MORE OUT OF TAILINGS:
METAL AND ACID PRODUCTION, CIRCULARITY AND ENERGY TRANSITION

By

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ABSTRACT

The need to "extract more from less' is not a byword that sits well in the mining industry. Head grade degradation, basically processing ever more ore to produce ever less final product with an inevitable increase in waste, is a fact for many operations.

The need for more circular solutions required for the emerging energy transition (i.e. the demand for ever more non-ferrous and critical minerals) requires us to rethink what we can do differently. The processing of tailings from the copper ore processing offers significant potential to recover valuable elements like copper, cobalt, and nickel as well as to produce sulphuric acid for different applications in the fertilizer and metallurgical industry. Perhaps the time is right for a well proven industrial process to be part of the push towards a true circular economy?

We intend to present our views on the renaissance of a technology value chain – the roaster-gas cleaning acid plant - widely used in the past and its applicability to the current scenarios. This process chain is capable of utilising virgin pyrite ores as well as pyrite tailings, with a view to maximum extraction of valuable ferrous, non-ferrous and critical minerals, reducing acid mine drainage, production of clean energy as well as providing a 'regionalised' sulphuric acid supply. When these commodity flows are considered in total as revenue streams, return on investment is, in many cases positive – substantiating the claim that one can obtain 'more out of ore'.

Keywords: fluid bed technology, roasting, tailings, pyrite, metal recovery, sustainable, circular solution, acid production, battery metals, valuable metals; CFB, fertilizer

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INTRODUCTION

Australia holds some of the world's largest recoverable resources of critical minerals like cobalt, lithium, manganese, rare earth elements, tungsten, and vanadium. The country's commitment to becoming a renewable energy superpower aligns with the growing demand for these minerals. The Australian Government's measures in the 2023–24 Budget highlight its commitment to a net-zero economy, leveraging its mineral resources(1). Additionally, in December 2023, they revised the Critical Minerals List and introduced a new Strategic Materials List. These actions recognize the importance of specific materials in the global shift toward net-zero emissions and broader strategic applications(2).

The existence of diverse pyrite and sulphide deposits in Australia offers ample opportunities for mining companies to explore, invest, and contribute to sustainable resource utilization. For instance, one example to highlight the importance of managing pyrite-rich materials in Australia is overcoming pyrite challenges in Queensland's Ore Reserves and Mine Tailings. Rresearchers are collaborating with several companies to extract copper from resources considered too difficult to process due to high pyrite levels. Using innovative processing solutions are essential to meet metal demand to achieve the target, which is to recover more base metals from pyrite and reduce losses to tailings(3). Additionally, for mining operations, recovering fresh, reusable water from tailings is highly valuable.

This significance is particularly pronounced in Australia, where conditions of aridity, high evaporation, and poor-quality groundwater are common[(4)].

The critical minerals industry in Australia is intrinsically linked to the issue of tailings. As the extraction and processing of these minerals often result in the production of large volumes of tailings, the management of these by-products is a significant concern. Tailings contain residual minerals that were not initially targeted for extraction but may now be valuable in the context of decarbonisation and the transition to renewable energy. For instance, cobalt, a critical mineral for battery technology, can often be found in the tailings of copper mines. Therefore, the challenge for Australia's critical minerals industry is not just about increasing production to meet global demand, but also about innovating and improving the efficiency of mineral extraction processes to reduce tailings and potentially recover valuable minerals from them. This approach aligns with the broader goals of sustainable mining and circular economy, turning a waste product into a resource, and contributing to the decarbonisation efforts. In 2022, Australia witnessed limited growth in its mining operations, contributing only 3% to global growth. Despite maintaining its status as a significant producer, it was overtaken by Indonesia as the second-largest producer of cobalt and nickel. Also, it is estimated that Australia has the potential to double its share of mined supply growth from 2022-30, potentially reaching up to 6%[(5)].

TAILINGS IN MINING AND METALS INDUSTRY

Pyrite is a common mineral in many types of metal ore deposits, and it is often found in association with other minerals that contain gold, copper, cobalt, and zinc amongst others. Pyrite-containing tailings are commonly produced in mining operations that extract these types of minerals. The amount of pyrite present in the tailings can vary depending on the specific deposit and the extraction process used. Sulphur content in pyrite tailings concentrate is typically anywhere between 30-50 wt%. In the past, sulphuric acid used to be produced from Pyrite concentrate as the main source of sulphur. Today Pyrite is a by-product of the mining industry that often ends up in tailings. Beside the requirements for circular economy, there are industry wide discussions, if future sulphur demand will be challenged by energy transition and de-carbonization. The usage of Pyrite could also address this topic at least locally, where elemental sulphur from oil and gas industry is imported.

