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Chilean mining's new regime

The Chilean government offers new regulatory clarity

According to recent data from the US Geological Survey, Chile has the largest copper reserves of any country by a wide margin. The country has 190 million metric tons (t) as of 2022, which is nearly double the reserves of second-placed Australia. The reserves guarantee copper production for the next century at the current rate of extraction.

The largest factor inhibiting Chile's full-throttle development of its already strong and established copper industry has been a lack of legal certainty. The country dropped significantly in the Fraser Institute's index of economic freedom, from 13th in 2019 to 33rd in 2022. Investors, wary of civil unrest and regulatory uncertainty, have been hesitant to move into Chile.

Pablo Peñaranda, director of business development at Black & Veatch, stated: "It has been forecasted that by 2031 at least US$74 billion in investment will be required for the Chilean mining industry to keep up with demand. However, approximately 60% of mining professionals and executives believe achieving this investment is not probable."

If the investment flowed in, however, the industry has the capacity to utilize it. Peñaranda continued: "There are enough resources and capacity to develop at least three new greenfield projects every year."

Fortunately, over the first three months of 2023, the mining industry received positive signals from President Boric's largely resource-nationalist administration. How investors will respond to these shifts remains to be seen.

The royalty reform is limited at last

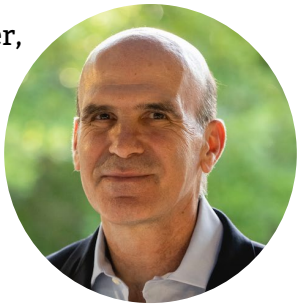
In early September 2022, President Gabriel Boric's proposed new constitution came to a referendum, where it was soundly defeated. The mining industry breathed a sigh of relief, as the proposed constitution would have dramatically dampened investor certainty. The proposals included a change to water use, which would be regulated via authorizations, rather than property rights; the prohibition of mining near glaciers without a clear definition for a glacier, potentially prohibiting projects such as Codelco's Andina; plurinational governance that would dramatically increase permitting requirements and the number of players involved in any given project; and a change in mining concessions for administrative approvals.

With the constitutional referendum's failure, a major crisis for the industry was averted, but the industry has spent much of 2022 and early 2023 concerned about changes to the royalties system. The proposed royalties bill, which was approved by the Mining and Energy Commission in early January 2023 and is now in front of the Treasury awaiting approval before it goes to final vote, is intended to reform taxation of the mining industry.

The proposal, modified by the government in October 2022 in response to industry protests, includes a flat rate ***ad valorem*** levy of 1% on copper production above 50,000 t/y and a tax rate between 8% and 26% on operating profits after depreciation. This tax burden, although an improvement upon a previous version which tied taxes to copper prices, is much heavier than amongst Chile's competitors. According to mining association Sonami, the effective tax rates in Australia, Canada, and Peru are not higher than 45%, while this tax would create a tax burden above 55%.

"We used to have 33% or 34% of the world's copper production and today we are at 26%. Demand will keep growing, and we will keep dropping because we do not have new projects."

Phillippe Hemmerdinger, President, APRIMIN



"Putting a royalty tax on sales is the same as raising production costs," said Manuel Viera, CEO of Metaproject. "Raising the costs will leave existing minerals in the ground because mining them is no longer economically viable. This reduces the life of the mine, in turn reducing revenue for the state."

It is more development within the mining sector, not higher taxes, that will increase the state's coffers and enable the Boric administration to fund its ambitious social plans. Viera continued: "It is vital to find the equilibrium point at which the government can maximize the funds it raises for social development and ensure that a mine is still sufficiently profitable for the owners."

The government has at last recognized the importance of a healthy mining industry. On March 21st, 2023, Finance Minister Mario Marcel expressed the intent of the administration to limit the mining royalty bill. One adjustment, Marcel said, is to include start-up expenses as a cost for the calculation of the adjusted mining operational taxable income. A second adjustment would establish a limit to the possible tax burden for all the various taxes combined. And, importantly, the modifications would exempt companies with operating losses from the ***ad valorem*** tax. Marcel stated: "When there is a very low or close to negative profitability, the same ***ad valorem*** component is also adjusted."

Productivity remains a challenge

To understand the current state of the Chilean mining industry, it is necessary to take a step back from mining-specific legisla-

tion. President Boric and his supporters have seized upon their electoral mandate as an opportunity to make wide-ranging transformations to the current Chilean system. Alicia Domínguez, tax consulting partner for Ernst & Young Chile, said the industry is also impacted by other reforms, especially the tax reform. She said, "The pension reform and the discussion of the new constitution are also flanks of normative discussion, generating spaces of uncertainty."

"The conversation in the mining industry primarily revolves around the royalties bill, but to discuss reforms, we need to put everything on the table, including labor, pensions, and health," Philippe Hemmerdinger, president of APRIMIN, agreed, noting however that the government's wide-ranging reforms have met with significant resistance: "The government came in with a revolutionary program, but over the past year, the country has communicated that it is not willing to accept such drastic constitutions or reforms."

Considering that wider public pushback, the greatest success for the government among these reforms is the 40-hour bill. Currently, Article 22 of the Chilean Labor Code allows for a 45-hour work week, divided into a minimum of five days and a maximum of six. The new bill will reduce the maximum weekly working hours to 40, which is comparable to the OECD average. However, Chile's worker productivity in terms of average hourly contribution to the GDP is below OECD average. According to OECD data, in 2020, each individual Chilean worker contributed US$30.4/hour hour to Chile's GDP. At this productivity level, of the 39 member states, Chile ranks 36th, with productivity well below the OECD average of US$54.5/hour.

Productivity per dollar spent is a major challenge for the country and the mining industry. On one hand, this is a nationwide problem – despite the country's stability, the education system has low levels of achievement in English, math, and other areas. It is also specific to the mining industry. Germán Millán, a partner at PwC, explained: "Compared to mining jurisdictions such as South Africa, Australia, and Canada, we have much lower productivity and outcome levels per person for every dollar spent on the workforce."

