Understanding the Basics of

LITHIUM EXTRACTION

A PUBLICATION OF SAMCO TECHNOLOGIES

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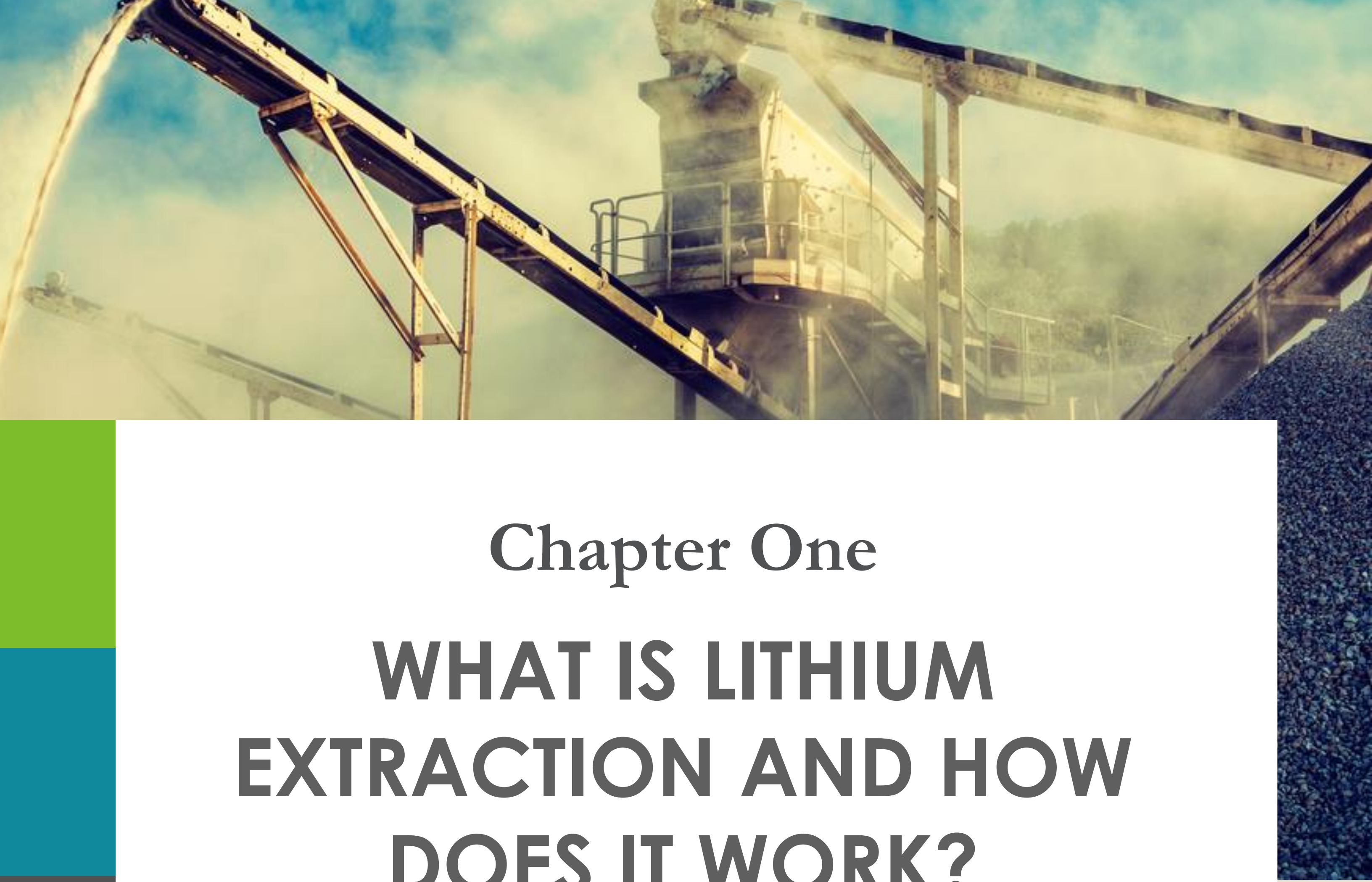


Chapter One

WHAT IS LITHIUM EXTRACTION AND HOW DOES IT WORK?

