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Northern Chile and Peru: a hotspot for desalination

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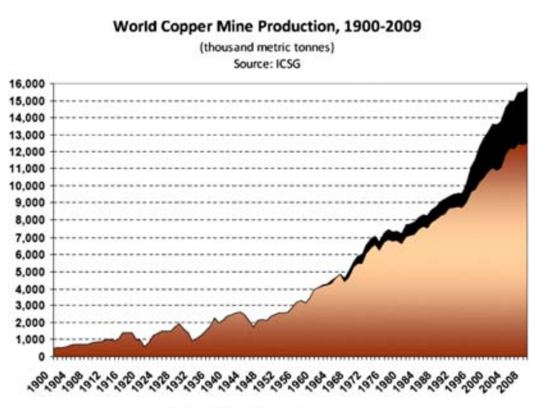
ABSTRACT

Northern Chile and Southern Peru are areas that are rich in mineral resources, but where water is very scarce. The Atacama Desert, while not the hottest desert in the world, is the driest. The first Mining projects in the region used water from underground aquifers containing brackish water. The overexploitation of these water resources has led to depletion of the aquifers, and there is now intense pressure on Mining companies to look elsewhere for water resources. Mining projects are often located at high elevations and great distances from the coast. There are currently more than ten large projects with a very aggressive timeline due to the high price of metals. The desalinated water supply for most of these projects will involve hundreds of millions of dollars and will be very challenging to execute, as they involve infrastructure requirements that cost a lot more than the desalination plants, such as pipelines and power supply and will require a consortium approach. The full paper will discuss the background of the most important projects and then focus on community and environmental issues, technical aspects, project delivery modes (EPC/EPCM/BOO), and the timing for their execution, and the positions of the different stakeholders.

Keywords: Mining; Desalination; EPC; EPCM; BOO

1. Introduction

Copper is used in vast amounts in automobiles, appliances, electronics, lighting, and a range of other products, because of its unique mechanical and electrical properties and comparatively low cost. The total world demand of copper doubles approximately every thirty years. In 1900, the whole world production was only 500,000 tons, while in 2010, the production reached 17,000,000 tons per year and demand continues to increase.



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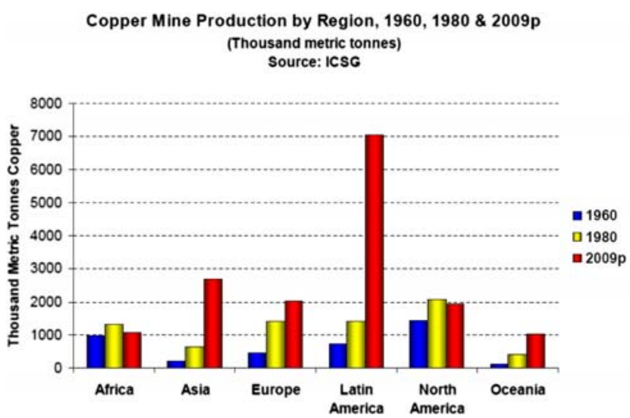
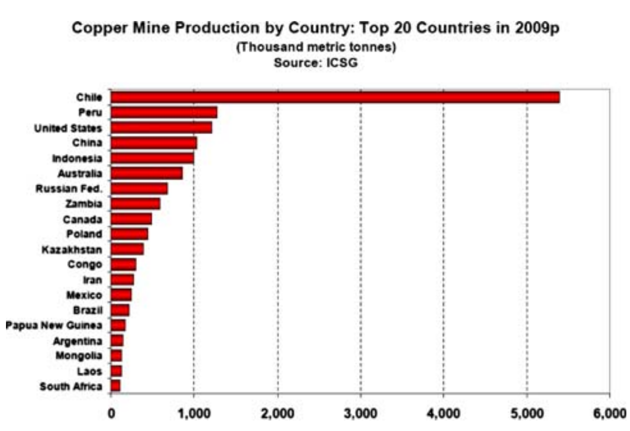
Over the years, there have been considerable shifts in production in different areas of the world. In the last decades, copper production in Latin America has undergone explosive growth in comparison with other regions, a trend which is forecasted to continue, with demand being driven largely by the very strong growth of Asia.