This lack of productivity has resulted in a slower development of local capability in the services industry. Millán continued: "A significant proportion of the mining services value chain is international players with a local presence rather than locally developed companies. In jurisdictions like Australia, a great part of mining services providers are Australian companies."

Chilean mining's productivity problem provides a window of opportunity for an industry-wide rethink of systems and processes. Historically, the mining industry has been comparatively risk-averse and slow to develop. Now, however, necessity is opening doors. On all levels of the Chilean mining value chain, from camp construction to drilling, new technologies and innovative approaches are filtering through the industry, building a more efficient mining sector. ■

Copper

Low productivity reduces output

Despite significant enthusiasm for copper early in 2023, recent copper prices have fluctuated drastically in response to global financial uncertainty. Chaos across the economy, triggered by the collapse of Silicon Valley Bank and the emergency merger of UBS and Credit Suisse, led funds to dump their bets on high copper prices. Despite positive projections for copper from Goldman Sachs and others, fund managers fell victim to fear of contagion radiating out of the banking sector and cut their exposure to copper.

However, this temporary shorting of copper did not last. By March 28, investors' fears were assuaged by the announced buyout of Silicon Valley Bank by First Citizens and a larger calming of the international banking sector. On New York's Comex market, copper reached US$4.11 per pound (US$9,042 /t), while on the Shanghai Futures Exchange it reached US$5.07 per pound (US$10,135 /t).

These fluctuations are no surprise to industry leaders interviewed for this report, but copper projections are overwhelmingly positive. "Over the next six months, we will see some price fluctuation in copper, most likely in the range of US$3.85 to US$4.50 per pound," said Alastair McIntyre, president and CEO of Altiplano Metals. "Once the Federal Reserve makes its decision to stop or slow the pace of rate hikes, then you'll see the USD further weaken and copper prices back over US$4.50."

McIntyre was not alone in his bullish perspective on copper prices. Martin Valdes, partner and head of Private Equity Fund VII at Resource Capital Funds, explained that by 2025, he expected copper to stay about US$4.00 to US$4.50, stating: "I know the consensus is probably more around US$3.70, but if you take a look at the different equity research channel analysts, all of them are out there. Everyone is quite keen on copper."

Valdes continued: "There are currently 22 million t/y of copper production in the world, which is expected to increase to 28 million t/y by 2030; essentially, that is as if the world added another Chile. The aggressive projections on demand are impressive, and supply will be the bottleneck for copper, so copper is a significant investment area in our portfolio."

Permit rejections dampen enthusiasm

The positive steps in the tax arena address only part of the uncertainty plaguing the industry. The country's ideological approach to permitting remains a concern. In January 2023, Chile's Committee of Ministers officially denied permits for Andes Iron's US$2.5 billion Dominga project on environmental grounds. However, within the mining industry the decision is seen as purely political. Rejecting the Dominga project was a campaign promise of President Boric, and he expressed his distaste for the project in his very first speech after winning the election.

"There will be no growth in the country without investment, and we are putting brakes on the industry's development. If there are no new projects, there will not be jobs in the many different industries that revolve around mining."

Manuel Viera,
CEO,
MetaProject

In a press conference, Nicolas Grau, the Minister of the Economy, rejected claims that the decision would dampen investor enthusiasm, saying: "When you see the wide range of investment projects that are being developed in the country, you see that this protection of the environment, and more specifically our contribution to the fight against the climate crisis, outside of being an obstacle, will be an opportunity and a catalyst for both national and foreign investment."

However, the Dominga rejection was part of a pattern. It followed on the heels of the environmental regulator's rejection of Anglo American's US$3 billion Los Bronces expansion in May of 2022. This mine is one of the two largest copper operations owned by Anglo American. Over 150 years old, it is running out of high-grade ore, a problem facing a wide range of mines in the country. The expansion was designed after a decade of studies and consultation with the surrounding community. In a period of decreasing grades, rejecting the company's intention to exploit higher ore grades of 1.7% underground and extend mine life through 2026 was received poorly within the industry.

Miguel Zauschkevich Domeyko, president of the Cámara Minera, Chile's mining chamber, criticized the willingness of purely political bodies such as the Committee of Ministers to intervene in decisions made by the Environmental Assessment Service (SEA), saying: "Such situations create uncertainty and reduce the country's competitiveness and attractiveness for investment. The problem is not the regulations' rigidity or the requirements, but the permitting process's uncertainty."

The general sentiment is that the mining industry can meet almost any regulatory requirement, but it must have reasonable certainty that if that requirement is met, the project will be approved. Manuel Viera, CEO of Metaproject, agreed, saying: "The

ministerial committee should not exist because the political decision prevails over technical opinion. Anglo American is one of the largest mining companies in the world, and this sort of behavior gives Chile a terrible image in the eyes of investors."

Environmental permitting challenges are not just a problem in Chile, but for Chilean operations across the region. On March 29th, 2023, Codelco lost its environmental license for the Ecuadorian Llurimagua copper project. Codelco's local partner in the joint venture, Enami, is now required to provide a new environmental impact study.

Chile still copper king despite diminishing grades

Chile's production levels fell in 2022, reflecting larger productivity issues. On February 3rd 2023, Cochilco announced a monthly drop in copper production of 0.5% in December of 2022, to 495,800 t/m. This short-term drop was part of a full-year decline of 5.3% in copper production on a year-to-year basis, to a total of 5.33 million t/y produced in 2022. This includes a 10.1% drop in output from Codelco and a 9.4% fall from Collahuasi on a yearly basis, although Escondida's yearly output rose by 4.2%.

The outlook for next year is mildly more positive: Cochilco estimates that in 2023, copper production will grow by 7.5% to 5.7 million t/y. Several brownfield projects are expected to be completed this year, increasing production. Yet from a more long-term viewpoint, production levels are unsatisfactory.