It is estimated that there are thousands of pyrite tailings dams around the world. A 2017 report by the International Council on Mining and Metals (ICMM) estimated that the mining industry produced between 10 and 20 billion tonnes of tailings annually. Most of the pyrite tailings originates from copper mining and mainly consists of sulphur, Iron, SiO_2, Al_2O_3, CaO as well as valuable non-ferrous metals[(6)].

Globally, there are 580 operations exploiting copper, with 190 cases from where resources and reserves are reported. Copper production in Australia for 2023 was over 1 million tons per year (tpy) with about half of it being exploited by the 5 biggest mines Olympic Dam, Cadia Mine, Mount Isa Mine, Ernest Henry Mine and Prominent Hill Mine (Figure 1)[(7)]. With approximately 197 tons of tailings generated for every 1 ton of copper produced, this makes about 200 million tpy of tailings alone for Australia. The sulphuric acid amount produced out of these tailings would amount to roughly 15 million tpy as compared to world production in 2021 of 260 million tons.

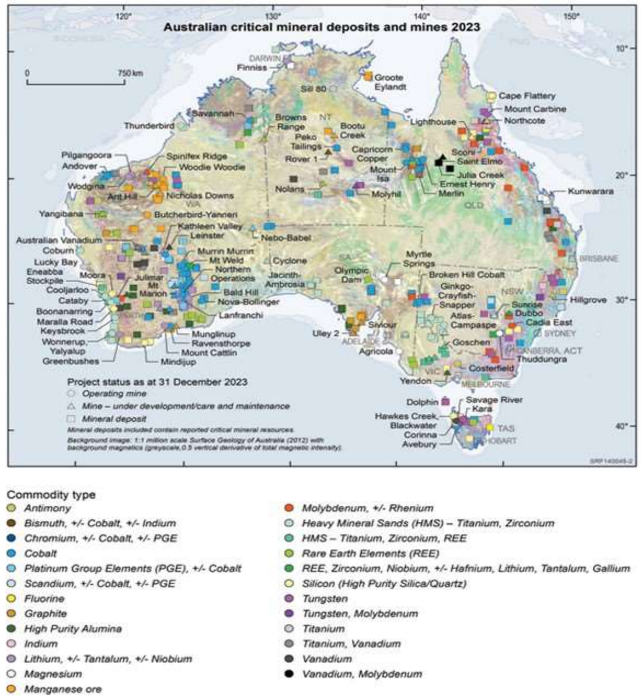

Figure 1: Australian Critical Minerals at Operating Mines and Major Deposits[2]

As global ore grades further deplete over time, the volume of tailings per ton of metal is continuously increasing. The mine operator has the challenge of treating an increased volume of mineral to maintain same metal production rate, this increases tailings waste and the associated operational costs. Mining operations inevitably generate waste and tailings, but there are strategies to ensure their sustainable management. Although mining waste is an established part of the industry, the methods of handling it can be modified[6]. According to Australia's Department of Climate Change, Energy, the Environment and Water's 'National Waste Report 2022', the mining sector produced substantial waste in 2020–21, totalling 620 million tons (Mt), a notable increase from 502 Mt in 2018–19. Approximately 96% of this mining waste was stored in tailings dams, which serve as storage place for mining by-products following ore extraction.

Figure 2 below presents the estimated mining waste by commodity indicating that the most wastes are produced from gold ores, followed by iron ore and copper ore mining[8].