LITHIUM EXTRACTION

What it is and how it works

The world's demand for lithium extraction is growing every day and is especially driven by an increased lithium use in new consumer electronic battery technologies and electric cars. While you've likely heard of lithium batteries, you might still want to know where all that lithium comes from and how it's produced. If so, you may be asking **"what is lithium extraction and how does it work?"**

Lithium extraction and processing can depend heavily upon the source of the metal, so in this chapter, we'll take a look at some of the more typical lithium production strategies and how they compare.

What is lithium extraction?

Lithium is a highly reactive alkali metal that offers excellent heat and electrical conductivity. These properties make it particularly useful for the manufacturing of glass, high-temperature lubricants, chemicals, pharmaceuticals, and lithium-ion batteries for electric cars and consumer electronics. However, because of its high reactivity, pure elemental lithium is not found in nature but is instead present as a constituent of salts or other compounds.

Similarly, most commercial lithium is available in the form of lithium carbonate, which is a comparatively stable compound that can be easily converted to other salts or chemicals.

Lithium salts are found in underground deposits of brine, mineral ore, and clay, as well as in seawater and geothermal well brines and water. **By definition, lithium extraction is a set of chemical processes whereby lithium is isolated from a sample and converted to a saleable form of lithium**, generally a stable yet readily convertible compound such as lithium carbonate. Most lithium extraction processes entail some form of mining to reach underground deposits of lithium-rich minerals or brines.

While lithium is fairly abundant in both land and sea, only a few sources are considered economically viable. This is expected to change in coming years as new technologies make extraction from alternative lithium sources more competitive in terms of cost.

How does lithium extraction work?

Commercial lithium arises from two major sources: underground brine deposits and mineral ore deposits. The methods of lithium extraction and processing vary depending upon the source material and include the following:

Conventional lithium brine extraction

An overwhelming quantity of today's lithium is extracted from liquid brine reservoirs that are located beneath salt flats, known as salars, most of which are located in southwestern South America and China. Other lithium-rich brine resources include geothermal and oil field brines, which are addressed below.

Lithium brine recovery is typically a straightforward but lengthy process that can take anywhere from several months to a few years to complete. Drilling is required to access the underground salar brine deposits, and the brine is then pumped to the surface and distributed to evaporation ponds. The brine remains in the evaporation pond for a period of months or years until most of the liquid water content has been removed through solar evaporation. Salar brines are very concentrated and, in addition to lithium, typically contain potassium and sodium as well. Facilities usually operate several large evaporation ponds of various ages and may extract other metals (e.g. potassium) from younger ponds while waiting for the lithium content to reach a concentration optimal for further processing. In some cases, reverse osmosis (RO) is used to concentrate the lithium brine to speed up the evaporation process.

Once the brine in an evaporation pond has reached an ideal lithium concentration, the brine is pumped to a lithium recovery facility for extraction. This process varies depending upon the brine field composition, but usually entails the following steps:

- **Pretreatment**; this step usually employs filtration and/or ion exchange (IX) purification to remove any contaminants or unwanted constituents from the brine.

- **Chemical treatment**; next, a series of chemical solvents and reagents may be applied to isolate desirable products and byproducts through precipitation.

- **Filtration**; the brine is then filtered to separate out precipitated solids.

- **Saleable lithium production**; the brine is finally treated with a reagent, such as sodium carbonate to form lithium carbonate, and the product is then filtered and dried for sale. Depending upon the desired product, different reagents may be applied to produce other commonly sold forms of lithium, such as lithium hydroxide, lithium chloride, lithium bromide, and butyl lithium.

Once the lithium extraction process is complete, the remaining brine solution is returned to the underground reservoir.

Hard rock / spodumene lithium extraction

While accounting for a relatively small share of the world's lithium production, mineral ore deposits yield nearly 20 tons of lithium annually. Well over 100 different minerals contain some amount of lithium, however, only five are actively mined for lithium production. These include spodumene—which is the most common by far—as well as lepidolite, petalite, amblygonite, and eucryptite.

Mineral ore deposits are often richer in lithium content than are salar brines, however, they are costly to access since they must be mined from hard rock formations.

Due to the added energy consumption, chemicals, and materials involved in extracting lithium from mineral ore, the process can run twice the cost of brine recovery, a factor that has contributed to its smaller market share.