A government report, viewed by Reuters, showed that copper output is expected to peak at 7.14 million t/y in 2030, two years later than expected due to project delays (a decade ago, the regulator had predicted a 7.62 million t/y peak in 2028). This projection for the future reflects the present reality; production is below where it should be as productivity lags. After the 2030 peak, production is expected to drop, because mines will close and there are insufficient greenfield projects coming up to replace them.

In the large mining sphere, interest from global companies continues despite Chile's current challenges, demonstrating the country's enduring reputation as a stable and reliable copper producer. At the end of March 2023, Lundin Mining announced that it will purchase a majority stake in the Caserones copper-molybdenum mine in from Japan's Nippon Mining & Metals. The deal, valued at US$950 million, demonstrates the Canadian company's confidence in the country. In a statement, Lundin's chief executive, Peter Rockandel, said: "The initial controlling interest increases our exposure to what we believe is a growing top-tier copper mining district."

In the mid-sized production sphere, the Pampa Camerones project is performing well, with Minería Activa investing in developing the processes at the mine. "We implemented a copper chloride leaching process, which allowed us to increase our extraction rates. We developed this project at the end of 2021, and it has been operational in 2022 with great success," said Pedro Linaza, CEO of Minería Activa. "Minería Activa is also working on a new environmental permit to reach a new production level to treat 60,000 t/m of ore."

Linaza sees high potential in the mid-size, high-grade project area, which he feels has been underdeveloped in Chile. Mid-sized mines require a smaller Capex, and see more rapid return on investment, while still having higher payoffs than small mines. "These types of projects are more aligned with how the world will see the mining industry in the future. It is a very different experience to have a huge open pit nearby compared to a small underground mine," Linaza stated, continuing: "The footprint will be less invasive to the local community and have different impact levels."

In the small-scale mining area, Altiplano Metals is seeing improved grades the deeper it goes, compensating for the extent to which it is more expensive to haul materials. The company, which has been underground at its Falleron site since 2018, expects to complete its own processing plate in the next few months. McIntyre, Altiplano's CEO, stated: "Altiplano has the utmost confidence in Chile, particularly in the small-scale mining space where we operate at under 5,000 t/m."

In addition to the extensive brownfield projects being carried out at larger copper mines, many small and junior companies are actively engaged in pursuing projects. For example, Golden Arrow recently announced significant planned activity at its San Pietro project, which has four main targets, and began a drill project in the first week of February 2023.

Pampa Metals, likewise, is taking advantage of highly experienced Joseph van den Elson joining the board in Q4 as President and CEO, driving the companies recently closed $2.2 million raise. Tim Beale, Pampa Metals' vice president of exploration, stated: "The money will enable us to drill our priority project, Block 4. I expect us to be drilling at Block 4 sometime in early April 2023."

The Cámara Minera is actively working to support the interests of small mining to compensate for the challenges of decreasing ore grades. Zauschkevich Domeyko explained: "Small mining is any mining activity that exploits up to 5,000 t/m. However, the refined copper produced from 5,000 t/m is now less than 30 years ago, so we are promoting updating this concept to increase it to 10,000 t/m, considering the decrease in mineralization."

The regulatory and tax burdens on small mines are significantly different, and this would be a welcome change for the industry.

In addition to new projects, Chile can use new technology to grow in the secondary mining market. Hemmerdinger of APRIMIN stated: "In secondary mining, we have a potential of 50-60 million tons of copper to recover that are in the tailings or other waste. We must turn to that because that's 10 years of production readily available."

A creative approach to increasing output, using all the copper available, will enable Chile to make up for some productivity challenges.

Concessions landscape: Law 21,420

In November of 2022, law 21,420 was submitted. Although covering several areas, the law would primarily impact the mining industry by changing the concessions system. At the moment, companies pay an annual payment for a patent with the right to explore or exploit. The changes would increase the grant term from two years to four years; however, renewal would no longer be an option. Although patents would remain indefinite, there would be stronger requirements for the companies to demonstrate that the value of the patent was being increased. Additionally, the amount of the license would increase from 1/50 Universal Transverse Mercator (UTM) to 3/50 UTM. The value of licenses is maintained only for those that demonstrate effective work.

The Cámara Minera and smaller mining players have come out strongly against the law. Zauschkevich Domeyko stated: "Multiplying the value of the patent by four would imply the bankruptcy of small mining and would put medium mining in trouble. Although we were able to get the authorities to postpone the implementation of this law for one year until 2024, there is still a need for further discussion on these issues."

However, although the law would be challenging for exploration companies, many members of the mining community see it as a step forward. Domínguez of Ernst & Young argued: "The changes may be positive in certain aspects because the current legislation allows people to hold onto the land without exploring; the current rules allow a company to pay to indefinitely hold onto a concession without exploring or developing a project."

For her and others, this modernization of the law will combat Chile's productivity problem. "The biggest challenge is increasing production," she said. "There will not be new mining projects if we do not incentivize exploration. So, these changes in concessions may be an incentive for new exploration." ■

Lithium

Public-private partnerships are the future

Lithium is the mineral of the moment, providing Chile and Latin America with a unique opportunity. At the Community of Latin American and Caribbean States (Celac) conference in July 2022, foreign ministers for Argentina, Chile, and Bolivia discussed the creation of a "lithium OPEC" to maximize the opportunities provided by soaring demand, an idea which President Luis Arce of Bolivia emphasized again in a speech in March 2023. Although there are serious questions about whether such an organization could come to fruition in the face of pushback from environmental groups and other parties, the high-level conversations demonstrate the new determination of the region to take advantage of lithium resources.

