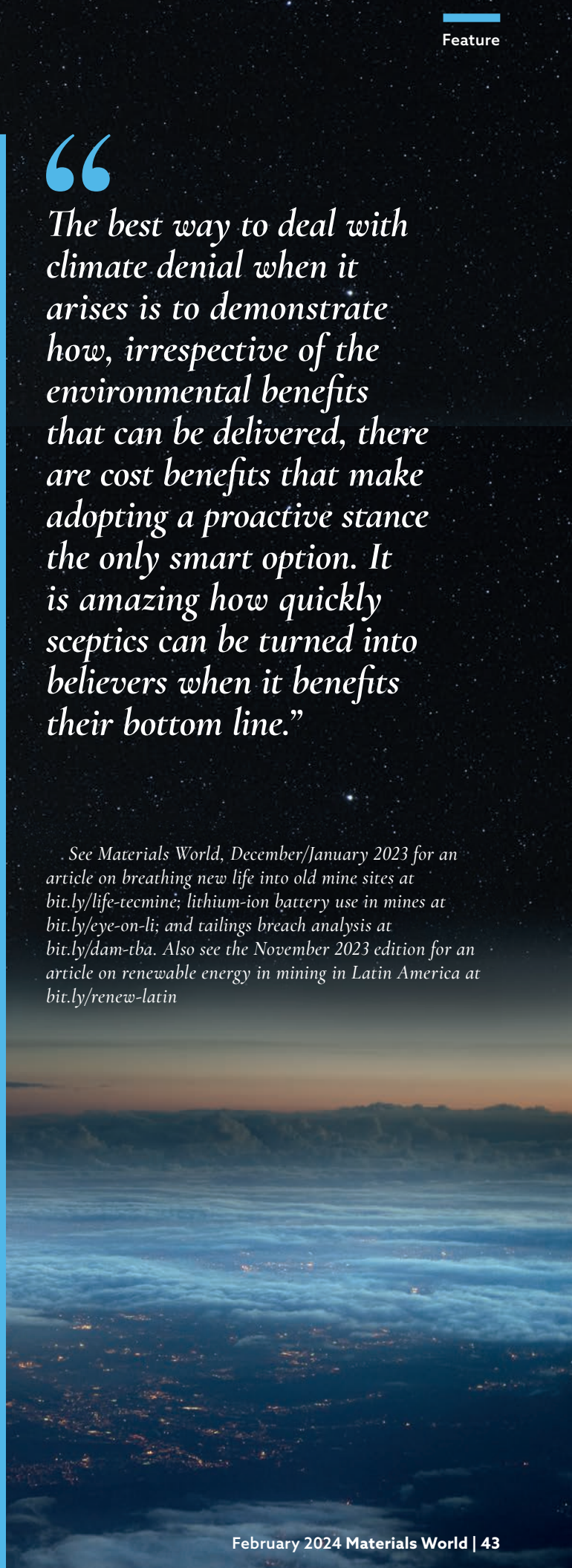
See Materials World, December/January 2023 for an article on breathing new life into old mine sites at bit.ly/life-tecmine; lithium-ion battery use in mines at bit.ly/eye-on-li; and tailings breach analysis at bit.ly/dam-tba. Also see the November 2023 edition for an article on renewable energy in mining in Latin America at bit.ly/renew-latin



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