Within Latin America, Chile and Peru are particularly worthy of note. In recent years, Chile has gone onto produce nearly one-third of all copper in the world. Peru currently ranks second in production, but it is expected that production will increase proportionally faster in Peru than in Chile in the coming years with the development of very large deposits. Mining investments in Peru are forecasted at around 50 Billion USD over the next four years.



Given that copper production requires significant amounts of water, it is, therefore, appropriate to focus on these two countries, because the water needed for future production growth is not readily available in them, and it is expected that seawater desalination will play a large role in the growth of the copper industry in these two countries.



2. Drivers behind the increased water demand in Chile and Peru´s Mining Industry

There are several drivers behind the increased water demand in the Mining industry in Chile and Peru, and it is important to understand them well in order to prepare to compete in the future increased market for desalination plants. Some of the drivers are very straightforward, and others not so much, so we will dedicate some time to examining them, as follows:

2.1. Increased production of Copper

As discussed above, copper production in Chile and Peru is growing quickly, and part of the increased water demand can be explained by increases in production from the expansion of existing mines and by completely new projects being built.

2.2. Declining copper grades

In addition to increased copper production, there is an important increased demand caused by declining copper grades at existing mines. Historically, the richest deposits were mined first, as they were less costly to mine. As copper grades decline, more mineral has to be processed in order to produce the same amount of copper metal. The use of water is proportional to the amount of ore, so it follows that more water is needed to produce the same amount of copper. For example, if the copper grade is 1.5% instead of 3%, it will be necessary to mine twice as much ore and to use twice as much water to produce the same amount of final copper.

2.3. Process changes

Processing of oxides vs. processing of sulfides (Leaching to Flotation). As a given ore deposit is mined, sometimes a full process change is required to continue to produce copper most economically. As there are several deposits of this type in the region, we will look at this particular driver in greater detail.

Due to the natural weathering of mineral deposits, the portion of a mineral deposit that is located closer to the surface of the earth is richer in metal oxides, and the portion of the deposit that is deep down, away from the surface, is richer in metal sulfides. For cost reasons, oxides and sulfides are often processed by different techniques, with oxides more frequently processed via leaching/solvent extraction/electrowinning, which are all performed at a single location to produce copper metal, while sulfides can be processed with more difficulty by leaching/solvent extraction/electrowinning and are processed more frequently by flotation/smelting/electrorefining, which is commonly carried out in two separate physical locations. Flotation is typically carried out at the mine, and the copper concentrate produced is shipped, sometimes over very long distances, for further processing at a smelter and a refinery.

Therefore, at the beginning of the life cycle of a mine, oxides near the surface are processed first, and when the oxides are depleted, the underlying sulfides are processed.

2.3.1. Leaching/solvent extraction/electrowinning

For oxides and certain types of sulfides, the mineral is crushed, agglomerated, stacked in heaps or placed in vats, and then sprayed with water containing acid. The acid solution dissolved the copper contained in the mineral together with other impurities, such as iron. The copper cannot be extracted economically from this solution, so a purification process is conducted, whereby the copper is first transferred to an organic solution and then to a clean acid solution, from which the copper is electrically plated out onto electrodes, resulting in high-purity copper.

2.3.2. Flotation/smelting/refining

For sulfides, the mineral is crushed and then ground to a very fine particle size. The ground ore is suspended in water and chemicals are added. One chemical attaches reversibly to the copper sulfide, and when air is bubbled through the suspension in a device called a flotation cell, the sulfide particles are transported to the surface of the water and stabilized on a layer of foam created by another chemical, while the nonsulfide containing impurities remain at the bottom of the cell and are flushed away for disposal as tailings.