Chilean lithium producers are raking in profits. In March 2023, SQM announced that it had earmarked US$3.4 billion in new Capex by 2025, with the intention of boosting production capacity of lithium carbonate from 180,000 t/y to 210,000 t/y. This is no surprise considering the soaring profits the Chilean company experienced during last year's lithium price boom. In 2022, SQM's income amounted to US$3.9 billion, a transformational growth compared to 2021's US$585.5 million.

Although lithium prices have been sinking since the record high in December 2022 of over US$82,225/t, the outlook for lithium remains excellent. Marcelo Awad, executive director

of Wealth Minerals, stated: "I would estimate that the long-term price is around US$40,000. However, based on market analysis and information available, I foresee a second shortage that may last longer, at least a few years, between 2025 and 2030. Due to the electrification transition and the number of consumer plants under construction that will be up and running around early 2025, the demand for batteries will jump."

The green transition drives demand

The US Investment Reduction Act, signed by President Biden in August 2022, included significant incentives for electric vehicles production, which are expected to lead to a dramatic boom in demand. That boom will directly influence the Chilean market.

Marcela Hernando, Minister of Mining, Government of Chile

Marcelo Awad, Executive Director, Wealth Minerals

Aldo Boitano, CEO, CleanTech Lithium

Aldo Boitano, CEO of CleanTech Lithium, said: "Our focus is to supply battery grade lithium to either the EU or US. electric vehicle markets, taking advantage of the recent Inflation Reduction Act in the US. The US only allows the benefits to go to countries with free trade agreements, which includes Chile. The Act is an excellent opportunity for us."

Electric car manufacturers are aware of the competition they will face to access battery minerals and are now knocking at Chile's door. For example, in February 2023, Tesla executives met with Chilean government officials, including the ministers of foreign affairs and mining, as well as with Albemarle executives.

Control of lithium and access to battery metals is, of course, a geopolitical concern. In the race for electrification, it is one that China is handily winning, with the country buying 70% of lithium compounds and supplying 70% of lithium production, despite holding less than 7% of the world's lithium reserves. Six of the top 10 lithium battery makers in the world are in China.

With batteries considered a new battlefield in a geopolitical race for control over the energy transition, the US and other Western countries are rapidly moving to enter the game. Self-sufficiency in raw materials is at long last a major priority for these nations, and the competition will only increase pressure on existing and future lithium production.

The government teases a lithium framework

Considering the opportunity, Chile's lithium industry is severely lagging. This is largely due to legal uncertainty, which has inhibited private investment. According to the Chilean constitution, lithium is a strategic metal, which means that it cannot be exploited by a private company.

For many years, the government has promised clarity on the rules for the lithium sector which have not come. "In the time that Wealth Minerals has been waiting, of the 17 companies that were in the space when we started, nearly 15 are out now because they decided not to continue pursuing Chile as an investment destination for lithium or they could not afford the administrative costs of maintaining the company," said Awad.

One need only look across the border to see the missed opportunity. Unlike Chile, Argentina has actively courted foreign investment in lithium, and according to JP Morgan, it is expected to go from supplying 6% of the world's lithium in 2021 to 16% by 2030. In this scenario, Chile will be bumped from its perch as the No.2 lithium producer in the world by 2027.

Chile's stability and infrastructural strength ensure that, were the rules clarified and liberalized, investors would flock to the country. After much delay, this March the government has begun to lay out the rules of the game. An official framework will follow, but statements from key government figures have given the industry a sense of what to expect.

In some respects, the plan is much as players in the industry have long assumed: the Boric administration plans to create a state lithium company, which will then partner with private firms to develop new lithium projects. In an interview with the radio station Cooperativa on March 6, 2023, Mining Minister Marcela Hernando said: "We are clear that the State is the owner of lithium, and for the President, that is not transferable. State companies will sign agreements with private parties."

In one way, however, the administration's plan is unusual. The government plans to require all new lithium projects to use Direct Lithium Extraction (DLE), a lithium production technique in which brine is reinjected back into the salt flats. This process utilizes significantly less water, which is crucial in a land defined by droughts and water scarcity. The technique has many potential benefits, but has not been tested commercially at scale, so to demand that all future projects utilize a technically challenging and comparatively unknown production process is a risk.

However, DLE projects are already in development in Chile. CleanTech Lithium has planned since its beginning to produce via DLE. CleanTech's CEO Boitano spoke enthusiastically of the technology's benefits, saying: "The recovery of the resin level is around 95%. The traditional method in the Lithium Triangle requires seven evaporation pools in a batch process, which takes over 315 days, while with DLE, it takes less than 24 hours. Additionally, drying out the subsurface aquifer is unnecessary because the spent brine is reinjected. DLE has an extremely high recovery rate, lower Capex, takes a shorter time to market, uses significantly less water, and leaves a smaller footprint on the area."

This all-in bet on DLE is risky, forcing investors to either go all in on an unfamiliar technology, or stay out of the Chilean lithium market entirely. It will undoubtedly dissuade some investors from participating. That being said, demand for lithium is so high that investors needed only clarity to engage, and after years of delay, that clarity is here, and the game is on. If DLE can be successfully implemented at scale across the country, Chile will be a leader in green lithium production. After years on the sidelines, the country is poised to be the source of choice for battery metals users across the world, standing at the forefront of the energy transition. ■

Engineering, Construction, and Consulting:

Renewable energy generation and desalination drive sustainability

Engineering, construction, and consulting firms have had a busy 2022, despite the lack of new projects. With a need to optimize operations and expand existing mines, mining companies have a slate of projects for which they need extensive support.

"After the release from Covid restrictions, we observed a boom in Stay-In-Business projects (SIB)," confirmed Patricio Maguire, director and Latam lead of digital transformation at Turner & Townsend. "Large projects work on slow timelines with lengthy permitting processes. However, after Covid, there has been a release in new phases of projects utilizing the money that was not spent during that period."