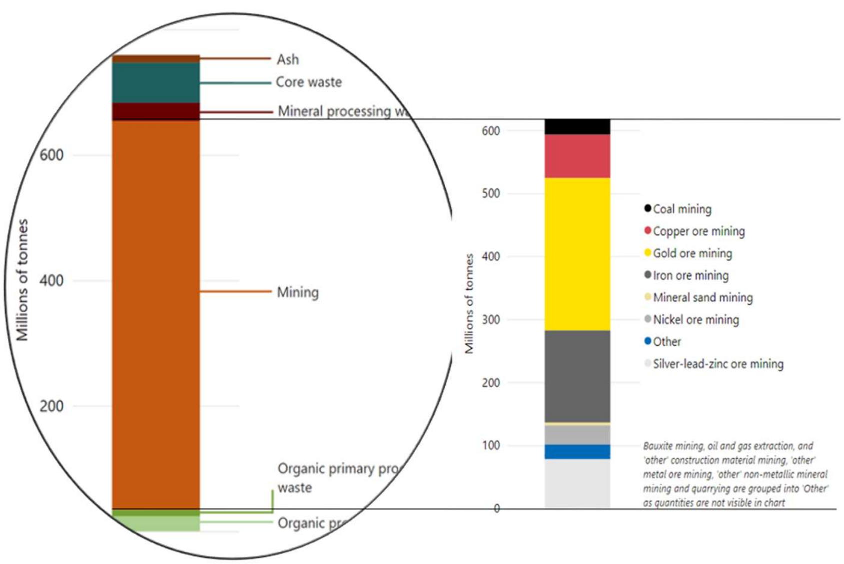

Figure 2: Estimated Mining Waste by Commodity in Australia, 2020–21 (Redrawn; Derived from[8])

It is important to note that processing of pyrite and tailings is indeed crucial for several reasons: pyrite-rich tailings can lead to acid mine drainage (AMD) when exposed to air and water. This acidic runoff can harm ecosystems, contaminate water sources, and affect aquatic life. Therefore, proper processing helps prevent AMD by neutralizing or encapsulating pyrite, minimizing its environmental impact. In addition, tailings often contain valuable minerals that were not efficiently extracted during primary processing. So, by reprocessing tailings, Australia can recover additional metals such as copper, cobalt, gold, or zinc, contributing to resource sustainability. Furthermore, unprocessed tailings pose safety risks, especially if they are unstable or prone to collapse. Therefore, proper processing ensures tailings are stable, reducing the risk of dam failures or environmental disasters[9]. Also, under the legal and regulatory compliance for tailings management, Australian mining regulations require responsible management of tailings. Therefore, processing tailings aligns with legal obligations and demonstrates commitment to environmental stewardship. In summary, the processing of pyrite and tailings is essential for environmental protection, resource utilization, safety, and compliance with industry standards of the country and understanding their effects is critical for responsible resource management[10]. At some locations, mining companies are legislated by the government to take care of the existing dumps before receiving new permits. At the same time, as attention to environmental, social, and governance (ESG) increases, mining companies are more aware of environmental issues and the related increasing costs. In conclusion, proper management of tailings is crucial for ensuring the safe and sustainable production of minerals and metals. A large amount of these tailings contains ferrous material in the form of pyrite as the main component. By upgrading the concentrate to a calcine or further processing it for metals recovery, Co, Cu, Ni, Zn, Ag, and Au can be recovered. In addition, sulphide-bearing tailings can be considered as relevant feedstock for acid production and potential Fe rich calcine from the hydrometallurgical retreatment can potentially be evaluated for further value recovery.

Australia's approach to managing tailings balances resource recovery with ecological sustainability. To cope with the future challenge of circular economy, technology requires adaptation. The amount of Pyrite to be processed requires a significant increase of the throughput of existing plant units to reduce capital intensity. We, at Metso, are working to increase the capacity of individual roasters using our unique knowledge of this technology. Recycling mine tailings can help reduce the volume of tailings for disposal, mitigate water contamination, and generate new revenue streams such as valuable metals extraction, sulphuric acid production, and energy generation. Dependent on the composition of the pyrite, the local acid market, and the volume of tailings to be processed, several different processing scenarios can be offered by Metso.

Today metallurgical processing plants are focusing on all valuable metal recoveries from the pyrite concentrate. The roasting process can be seen as a pretreatment process before processing the calcine in a downstream hydrometallurgical process for the recovery of the valuable metal. However, important revenue streams, such as sulphuric acid, steam and in some cases iron oxide may well add further revenue upsides to the project.

Figure 3 shows all relevant material streams for a conceptual evaluation.