The process for recovering lithium from ore can vary based on the specific mineral deposit in question. In general, the process entails removing the mineral material from the earth then heating and pulverizing it. The crushed mineral powder is combined with chemical reactants, such as sulfuric acid, then the slurry is heated, filtered, and concentrated through an evaporation process to form saleable lithium carbonate, while the resulting wastewater is treated for reuse or disposal.

Other lithium extraction processes

Beyond salar brine and mineral ore, lithium can be produced from a few other sources, though such production is not widespread at this time. These other lithium sources include:

- **Hectorite clay**; extensive research and development has been invested into developing effective clay processing techniques, including acid, alkaline, chloride and sulfate leaching, as well as water disaggregation and hydrothermal treatment. To date, none of these technologies have proven economically viable for extracting lithium from clay.

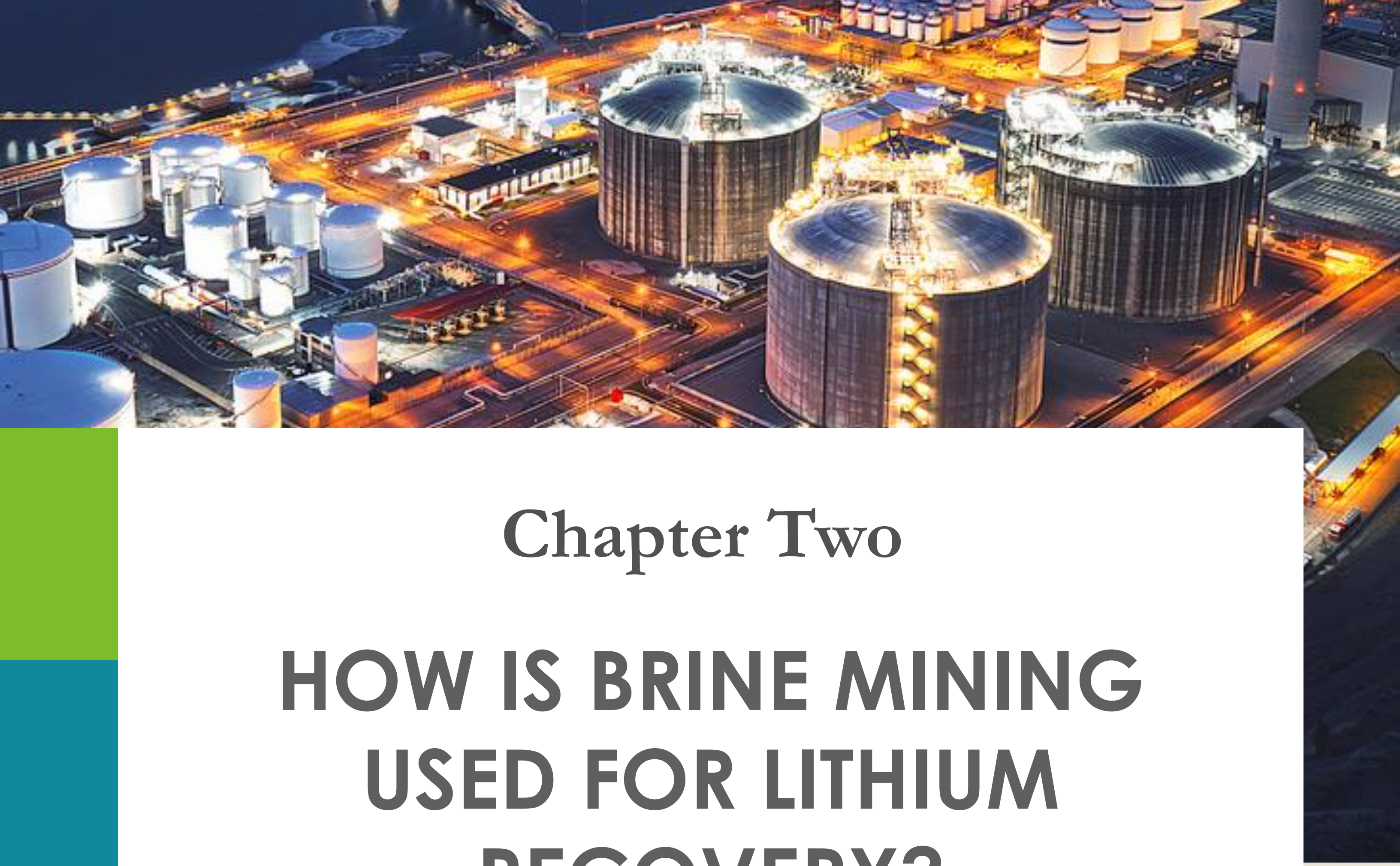
- **Seawater**; hundreds of billions of tons of lithium is estimated to exist in our oceans, making them an attractive source for meeting future lithium demand. While existing processes—including a coprecipitation extraction process and a hybrid IX-sorption process—have succeeded in extracting lithium from seawater, newer membrane technologies are showing greater promise for bringing the costs of seawater extraction down.