The copper sulfide containing foam is separated by paddles from the suspension, collected, and filtered to yield copper (sulfide) concentrate. At this point, the concentrate is usually transported to a smelter, where the sulfide is roasted at high temperatures and smelted giving hot liquid copper and poured in molds and cooled to form impure copper bars or plates shaped as an electrode called anodes.

In a further processing step, the anodes are hanged in an acid bath and subjected to an electric current, causing the copper to dissolve and replate, such that impurities sediment in the bottom of the cell and pure copper cathodes are formed.

Unfortunately, flotation/smelting/refining and leaching/solvent extraction/electrowinning have little in common, beginning all the way from size reduction, where sulfides are ground very finely and oxides are instead crushed and agglomerated to a larger size. The rest of the equipment is also incompatible, and while sometimes both oxides and sulfides are processed at the same site by different means, it is also common that a full process change necessarily takes place at some point during the life cycle of the mine.

An important consequence is that the processing of oxides and processing of sulfides require vastly different amounts of water. While the processing of oxides in the early stages of a mine typically requires 200 L of water per ton of mineral or ore, the processing of sulfides requires on the order of 800 L of water per ton of mineral.

Therefore, when a mine changes from processing of oxides to processing of sulfides, it has to completely revamp its water supply, as the water infrastructure that was built to process oxides will be completely inadequate to process sulfides.

Main Water constrained Projects Chile	Type	'000 Tons/yr Future Copper production	USD MM Investment	Stage
Cerro Casale	New Mine	90 + 800 K oz Au	6,000	PF
El Morro	New Mine	100 + 210 K oz Au	4,000	E
Quebrada Blanca	Conversion Leaching to Flotation	200	3,000	F
El Abra	Conversion Leaching to Flotation		1,000	PF
Candelaria	Water Supply		270	E
Escondida Phase V	Expansion	150	4,000	PF
Pelambres	Expansion	800	10,000	PF
Doña Inés de Collahuasi	Conversion leaching to flotation	800/1,200	6,500	PF
Antucoya	New Mine	80	1,300	E
Radomiro Tomic	Conversion leaching to flotation		4,500	PF
Caserones	New Mine	160	3,000	E
Caspiche	New Mine	60/210	350/5,000	PF

Main Peru Projects	Investment, MM USD	Type
Las Bambas	4,200	New Mine
Michiquillay	2,500	New Mine
Río Blanco	1,500	New Mine
Quellaveco	3,000	New Mine
Tía María	1,000	New Mine
Cerro Verde	2,800	Expansion
Conga	3,400	New Mine
Antamina	1,300	Expansion
Tintaya-Antapacay	1,500	Expansion

Following is a list of major projects in Chile and Peru and a comment on what type of project it is, a new mine, an expansion to increase the capacity because of lower grade or increased overall production, or a change from oxides to sulfides.
The drivers for increased water demand discussed above are happening in a context of decreased water availability. Water levels in aquifers and wells are decreasing quickly, and to make matters worse, water-use rights granted exceed the amount of water that is physically available and replenished in the aquifers. This is causing significant conflict between Mining companies, Municipal utilities, farmers, Indigenous communities, and consumers.

Other important issues that are relevant to the role that desalination will play in this industry and geography are discussed as follows:

2.3.3. *Use of straight seawater instead of desalinated water for mineral processing*

There is some experience in the use of seawater, both in leaching operations (oxide processing) and in flotation (sulfide processing) operations. Minera Michilla leaches oxides on a large scale with seawater, and Minera Las Luces has been floating sulfides with direct seawater for several years. Both Chile and Peru both have extensive coastlines, and seawater is readily available in both. If Mining operations are fully successful in using direct seawater, then there will be no need for future desalination plants. It appears so far that those mines that are successful in using seawater are those that are quite close to the coastline. The exception is Minera Esperanza, which has been operating for a few months and which pumps seawater over 100 km and at a considerable altitude. The Mining industry is watching this case with interest to see whether the assumptions made for carrying out the project were correct. Some have pointed out that the additional cost in infrastructure and chemicals required to deal with the corrosive nature of seawater and its buffering capacity fully compensates for the lower cost of not having to desalinate the water prior to pumping it to the mine site. This is yet an unresolved issue that depends on the specifics of each projects, and Mining companies are well advised to fully study both options during early Engineering study phases in order to not lose project execution time if only one option is studied, and it is discovered late in the project cycle that the other option was better.