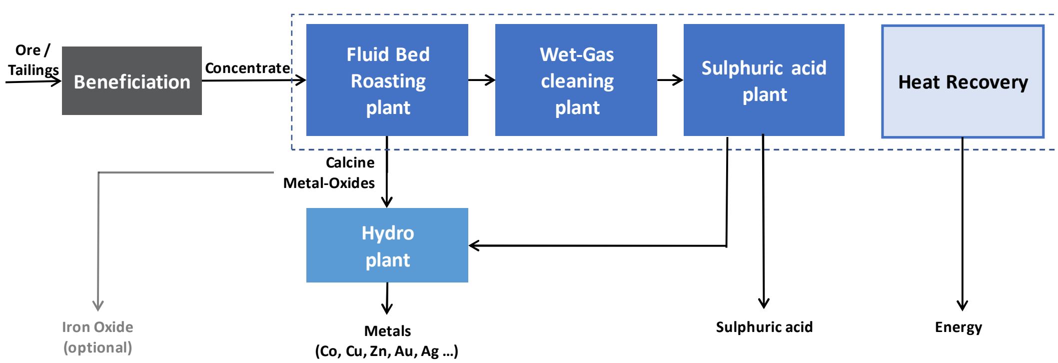

Figure 3: Metals Value Chain of Pyro / Hydro Metallurgy

CONCEPTS OF PYRITE ROASTING

Whilst the fundamentals of the roasting process have not changed significantly, each plant has its specifics and optimum key plant configuration. Over the last sixty years, Metso (including former Outotec and Lurgi companies) has built more than 470 fluid bed applications. Approximately two thirds of these references are based on the bubbling fluid bed technology (BFB) and the rest employ circulating fluid bed technology (CFB). In the following sections, three roasting plants related to pyrite are briefly described.

In the past the capacity of a pyrite roasting plant has been typically based on the sulphur content of the feed pyrite and market requirement and few plants reached beyond 1,000 t/d for one fluid bed roaster. In general, the bubbling fluid bed technology has been applied for more than 165 pyrite roasters.

Figure 4 shows the latest reference of Metso installed roaster at Mazidaği/Turkey which has a total capacity of 2 x 750 t/d pyrite based on the BFB technology.

Figure 4: Pyrite Roasting Plant at Mazidaği/Turkey[11]

The process chain starts with the roaster, followed by a boiler system. The off-gas with some dust entrainment is further cleaned in the cyclone system and finally in the hot-electrostatic precipitator (H-ESP). Hot solid product (calcine) is discharged from the plant from the roaster down to the H-ESP and cooled down further. After the hot gas cleaning, the off-gas enters the wet gas cleaning section, which traditionally includes the quench tower (Otovent), gas cooling tower, wet-ESP, and any impurity removal steps. Finally, the purified SO_2 gas enters the sulphuric acid plant for conversion to sulphuric acid.

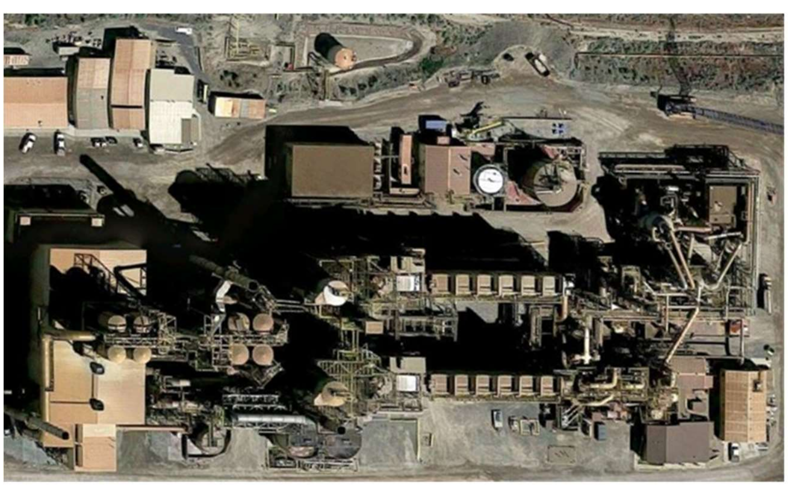

Figure 5: Gold Roasting Plant at NGM, Nevada/USA(12) (left) and Resolute Mininig - Gold Roaster at Syama / Mali (right)

The NGM Carlin gold roaster (
Figure 5, left) was designed in the 1990s for a throughput of 2 x 3,900 t/d and operates today around 30% higher than initially designed, which is a credit to the operation/maintenance philosophy locally employed. The fluidizing air is recycled from the H-ESP off gas back to the roaster and enriched with preheated oxygen before it enters the CFB(13).

A third example is the roasting plant at Syama in Mali (
Figure 5, right) and this operation consists of a single roasting train and is designed to operate a maximum capacity of 590 t/d with a sulphide-sulphur equivalent of minimum 31.1 %(14).