- **Recycled brines from energy plants**; efforts to retrieve lithium from geothermal brines are gaining popularity as worldwide demand for lithium increases and as new technologies emerge. The processes used follow conventional brine extraction, though they might be adapted based on the content of the brine stream.

- **Recovered oil field brine**; retrieval of lithium from oil field brines is technically just another form of conventional brine extraction, with the difference being the source of the brine.

- **Recycled electronics**; lithium battery recycling doesn't truly meet the definition of extraction, however, as demand grows, lithium-ion battery recycling will become an increasingly valuable source of the metal.

While each of these poses a potentially valuable source of lithium, the technologies to extract brine from them are not yet developed enough to make them cost-effective or viable alternatives to salar brine mining or mineral ore mining.



Chapter Two

HOW IS BRINE MINING USED FOR LITHIUM RECOVERY?

BRINE MINING

How it's used for lithium recovery

Brine mining is by far the most common method of lithium recovery used today. But what is it, and **how is brine mining used for lithium recovery**?

In this chapter, we'll look at **how and why brine mining relates to lithium production** and explore how the principles of brine mining are leveraged to develop new lithium extraction technologies capable of isolating the metal from alternative sources.

What is brine mining?

Brine mining is the extraction of any desirable compounds or elements from a naturally occurring salt solution, such as brackish groundwater, seawater, and surface water (e.g. saline lakes). Brine mining operations may extract numerous materials from the same deposit, and production may include lithium as well as a variety of other elemental substances and compounds.

How is lithium produced by brine mining?

The actual process for recovering lithium from brine varies depending upon the source of the brine. The three main types of lithium brine deposits include continental, geothermal, and oil field deposits, as outlined below:

Continental brine deposits

Continental brine deposits are found in underground reservoirs, typically in locations with arid climates. The brines are contained within a closed basin, with the surrounding rock formations being the source of the dissolved constituents in the brine. In conventional lithium brine extraction, the brine is first pumped to the surface, where it undergoes a number of steps to ultimately produce a saleable lithium salt, such as lithium carbonate. This can include concentrating the brine, pretreatment to remove contaminants, and chemical treatment to precipitate the lithium out of solution. While rare, lithium-rich continental brine deposits remain the most economical source for lithium production, and, as a result, well over half of the world's lithium is produced from just a handful of continental brine mining facilities across the world.

Geothermal brine deposits

Found in rocky underground formations with high heat flows, geothermal brines are highly concentrated, often with significant dissolved metal content. The brine is typically pumped to the surface by a geothermal power plant, used for energy generation, and then returned to the underground deposit via an injection well, or discharged to a surface waterway. In an effort to maximize efficiency and cut waste, some facilities have implemented technology to extract valuable materials, such as lithium, manganese, and zinc, from the brines prior to disposal. Recovery of lithium from geothermal brines may entail reverse osmosis (RO) and ion exchange (IX) units, among other technologies.

Oil field brine deposits

Oil fields are lands with underground petroleum reservoirs. In extracting oil and gas from oil fields, a significant amount of brine is also brought to the surface as well. Known as "produced water," these brines are often rich in dissolved metals, which can include lithium in some locations. Over the past several years, the increasing demand for lithium has inspired some oil field facilities to implement technologies to recover lithium from produced water. Technologies used for this purpose have included gravity separation, gas flotation, and flocculation, among others.