Tailings is one area where companies must comply with extremely strict regulation. Hugo Andrade, CEO of Shimin, which has operations in both Brazil and Chile, noted that Chile has significantly stricter regulation and, therefore, safer tailings dams than Brazil. Brazil, reeling from the Brumadinho collapse, is changing its tailings completely. "The solution in Brazil is filtering everything and transitioning to dry tailings deposits," stated Andrade. "However, this is extremely expensive, so much so that it would dramatically raise production costs. I do not expect the Chilean mining industry to transition to dry tailings en masse for a long time. There needs to be an intermediate solution because the market will not pay for the most expensive option."

Rosario Urrutia, country manager at Stantec, agreed that such a switch will be slow: "ICMM is doing vitally important work for the future of tailings management. Conventional tailings are associated with high water consumption. Other alternatives, such as thickened tailings, considerably reduce water consumption. However, these trends involve significant investment as they imply fundamental engineering and energy consumption challenges."

As mining, engineering and construction demands become more complex, digital and data analytics technologies are coming to the forefront. Data analytics is an area where many mining companies are expressing interest. "The mining industry has historically depended on deductive models," explained Juan Ignacio Guzman, CEO of GEM. "However, as the mining industry has become more complex because minerals are located deeper underground and have more complex properties, creating a deductive formula has become impossible in some areas. Analytics uses the computational capacity to look for patterns in the data without having a theoretical model to determine how the variables behave in certain circumstances."

In construction, the move towards a more technologically advanced industry has been particularly slow. "Construction is the fourth least digitalized industry among 100 industries. When it comes to adopting technologies, there is an extent to which resistance is cultural. If something worked in the past, construction workers tend to keep it the same," said Maguire.

This delay in adaptation of digital tools is something STRABAG and Züblin is well aware of. Not all digital tools the company has tested have changed productivity levels, explained Mairo Theurl, managing director of STRABAG and Züblin: "Our strategy is to make sure that these tools have a direct impact on our productivity and it is crucial that our people are convinced of its benefits in the first place to have a successful result."

Renewable Energy

On March 16, Chile and Peru formed an alliance to develop a roadmap to promote green hydrogen usage in mining, as part of the drive towards a carbon neutral industry. Green hydrogen is one of a variety of renewable energy sources contributing to the Chilean mining industry's shift towards cleaner energy. Chilean mining companies' clean power purchase agreements signed during 2022 totaled 40% of their total energy consumption, with that rate estimated to reach 65% in 2025.

On a wider scale, the Chilean government has not actively supported the renewable energy sectors. Sergio del Campo, director of operations at Sonnedix and former Chilean Minister of Energy, stated: "In Chile, there are no subsidies for renewable energy—at least not at the magnitude of subsidies in Europe or Asia. Therefore, you must compete with your technology like any other energy generation technology, from coal power to hydrogen. This makes Chile's energy market one of the world's most competitive."

Green hydrogen, wind, and solar are all rapidly increasing, but they are only some of the renewable opportunities reaching the market. Each of these areas needs a dramatic increase in investment to meet demand, and there are a significant and encouraging number of projects in the Chilean pipeline.

However, a creative approach to renewable energy drawing from successes in other regions of the world is possible. Pascual Perazzo, regional commercial director of Carpi Tech, a company that specializes in waterproofing solutions for dams and tailings dams, highlighted the potential for pond storage in Chile. The company has already worked on several pond storage projects in Europe and has experienced interest for the energy system in Chile, although none are yet in construction.

Pond storage operates like a battery, turning wind energy into storable energy. Perazzo explained: "In this system, the operator pumps water to the top of a hill during high wind and solar energy output. When wind or solar energy is reduced, the water is released through a turbine, producing electricity. This electricity can be sold at a higher price because it is produced in a moment of peak demand."

"Achieving carbon neutrality is a top priority for our company. We are therefore actively taking steps in this direction. We believe that the path to a carbon neutral future will only be successful if the construction and mining industries recognize the need to reduce their emissions to leave a better world for future generations."

Mario Theurl,
Managing Director,
Strabag Züblin

The system addresses one of the primary challenges facing solar and wind: the unreliability and inconsistency of energy production. Perazzo said: "We see potential in the region and are confident that when energy prices make such a system attractive to investors, we will see movement in Chile."

For a country with abundant natural resources and ambitious renewable energy targets, Chile still has a long way to go. "The so-called non-traditional green energy makes up approximately 20% of the energy matrix, while coal power generation is still running at about 38%. The goal is to reduce that 38% to zero by the decade's end," stated Germán Millán of PwC.

The private sector, and particularly mining, is driving renewables. Del Campo explained: "Sonnedix has come to Chile recently because the country is actively transitioning to renewable energy independently of the government. Chile is unique because it has the resources to enable the country to transition from a nation powered by conventional fuel sources to one that is entirely powered by renewable energy comparatively quickly, including solar, wind, and biomass. With all our current resources, we could multiply our renewable energy generation in Chile by 60."

Desalination

Chile is currently reaching a crisis point: wracked with drought and water shortages, it is burdened by continuously increasing water demand and continuously less water to meet that demand. In that context, the government is refusing new freshwater concessions to mining. All water usage going forward will be desalinated.

However, despite continuous innovation to reduce water usage, there is still a dramatic need for water from the industry. "Demand will increase for water because of the operations situation today, in that some oxide operations are utilized less as minerals are reducing in grade," explained Daniel Caro, CEO of Bermad Fluid Solutions. "They will be replaced by traditional flotation and concentrate processes. These processes are more demanding in terms of water because more water is required to separate concentrates."

According to ACADES, there are 24 desalination plants currently in operation in Chile, and 75% of the production of desalinated water is used by the mining industry. According to State copper commission Cochilco, demand from the copper sector for desalinized water will increase by 167% in 2023 compared to 2021 demand. There are multiple desalination projects currently in development in the mining sector, among them Codelco's US$1 billion Distrito Norte plant, Antofagasta Minerals' US$2.2 billion INCO plant, and Teck's plant for the Quebrada Blanca 2 expansion.