The application of the CFB technology allows for both gold roasters mentioned above to produce a significantly more homogeneous temperature distribution in the roaster, enhancing production efficiency in the downstream leaching process. The key advantage of the CFB over the BFB technology is to obtain higher throughput in a single fluid bed reactor. For the Mazidaği plant, two roasters are installed in parallel (total 1,500 t/d). If higher capacity is required at a specific location (e.g., above 2,000 t/d), circulating fluid bed technology could be applied to handle all the material in a single unit.

The two pyrite projects at Mali and Cengiz are at the lower end of current sulphuric acid production capacity globally but form the basis for any future plants in this capacity range. The sulphuric acid industry however is defined by sulphur burning and metallurgical off gases with much higher capacity than currently exist for a roasting plant configuration.

The circulating fluid bed technology for high throughput is more defined by whole ore roasting, such as the NGM gold roaster, alumina calcination or the Enefit oil shale combustion. All these applications from Metso are already operating with much higher solid throughput rates. Metso is now combining all this experience from different projects in the sulphuric acid and fluid bed industry, as well the experience from metallurgical acid plant projects to meet the demands of the market for higher throughput pyrite plants. The next logical step from this trend in pyrite roasting is therefore to build pyrite roasting plant with higher acid production and higher solids throughput utilizing CFB technology. Metso is minimizing the technical risk of development by applying a proven technology for the renaissance of roasting for the treatment of pyrite tailings. This step is now in focus and already applied in ongoing development and engineering projects. This future step is demonstrated in Figure 6 as a future reference base with capacities of approx. 1,500 – 3,000 t/d of concentrate and acid production of 2,000 – 3,500 t/d.

The operation area and size and number of roasters of the future references are defined by the amount of concentrate as well as by the sulphur content and with this, the formation of energy in the roaster. Typical sulphur content in the pyrite concentrate is in the range of 30 – 50%. Therefore, beside the capacity, the sulphur content and acid production are also shown in Figure 6. A lower sulphur content allows a higher solids throughput in the plant. The figure shows an orientation for the possible capacity increase marked as future reference base. The feed capacity for a pyrite tailings roaster can reach ca. 3,000 t/d with a 30 % sulphur content, however the capacity will be lower if the sulphur content is higher. A fine example to illustrate this trend is Metso's gold roaster reference at NGM in Nevada which treats whole ore with only ~3 % sulphur. With this low energy content, one roaster unit can operate with throughputs up to ~ 5 000 t/d. This gold roaster is a unique solution as the intention there is only gold recovery, however it clearly shows that the handling and treatment of such a huge volume of material in one fluid bed roaster based on CFB-technology is possible (see also Figure 6). The large throughput roasters follow the development under the Circoroast® approach, which combines increased heat recovery with traditional roasting technology.

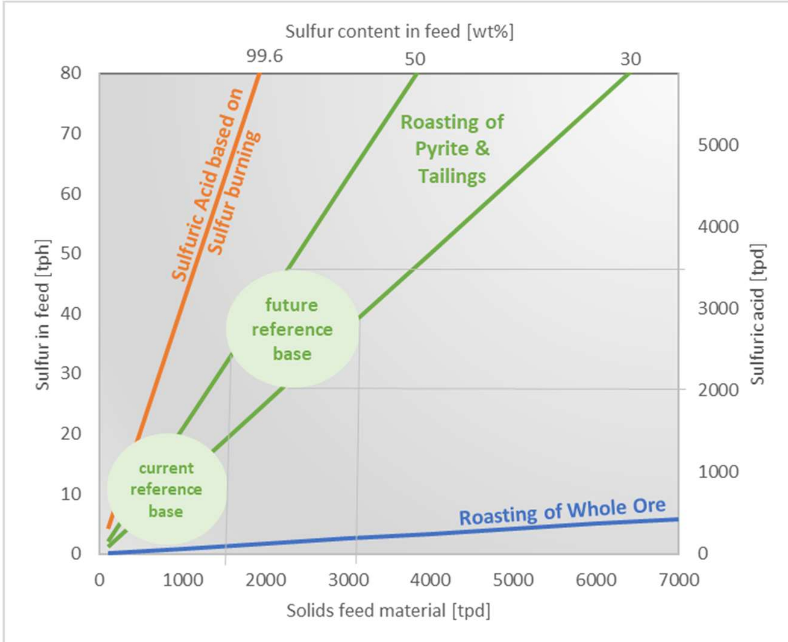

Figure 6: Roasting & Sulphuric Acid plant Capacity Trends

Metal Recovery

The composition of the pyrite concentrate varies depending on the ore body. Table 1 shows a typical composition of pyrite concentrates that has been analyzed in recent projects or are already treated today in existing operations.