Alternative sources of lithium

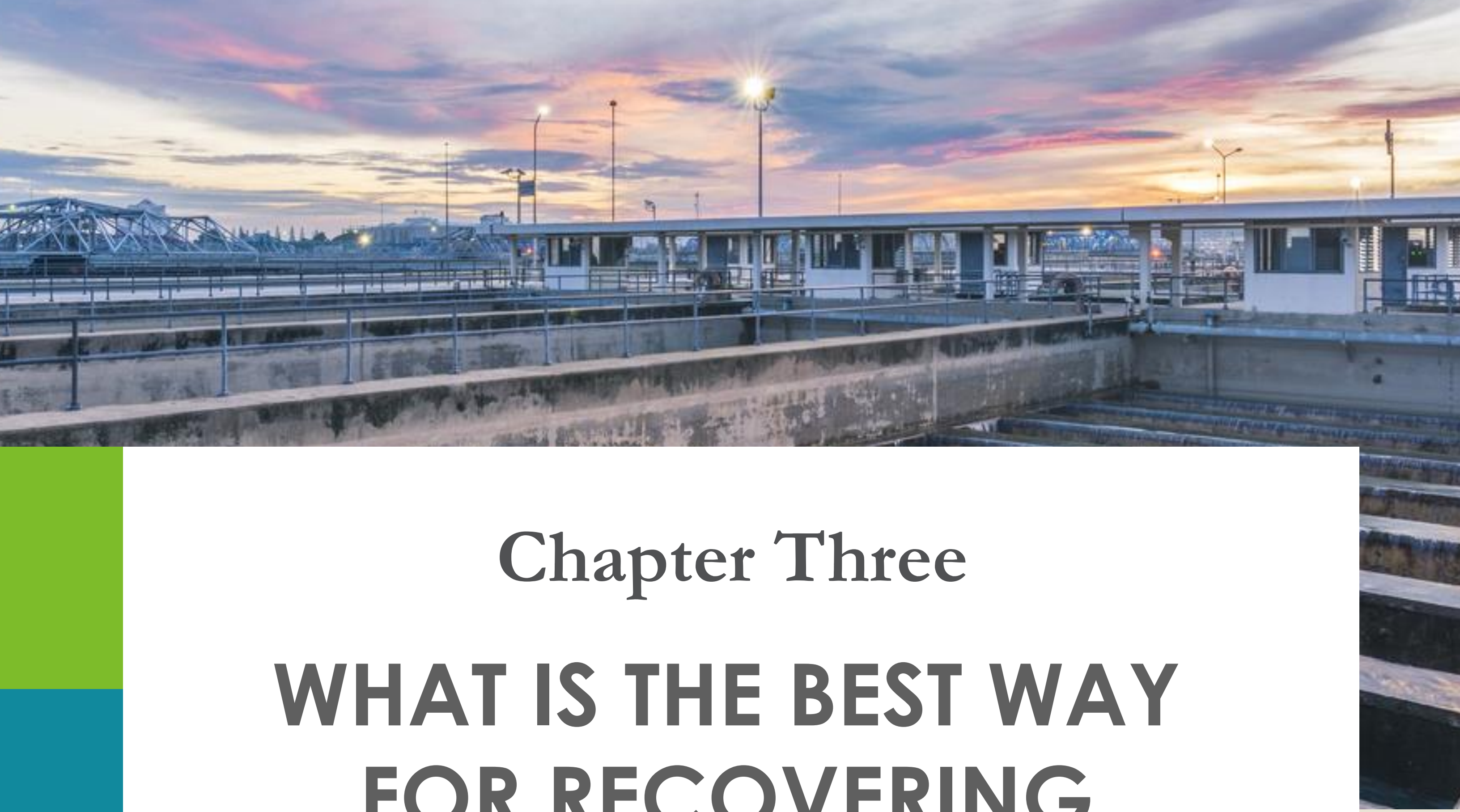
Lithium is present in land and water across the earth, though generally in such small concentrations that commercial extraction simply isn't viable. Existing brine mining operations exploit the few known brine deposits that are naturally rich in the metal. With the rising demand for lithium, however, some facilities are implementing new technologies that are inspired by standard brine mining techniques but are instead designed for use with produced water and brine waste streams.