2.3.4. *Sharing of infrastructure*

While an outside observer may very rightly think that it makes absolute sense to share desalination and water transport infrastructure between at least neighboring Mines and better yet, between Mining companies and Municipal water supply utilities, in practice, this is very disappointingly not at all (at least until now) the case. This is an interesting topic in itself, and there are a number of reasons for the lack of interest in infrastructure sharing, and hopefully in the future, we will see at least some of these initiatives be implemented. Basically, these projects involve significant amounts of capital (often several hundred million dollars when everything is considered), and there are many steps along the way to project implementation. Firstly, Mining companies spend significant amounts of money on Engineering studies for projects that never are executed. For the typical new orebody discovery, a study is first carried out at a conceptual stage, for which one of the main objectives is to provide a rough estimate, often with no better than 50% accuracy of how much capital will be required to develop the orebody. With that information, the Mining company determines whether it is attractive or not and then commissions further studies that will increase the level of detail for the assumptions made and also the accuracy of the level of investment required. Many studies are performed for projects that do not materialize because they so not provide a high enough return on investment and are abandoned along the way. Sometimes, metal prices change significantly, and studies are resuscitated to continue with further evaluations. At the end of the process, the Mining company ends up with an Engineering study, typically at the 10% level of accuracy, and with very detailed assumptions, which is presented to the Board of Directors for a go/no go decision. The point is that the process is quite complex and depends on a number of factors, some of which are Mining company specific. Therefore, it is extremely difficult to coordinate between two Mining companies in such a way that both will be ready to make the investment decision at precisely the same time, as initial studies would have to consider infrastructure sharing, which complicates the study considerably. When the decision to go is made by the board, often the project is executed immediately with no delay to take advantage of market conditions, and there is no possibility to wait for months or years for another Mining company to be ready to decide to invest in the infrastructure sharing project. Coordination between a Mining company and a Public utility has even less chances of being successful.

This does not bode well for projects where one company builds significant infrastructure in the hope of later selling water by cubic meter to Mining companies, which are the largest users. Mining companies are not in a position to sign a supply contract two years in advance committing to buy a given amount of water; because at that point they are not yet sure that the project is economically attractive. If they did, they would probably already be building the water supply infrastructure on their own. No commitment from the board of directors will be possible, and therefore, anyone who builds such infrastructure thinking of future sales to others will have to carry out the project without supply contracts in place, and at a considerable financial risk, which most banks would never carry.

Secondly, Mining companies are very concerned about stability of their water supply and are very sensitive to risk. Therefore, they do not look upon favorably to sharing infrastructure with others, as they are worried that issues affecting the other company, for example, a strike by the other companies' workers, could affect its water supply and, therefore, its production. Any downtime by a Mining company is typically measured in thousands of dollars per hour, and Mining companies are not willing to take much risk on their production.

Thirdly, sharing of water infrastructure with the community is not looked upon favorably for similar reasons. If anything happens whereby the supply of water to the population is affected, Mining companies worry that the water will be diverted firstly to the residential consumers, again at the detriment of mine production.

We still retain some optimism for these infrastructure sharing projects, but it is clear that the coordination and timing challenges are significant.

3. Challenges faced by traditional desalination companies when executing projects related to mine water infrastructure

A relevant part of Desalination projects so far have been geared toward water supply for consumer use in water scarce areas such as Southern Spain, and it is important to point out that there are significant differences between how these projects are typically carried out and how the Mining industry executes its projects. Understanding these differences will be important toward ensuring that Mining Desalination projects will be successful.