For economical evaluation of a concentrate, all valuable metals must be considered. Combined with the local market situation for sulphuric acid and power generation a project can become economical. The basis for all evaluations is the described fluid bed roasters above. The economics of the metal recovery section depends on the metal content and the market value of the metals. Today due to the above-described trend to electromobility and energy transmission the most important factor is the cobalt content. With a value of 26,000 Euro/t, it is far above all other metals in the concentrate. However also copper and zinc can bring additional revenues to the project.

The composition of pyrite concentrate typically encompasses a range of elements, each playing a distinct role in its overall properties and applications. As shown in Table 1, sulphur (S) and iron (Fe) stand as primary constituents, forming the backbone of pyrite's chemical structure. Beyond these foundational elements, pyrite concentrate often contains trace amounts of other metals, which can be categorized into different groups based on their significance and utility. Firstly, critical elements such as zinc (Zn), copper (Cu), and cobalt (Co) are commonly present, each contributing to various industrial processes and applications. These elements are integral in sectors like electronics, renewable energy, and infrastructure development, highlighting their importance in modern technologies. Additionally, silver (Ag) and gold (Au) are often found within pyrite concentrate, representing valuable precious metals that hold significant economic and industrial significance.

In the context of upgrading pyrite concentrate for downstream processing while simultaneously recovering energy and producing sulphuric acid, the elemental composition assumes paramount importance. The S- content within the concentrate is of particular significance, as it serves as the primary source for sulphuric acid production. Pyrite's high sulphur content makes it an ideal feedstock for sulphuric acid manufacturing, a process vital in various industrial sectors including fertilizer production, chemical synthesis, and metal extraction. Additionally, the Fe content in the concentrate holds potential for energy recovery through processes such as pyrometallurgical smelting or hydrometallurgical leaching. By harnessing the exothermic reactions associated with these processes, valuable energy can be generated, contributing to the overall sustainability and efficiency of downstream operations. Moreover, the presence of base metals such as Zn, Cu, and Co further enhances the economic viability of the upgrading process. These metals can be selectively extracted and purified through hydrometallurgical techniques, yielding additional revenue streams while facilitating the production of high-purity products for various industrial applications. Furthermore, the recovery of precious metals like Ag and Au presents opportunities for further value addition, as these metals command high market prices and are in demand across diverse sectors. Therefore, by strategically leveraging the elemental composition of pyrite concentrate, it becomes possible to optimize downstream processing while concurrently recovering energy and producing sulphuric acid, thereby maximizing resource utilization and minimizing environmental impact.

Table 1: Typical Pyrite Compositions

Element		Pyrite/Tailings	Calcine
		content (wt%)	
Sulphur	S	48 - 52	1 - 3.0
Iron	Fe	40 - 45	60 - 65
Base Metals	Zn	0.1 - 0.5	0.2 - 0.8
	Cu	0.5 - 0.9	0.8 - 1.4
Critical Elements	Co	0.7 - 1.3	1 - 1.7
	Ag	> 10 g/t	
	Au	> 1 g/t	

Based on the latest reference plant with a concentrate feed rate to the roaster of 500,000 tpy a calcine amount of around 375,000 tpy is produced. In addition to the solids feed and production rates, sulphuric acid of around 750.000 tpy is produced as well as and energy of 140 GW in one year.

Pyrite concentrates with high metal content tend to be more economically valuable due to their potential applications in metal production and energy. In addition, having a high sulphur and iron content in the concentrate would make the metallurgical process very attractive with acid and energy as the by-products.

When the gold content is high in pyrite concentrates, however, in modern practice, such pyrite is often bypassed for further treatment in the hydrometallurgical process. Despite this, the presence of low non-ferrous metals can be viewed as an advantage because it enables the production of a calcine with high iron content and low sulphur content. This strategic utilization aligns with efficiency and resource optimization. In ferrous industry, the presence of non-ferrous metal in the calcine is a common challenge so where the non-ferrous metal content is low, it can be added into the feed stream in the steel production process. In addition, the other main concern would be the calcine sulphur content. However, the content can be reduced during the roasting process, resulting in calcine suitable for steel industry, acid, and energy.