"The supply of desalinated water depends on several factors such as flow capacity, site conditions, technology selection, location of the water delivery which in case of mining operations are usually at high altitudes and longer pipelines, therefore leading to higher energy costs and higher Capex that significantly influence the water cost," said Rubén Muñoz, lead practitioner dealination at CDM Smith.

Desalination is a major portion of a mining project's Capex; as much as US$1 billion out of a US$3 or US$4 billion copper project. Today's desalination industry in Chile has two typical contract structures. In the first, the mining companies themselves fund the construction of a desalination plant, thus owning the plant and the water production. The second option is a BOOT (build-operate-own-transfer) mechanism, in which a private sector group finances, designs, constructs, owns, and operates the plant; it then sells the water to the mining company. At a certain designated point years down the line, the mining company gains ownership of the project.

According to Muñoz, BOOT contracts are a useful route: "In this model, the client outsources the risk of project execution and just pays a fee during the operation. This is helpful for greenfield projects to reduce the initial Capex."

Desalinated water production is an area of opportunity for mining companies to improve relationships with the local communities, utilizing their own water assets to support the community water needs. Peñaranda of Black & Veatch explained: "The plant owners can decide whether to sell additional water production to a city or community, which is often encouraged by the mining company as part of their ESG efforts."

Desalination provides a point of collaboration between mining companies and the local populations, enabling dialogue and demonstrating the value add mines can bring to their surrounding areas.

A study by the environmental sciences center (EULA) at the Universidad de Concepción and the Mileno Socio-ecological Coastal Institute (SECOS) determined that as little as 4.5% of the coastline between the Santiago metropolitan region and the Arica y Parinaco region are "highly appropriate" locations for desalination plants, while 60% of that area was "little" or "not" appropriate. However, 17 plants are either in operation or planned in areas considered inappropriate.

The challenges do not stop with the plant itself. David Alaluf, managing director at Endress + Hauser Chile, explained: "Chile has had had water desalination plants for 20 years or more, but these plants are technologically challenging, requiring corrosion-resistant systems. We must process the water and bring it up to an altitude of 3,500 m over distances of 250-300 km. That requires massive amounts of piping and complex pumps, valves, and instrumentation to monitor the process." ■

"The mining industry has been a pioneer in developing and implementing seawater desalination projects. Currently, most demand for desalination (80%) is still coming from mining."

Pablo Peñaranda,
Director of Business Development,
Black & Veatch

Equipment & Technology

Electrification and automation improve productivity

In early March 2023, a group of the world's largest copper producers came together and publicly pledged to reach net zero emissions by 2050. The group, including Codelco, BHP, Glencore, and Freeport McMoRan, intend to reach this goal by turning to renewable energy, becoming more efficient, and utilizing scrap collection.

Progress is being made, although the speed of progress must rapidly increase. In 1990, the average emission intensity of refined copper production was 5.4 t carbon dioxide equivalent (CO_2e) per t of copper, while by 2018, that number had dropped by 13.4% to 4.6 t CO_2e. Central to this shift is transformative innovations in the equipment and technology segment.

Even as trends in electrification, automation, and circular economy have become more popular, the way in which mining companies engage with equipment and technology providers has shifted as financing has become less steady. "Previously," explained Andrés Osorio, general manager of STM, "the client would commit up front to a complete project, beginning to end, and be willing and able to advance significant sums to carry out not only the engineering design but also the purchases, and so on. Now, however, they are focused on reducing risk in their investment."

To respond to this, STM now allows clients to commit to smaller project segments rather than the complete project.

Towards asset-centered operations

Central to a shift towards the circular economy is changing how companies think about their inputs. SKF is currently launching its RecondOil Box, a product with a patented process to recondition industrial oils so that they never need to be replaced. "The goal is for our clients to stop viewing oils as a consumable and shift to seeing them as an asset that can be regenerated rather than changed," said Carlos Lahura, managing director of the Andean region at SKF.

Turning oil into a service business model centered around changing the oil rather than disposing of it lowers CO_2 emissions.

Hilti, too, is focused on encouraging the client to rethink how they utilize the company's tools with a circular economy mindset. Alfonso González, sales director at Hilti, said, "We aim to

Andrés Osorio, General Manager, STM

José Castillo, Managing Director, Rema Tip Top Chile

John Swift, Managing Director, Epiroc

Óscar San Román, Country Manager, Yokogawa Chile

transform the current situation in which a client changes a lithium battery and then disposes of it. In our business model, we tell our clients to use our tools as if they are rented, and when they are finished using the tool or the contract is over, we take the device back and extract every reusable element."

Providing a customer with circular economy solutions is not just about external offerings, but also about how a service provider operates internally. "We are working in becoming part of a circular economy and recycling processes, seeking used rubber recycling," said José Castillo, managing director of Rema Tip Top Chile.

A significant part of a producer's sustainability targets is related to the sustainability of its suppliers. Castillo continued: "We are very careful to recycle all of our inputs and align our operations with the protocols of the mining companies we work with."

Electrification makes strides

Across the board, innovations in electrification are redefining mines. Sandvik recently launched machines that are both electric and automated. Ricardo Pachón, vice president sales for the Andean and Southern cone area at Sandvik , described: "Previously, we had electric equipment, but it was impossible to automate them. Now, we can effectively have a fully electric and automated mine."

Epiroc, too, has made dramatic strides in electrification. In 2022, the company introduced its first electric underground machines into Codelco's El Teniente, which managing director John Swift described as "an enormous success for us, Codelco, and, frankly, the future of Chilean mining." Swift identified the move towards electromobility as driven both by ESG priorities and by the technical requirements of underground mining. "As mines go deeper and more surface mines go underground, that will push the technology in electrification and other areas, as the underground space is much more complicated."