3.1. Speed of execution

As mentioned above, Mining projects are typically studied for several years before they are executed, and once the decision is made by the Board of Directors to go forward, they are typically executed at breakneck speed and with a relentless focus on early completion. This typically catches Desalination plant suppliers by surprise, as Municipal water supply projects do not have these time pressures, at least not as intense as are seen in the Mining industry. The reason for this is that Mining projects attempt to capture revenue from Copper production as soon as possible, and a shortened schedule can mean hundreds of millions of dollars in income, whereas Municipal water supply projects are subject to comparably minor penalties for late completion.

3.2. Relative project size

When desalination suppliers carry out a Municipal Desalination project, the desalination plant is the major component of the project and the Desal supplier is the main supplier. Because of this, the Desal supplier has a strong influence on the timing of the project and often manages the whole project. At the very least, the voice of the Desal plant supplier is clearly heard. For a new Mining project, the Desal plant is on the order of 5% of the whole project. Therefore, the Desal supplier now finds itself having to accommodate to the way Mining companies run projects, with large demands of specifications, drawings, progress reports, formal document management requirements, and a large owners team controlling everything that the Desal supplier does and demanding top speed of execution.

3.3. Project delivery methods

Mining projects are typically carried out as EPCM (Engineering, Procurement, and Construction Management) projects between the Mining company and a very large Engineering and Construction firm, which then manages EPC (Engineering, Procurement and Construction) contracts between the Mining company and the suppliers, in contrast to BOT (Build, Operate, and Transfer) or BOO (Build, Own and Operate) or other models that are more common in Municipal markets. This places enormous requirements on Desalination plant suppliers, in the form of a very large additional demand for detailed drawings, Engineering documents, weekly progress reports, quality control, etc. The Engineering company will assemble a team with several Engineers who will be dedicated full time to the following progress of the desalination plant supply and the water infrastructure. It is advisable that the Desalination plant supplier hire a few Engineers with experience in these types of projects for the duration of the project being delivered in order to minimize the animosity between them and the Mining company.

3.4. Safety standards

Mining companies are very safety conscious and have developed very sophisticated accident prevention and reporting systems. Something as a speeding ticket on the way to a mine site may disqualify a person from working on a project, so it is important that companies entering into supply projects with Mining companies quickly catch up with the particular philosophy, programs and requirements for the particular Mining company that they are dealing with.

3.5. Construction standards

Because of the focus on low downtime, construction standards are very high and redundancy is always a consideration. It is particularly advisable that this is taken into consideration at bidding time, as a high end robust product will be expected.

3.6. Change orders

It can happen, and it often does, that opportunities for additional scope of supply will arise during the delivery of a project. For example, the supply of the seawater intake structure may bid after the desalination plant has been awarded, and the desalination supplier could bid and win that part of the scope, or an opportunity may arise for faster project delivery or cost savings. On the other hand, a situation may arise where a higher cost will arise that was not previously considered. Mining companies are not against change, but is important to point out that change should be very well documented and justified, as well as notified as early as possible, to avoid problems with changes in the scope.

3.7. Components of a water supply project

Typically, a Mining water supply project is split up and bid out as four main supply contracts: (a) The Seawater Intake Structure and Marine Works, (b) the Desalination Plant and its Pretreatment, (c) the Pipeline and Pumping Stations to deliver the water to the mine, and (d) the Power supply for the desalination plant and the water delivery system. When all these are put together, the desalination plant ends up being a rather small portion of the total supply, and typically the pipeline and the pumping stations are the largest part. There will be many companies that need to work closely together and coordinate to achieve a successful project, and this places additional requirements on the Desalination plant supplier, as a lot of information is needed from the Desal supplier for the other components of the project.

4. Summary and conclusions

A large increase is expected in the supply of Desalination projects for Northern Chile and Peru. The demand will be driven mainly by growth in the Mining industry. Desalination projects for the Mining industry have particular issues associated with them which are important to understand in order to be a successful player in this market.

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