For the pyrites with high base metal content, test work must be carried out and the target of these tests is always to increase the recovery of valuable metals, such as cobalt, copper, zinc, silver, gold, etc. whilst keeping the iron portion in solid form. Only with a low Fe-content in leaching-solution, then it is possible to avoid producing high amounts of waste and selling the final residues to the ferrous industry. The results of the recovery rates can vary from one pyrite concentrate to another and the complete process chain, roasting as well as leaching, must be tested. In the Mazıdağı plant a pressure autoclave leaching has been implemented[15], since it was confirmed by testwork that better results in recovery of the metals as well as for the consumables acid, steam, and solubility of iron were achievable[16].

In another internal project, we also analyzed pyrite and made atmospheric leaching tests. Table 2 shows the recovery development in relation to the roasting temperature, leaching temperature and acidity. The recovery in these test campaigns has been on the lower side. Based on a roasting and leaching test series the process condition with the overall best performance has been conducted. While a conventional roasting process at (or above) 850 °C followed by atmospheric leaching results in lowest recovery rates, the combination of correct process conditions can result in excellent overall plant efficiencies. Starting out at low roasting temperatures (less than 700 °C) and atmospheric leaching, the metals recovery rate is still below its potential. Looking at table below, the extraction rate of metals is at about 60-70%. Increasing the roasting temperature and acid concentration further results in improved recovery rates in some cases, however high amount of unwanted iron is leached as well (Test 3) at certain process condition under atmospheric leaching.

Table 2: Metals Recovery Rates Based on Roasting and Leaching Conditions

Test	Roasting	Leaching		Extraction Rates			
No.	Temp.	Temp.	Acid	Co	Cu	Zn	Fe
	°C	°C	g/l	%	%	%	%
1							
2							
3							
4							
range	*640-850*	*20-220*	*35-100*	*24-95*	*33-95*	*19-97*	*0.1-11*

In Test 4, we observe a remarkable metal recovery rate, exceeding 95%, while minimal iron leaching occurs. The process involves a roasting of the feed material at a temperature of 820 °C, followed by a high-pressure and high-temperature autoclave leaching to achieve the optimal metal recovery while minimizing acid usage. The overall best plant performance can be reached at optimized roasting temperature and optimized autoclave leaching. The high recovery rates of around 85 to 98% found in laboratory conditions match typically what can be achieved in the industry, although industrial applications tend to operate at the higher end of this spectrum. With respect to a gold roasting plant, the operating temperature window is normally lower, however when operated in combination with autoclave leaching the extraction is optimized. There are several advantages for this change in roasting process conditions for the metal recoveries, which are related to better heat recovery, lower effluents, and higher acid production in the roaster. All these factors are important for an attractive and feasible process.

Sulphuric Acid Production

Apart from metal recovery, the demand for the sulphuric acid will further increase in the decades to come. As the availability of elemental sulphur from the oil and gas industry reduces, new sources must be found or re-developed. In the past, pyrite was already one of the main sources for sulphuric acid production and it can certainly fill some of the expected gap in demand. The surge in low-carbon technologies, including batteries, lightweight vehicle motors, and solar panels, will intensify mineral mining. Ores that are rich in cobalt and nickel will play a crucial role. By 2050, cobalt demand could soar by 460%, nickel by 99%, and neodymium by 37%. Remarkably, all these metals rely on substantial sulphuric acid extraction. Simultaneously, global population growth and dietary shifts will boost sulphuric acid demand. The phosphate fertilizer industry, a major consumer, will drive this increase. Therefore, balancing supply and demand become pivotal for sustainable resource management[17].

In the context of Australia, the potential sulphuric acid shortage highlighted in the study could have significant implications for various industries in the country. Australia heavily relies on sulphuric acid in vital sectors such as mining, agriculture, and manufacturing. A shortage of sulphuric acid could disrupt mining operations, leading to economic consequences due to reduced production of key commodities like copper and gold. It would also impact agriculture, hindering crop yields and fertilizer production, affecting both domestic food security and export potential. Additionally, such a shortage would impede the manufacturing of industrial chemicals and green technology products, hampering Australia's transition to a low-carbon economy. Moreover, environmentally damaging sulphur mining practices could worsen, leading to habitat destruction and pollution, further harming Australia's environment. Thus, ensuring a stable sulphuric acid supply is essential for Australia's economic resilience and environmental sustainability.