Reducing a company's carbon footprint is not a matter of checking a few boxes, shifting to renewable energy and commissioning electric trucks. It requires an examination of the complete mining system. For example, conveyor belts are more energy efficient that trucks, providing an opportunity for bulk materials transport providers. Sergio Zamorano, CEO of FAM Minerals & Mining – part of Boehmer Group, said: "There is significant demand for transformational engineering projects to reduce the carbon footprint of existing mines and move into continuous handling."

Efficiency against declining grades

Improved efficiency is not just an issue of reducing the carbon footprint of mines. It is also, and equally importantly, a matter of maintaining profits in a moment of declining ore grades. When Escondida, the world's largest copper mine, started production in 1990, it had a grade of approximately 2.5% to 3% copper. The reserve grade today is around 0.5%. These declining grades are mirrored at mines across Chile and are leading to a shift underground, forcing an intense investment in improving efficiencies throughout the process to maintain profits.

How companies go about improving efficiencies has changed. "Historically, there has been significant investment in enlarging machinery and processes to improve efficiency: bigger mills, bigger conveyor belts, and so on. We have reached the limit of growing the size of equipment and mills because, at a certain point, the mechanical components will generate more failure points than benefits," stated Óscar San Román, country manager at Yokogawa.

Now, increases in efficiency will come out of optimizing processes and reducing downtime. For companies that provide products directly oriented at improving efficiency, this is a moment of opportunity. Rodrigo Diáz, CEO of High-Res, a company that provides advanced coating products utilizing plasma technology to reduce wear and tear on machinery, explained: "For many companies in the copper industry, when the price of copper falls, they lose business. However, when it is low, we have higher sales rates because mining companies are more focused on improving efficiencies and maximizing their use of resources."

As the pressure to optimize increases, equipment will be a major area of growth. RCF is investing heavily downstream in response utilizing its recent Jolimont Innovation Fund. Valdes, a partner, said: "Jolimont came in as a venture capital fund in 2016 after we started seeing a trend in which many new and exciting technologies were coming onto the market."

Those technologies, however, were often introduced by entrepreneurs without the market knowledge to capitalize on their technologies. Valdes continued: "Our strategy is to take on disruptive technologies for the mining industry – most of them having already been proven and are generating some revenue – and help the entrepreneurs grow the business properly."

Valdes highlighted one company, Phibion, with technology currently being implemented at Escondida. The "mud master" moves mud on tailings dams to squeeze out water through

pressure on the soil, which then recycles the water and makes the tailings safer by compacting the soil. Valdes said: "This technology simultaneously improves safety and enables the reuse of water. The depletion of resources is making mining more expensive, so the industry needs to find ways to counteract this to survive."

The Mine of the Future: Automated

Automated mines, controlled remotely, are the mines of the future. There are multiple benefits: the fewer people in the mine itself, the less risk of accidents and safety issues; the ability to control mines remotely allows the workforce to be based in cities rather than the wilderness, improving workforce retention; and operating machinery remotely allows for one person to handle multiple machines, improving productivity, to name only a few.

Zauschkevich Domeyko of the Cámara Minera highlighted the industry's role in advancing automated technologies. "The mining industry has been a pioneer in automation, particularly in fluid flow regulation processes. There is also a trend in large-scale mining to automate conveying and crushing equipment. Although these investments are more likely to be considered for large-scale mining, the technology will become cheaper over time."

Handling the wide variety of new automation technologies and equipment offerings is a complex endeavor. Domínguez of EY explained: "One of the digital services we provide consists of implementing integrated centers of operations, from which the client can remotely operate the complete chain of mining operations. Control rooms significantly reduce costs, not only by urbanizing control but also by reducing losses through operations integration."

Highlighting the importance of fiber optics for real-time communication in the future of mining, César Ortega, CEO of Telemining, said: "Remote operation is gaining importance due to the movement underground. The mining of the future will be almost completely automated, with no personnel underground. We need communications networks that can report in real-time to operators outside the mine, 100 km away."

The communications challenge offered by underground mining was affirmed by Agostino Mattoli, regional CEO at Prowinch, a company specializing in hoists. As mines move deeper, he said: "They will have to keep building extremely long shafts, which is a technically challenging task. For example, communicating with computers from 100 meters away is very different from doing so at 500 meters, and we need to continue developing our hoists and winches to meet these new challenges."

"Over the last six months, we have seen a boom in interest in rebuilding and refurbishing machines – different words for the same concept: the circular economy."

Roberto Montiglio, Managing Director, Andean Region, Haver & Boecker

Automation is transforming the industry at all points along the value chain. MJ Gerüst, a scaffolding manufacturer, is actively investing in automating its offerings. "Our integrated technological system allows us to run an operation with less labor. The process is automated, which reduces costs," explained Christian Abt, area sales manager South America at the company. "This cost reduction is passed on to our clients while they still receive a product that meets the highest industry standards."

In the perception of some service providers, the dial has swung too far towards automating everything, at the expense of recognizing the need for on-site service. Roberto Montiglio, director of the Andean region at Haver & Boecker, said: "Covid convinced people that everything can be done remotely; unfortunately, that is untrue. Many customers resist on-site visits, making returning to normal an issue. We offer a no-cable, wi-fi enabled conditioning monitoring system that operates 24 hours daily. However, this does not replace our service technician on-site to keep the machine running." ■

World-Class Suppliers

A strong services sector centers innovation

In addition to safety and efficiency, service companies are taking tangible steps to improve their sustainability and water management metrics along the value chain. As both regulatory and public pressures grow, these issues no longer concern only mining companies, but all players involved in the mining value chain.

The modular construction segment can be an ally for circular economy and sustainability. Pablo Rosales, CEO of Tarpulin, highlighted the investments the company has made to incorporate circular economy practices: "We have partnered with DEX to manufacture modular floors made from recycled plastics here in Chile. This floor can hold up to 1,000 t of pressure per square meter and is a modular solution to replace concrete in temporary projects."