According to a recent study on the global demand for sulphuric acid and its potential crisis in the future showed that over 246 million tonnes of sulphuric acid are used worldwide annually. However, as the green economy grows and agriculture intensifies, demand could surge to over 400 million tonnes by 2040 (

Figure 7). Currently, more than 80% of global sulphur supply comes from fossil fuel desulphurization to reduce sulphur dioxide emissions. Yet, decarbonization efforts will reduce fossil fuel production, potentially causing a shortfall of 100 to 320 million tonnes of sulphuric acid by 2040. Addressing this challenge is crucial to avoid environmentally damaging mining[17].

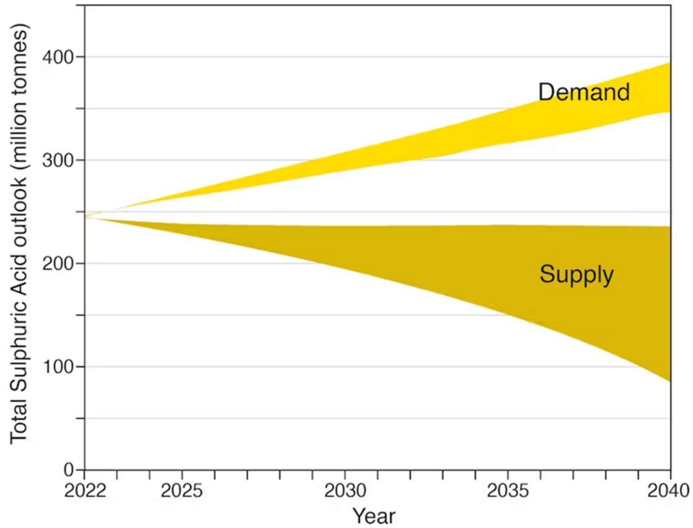

Figure 7: Estimated Future Supply and Demand of Sulphuric Acid[18]

ECONOMIC EVALUATION OF PYRITE ROASTING

On the earnings side it is particularly important to use a realistic local market value for the acid. Many projects are failing by using wrong or very conservative figures for the local acid price. The biggest revenue at the Mazidaği project in Turkey emanated from the cobalt and acid recovery. In 2018 the metals import has been reported at $270 million a year[19]. The acid in this project is used at site in the fertilizer plant. With an annual production of 750,000 t of fertilizer, the production meets the entire fertilizer requirements of the region[20].

As a reference study case we assumed a pyrite roaster plant based on CFB technology a capacity of 2,000 t/d pyrite plant with the metal composition of Cu 0.5%, Co 0.5%, Zn 0.2%, Ag 5 g/t, Au 1 g/t, the earnings are shown in Table 3. For a hypothetical operating cost on essential plant units (including leaching) the ROI is about 150 MEuro per year. Of course, this number is dependent on initial capex cost and market unit rates as shown in table below.

Table 3: Project Example of Earnings Based on Revenue Streams

item	amount		price		total/year	
Co	3162	t	26000	Euro/t	82.2	Mio€
Sulphuric Acid	999600	t	60	Euro/t	60.0	Mio€
Au	632.4	kg	54000	Euro/kg	34.1	Mio€
Cu	3162	t	7600	Euro/t	24.0	Mio€
Power	184960	MWh	40	Euro/MWh	7.4	Mio€
Zn	1264.8	t	2800	Euro/t	3.5	Mio€
Ag	3162	kg	670	Euro/kg	2.1	Mio€
CO_2	to be evaluated by location					
Tailings	future regulations may apply					
Groundwater	future regulations may apply					
Total Earnings					**213.4**	**Mio€**

SUMMARY

Australia, with its vast geological reserves and expertise in mineral extraction, stands at the forefront of a global transition. The Critical Minerals Strategy 2023–2030 is a visionary roadmap unveiled by the Australian government to explore how this strategy aligns with our collective goal of a sustainable future. By extracting these vital minerals, Metso paves the way toward a cleaner future. Such dedication aligns with net-zero goals, tackles mine waste issues, and fulfills the worldwide need for environmentally responsible metal extraction.

In conclusion, the application of the high-capacity roasting process applying CFB technology can contribute to a planet positive development. While the transmission to electromobility and renewable energy is accelerating, the request for valuable metals as cobalt is increasing. Besides sulphuric acid and CO_2-free energy production, this allows for studying the economics of recovery for cobalt, copper, zinc, gold, and silver from pyrite feed sources. This is then dependent on the compositions of the feed material, as previously discussed in the article.

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