Rodrigo Prado, General Manager, Tecno Fast

Another modular construction company that has taken significant steps to reduce its carbon footprint is Tecno Fast. Rodrigo Prado, general manager of Tecno Fast, stated: "We are currently working on programs to reduce waste, recycle, and supply approximately 85% of our plants with solar energy; finally, we have recently focused on carrying out an accurate measurement of our carbon footprint to provide us with the information necessary to reduce our carbon output."

Service companies prioritize water management

The Chilean government estimates that water availability has declined by 10 to 37% over the past 30 years and could drop by 50% by 2060. Mining companies demand effective water treatment products at all stages along the extraction process. Jorge Marchant, vice-president of mining Latin America at Mathiesen, explained: "There are two areas where water usage can be influenced – continued improvement of the metals recovery with our flotation reagents products, and thorugh our rheology flocculants and standard flocculants to recover water at the thickener stage and put it back into the process."

Ricardo Capanema, global marketing and business development director of mining solutions at Solvay, a specialty chemicals company, highlighted areas of innovation for water waste reduction in mineral processing. "The typical method for lithium extraction is evaporation. However, since this involves excessive water consumption, we have developed a solvent extraction technology that does not require evaporation and can extract lithium from brine in real time," Capamena said.

Another company that specializes in producing chemicals for the mining industry is Noracid. The company is Chile's main producer of sulfuric acid, and in that pursuit, it has focused on new technologies to improve the process, including one that improves the desalination process. Warner Wartznauer, CEO, explained: "Our two major innovations are a liquid sulfur decanter, which has worked well because sulfur needs to be extremely clean before the process begins, and an osmosis process to turn seawater into freshwater."

Drilling

For Chile's drilling companies, the current focus is on safety and optimization; producing more at a lower cost in a sustainable manner. These objectives are in large part being achieved by incorporating new technologies, such as automation. However, improving the efficiency of the drilling process requires a more fundamental understanding of the geology of the rocks themselves.

Trinidad Carmona, sales & marketing director of DrillCo, described the material science focus of the Chilean company's international research partnerships, saying, "Our investigative approach focuses not just on improving the mechanics of our machines, but on improving our understanding of rock behavior and the fundamental nature of rocks. Studying a rock means knowing how it breaks and what happens during that process – developing a deep knowledge of the behavior of the rocks."

It is not enough to attach more bells and whistles to a gadget. Improved efficiency requires a willingness to go back to the drawing board, to the very identity of the material itself in order to determine the optimal way to advance. In a period when minerals are more often behind harder rock, or in more challenging areas, this building blocks approach to drilling provides a necessary foundation.

On the technological side, automation is undeniably one of the main trends in the mining industry; contractors and service providers across the value chain are moving in this direction, and drilling companies are moving right with them. Gregory Duncan, general manager of Major Drilling Chile, pointed out that some major mining companies, such as BHP and Codelco, require very specialized drilling equipment for their sites, including 100% hands-free rod handlers on their drills. Major Drilling is therefore actively working on integrating automated drills. "We have a 100% hands-free drill being tested in Suriname right now. Once that testing period concludes, we will send three or four to Chile, so we will soon have eight to ten drills operating in Chile," Duncan stated.

Automated drilling has near limitless potential to optimize mining operations. However, to be done successfully, automa-

tion must be paired with human experience and insight. "Mining is rooted in a physical medium. You can build software and automatize, but the final objective is to obtain a mineral from a rock as efficiently as possible with the least environmental impact," emphasized Carmona.

However, when handled by skilled and knowledgeable drilling experts, automatization offers several advantages that lead to benefits in the medium and long term. Duncan highlighted the importance of automatization for safety and water management.

Javier Varela, CEO of Drillco, explained that pressure upon the drilling sector was coming from multiple directions. "On the one hand, service providers are experiencing pressure in terms of inflation and higher costs for raw materials; on the other hand, there are more intense demands from mining companies for us to lower our costs to reduce their operational expenses," Varela said. "Finding that balance is a challenge that requires the industry to emphasize collaboration and innovation, increasing the value proposition at all levels."

Logistics

On the logistics side, Tomas Valenzuela, vice-president of mining and energy at Agunsa,, emphasized that although Chile possesses a strong infrastructural base and diversified energy generation matrix, the country could build upon these strengths. Valenzuela said: "There remains room for improvement in the development of a robust rail network and the creation of cost-effective alternatives to unexpected events or calamities. Recently, major fires broke out in two of Chile's largest bulk ports, disrupting operations for mining and energy companies and highlighting the critical importance of diverse and flexible supply chains."

This is particularly true for energy. Valenzuela noted, "Chile's potential and advantages make green hydrogen and ammonia increasingly popular. However, developing these projects will require significant public and private investments in infrastructure.

When asked what the greatest factor inhibiting a renewable energy sector, Hemmerdinger of APRIMIN said bluntly, "Infrastructure." He elaborated: "Our port infrastructure in the north and center of the country is good, but the port infrastructure that Magallanes needs for its green hydrogen production in the south needs to be created. When I talk about port infrastructure, I mean the infrastructure required to receive basic supplies."

It is crucial, however, that every single hydrogen project does not come with its own individual infrastructure construction. Hemmerdinger explained: "We must develop shared-preference infrastructure and shared corridors. We need shared use of ports, as well, because the more that ports and other infrastructure are shared, the more sustainable the industry is."

The disconnect between the quality of infrastructure in the north and the south is noticeable and is an issue that requires conscientious attention from the government for the logistics industry to be able to equally serve all areas. That being said, the mining industry, which is primarily based in the north, benefits from high quality and thorough infrastructure. Chile's logistics industry is, accordingly, comparatively strong and adaptable; excellent infrastructure and logistics differentiates the Chilean mining industry from other competitors in the region and is a tangible demonstration of the country's long history of stability and high levels of development. ■