These include:

- **Hydraulic fracturing brine**; Hydraulic fracturing, or “fracking,” operations entail high pressure injection of brines into underground rock formations for the purpose of extracting oil and gas. When the liquid is brought back to the surface, it contains not only the water, oil, and gas, but also dissolved materials from the surrounding rock. To make more efficient use of resources, some companies are incorporating water and waste treatment technologies to recover these dissolved metals and salts from the fracking brine, as is the case for a lithium recovery operation at shale gas fields in Texas.

- **Heavy oil wastewater**; Heavy oil mining operations produce significant volumes of evaporator blowdown wastewater, which, depending on location, can contain dissolved materials. At some locations, facilities are implementing water treatment technologies to recover lithium and other valuable materials from heavy oil wastewater, and to cut costs by reducing wastewater discharge volumes.

Recovering lithium as a byproduct of mining activities is challenging, as the metal is almost always present in very low concentrations. Still, with the development of new metals recovery technologies, it is becoming economically viable to extract lithium from brines and waste streams, especially as many of these emerging techniques offer a faster production timeline than conventional evaporation methods.



Chapter Three

WHAT IS THE BEST WAY FOR RECOVERING LITHIUM FROM GEOTHERMAL BRINE?

LITHIUM AND GEOTHERMAL BRINE

What is the best way to recover lithium from this naturally occurring source?

Geothermal brines, the naturally heated fluids found within the earth's crust, have been utilized for thousands of years. Ancient civilizations used them for bathing and heating small rooms, and today they heat entire homes, pools, and greenhouses; are used agriculturally; and even produce electricity. As technologies advance and more is learned about the potential value of geothermal brines, the resource is gaining attention.

A cleaner and more sustainable energy source than fossil fuels, geothermal brine can not only be used to power entire cities but can also be a potential source for other commodities. Since the brines come from deep within the earth and spend time collecting debris around volcanic formations and volatile tectonic plates, they come to the earth's surface containing energy-producing heat as well as all sorts of minerals and metals that, if efficiently separated out and concentrated up, **could provide geothermal energy companies a second—and significant—stream of revenue**.

Why lithium?

Energy and mining companies, as well as governments around the world, are funding research initiatives to find the best methods for "mining" geothermal brines for the valuable metals they contain, which can include silica, manganese, zinc, and, what this ebook focuses on, lithium.

Depending where the geothermal brine is located, it could potentially be rich in lithium, which is one of the main components used in rechargeable lithium ion-battery manufacturing. As we mentioned in prior chapters, the cell phone and electric car markets continue to grow, and forecasts expect them to grow substantially…so will the demand for this valuable metal.

So **how are companies recovering lithium from these geothermal brines, and what is the best method for doing so**?

The best lithium extraction methods

The potential for mining geothermal brine for lithium has been recognized for decades, yet many methods and technologies, which are still being tested and have yet to break through commercially, can be inefficient or costly. Membranes foul, pipes corrode, land or energy requirements skyrocket, and companies often find themselves frustrated with the many difficulties than can arise while managing these often-problematic streams.

Some extraction methods that might eventually prove beneficial include **solvent extraction, molecular recognition technology, using engineered microbes, and magnetic separation**, to name a few. But as new methods and technologies surface, the processes are getting more efficient, and while there is still some innovation left to be had when it comes to mining geothermal brine for lithium, the following are some of the more promising:

Adsorption

One of the methods researchers continue to pursue include using sorbents to **adhere to the lithium for selective removal**. Some sorbents developed can recover about 90% of the lithium present, including a recently tested lithium aluminum layered double hydroxide chloride sorbent, or LDH, as described in a recent study published by Environmental Science & Technology. During more recent testing, the LDH sorbent was made by intercalating aluminum hydroxide with lithium chloride, which made several [LiAl2(OH)6]+ layers in the sorbent. These layers were separated by water molecules and hydroxide ions that created the spacing requirements to allow lithium chloride to enter more readily than other ions, such as sodium and potassium. After the sorbent was loaded with the lithium chloride, it was washed with a diluted lithium chloride stream to remove unwanted ions, then washed a second time to unload the lithium chloride.

As outlined in the study, this method doesn't require an acid wash or other chemicals, as some sorbents do (such as delithiated manganese oxides or layered hydrogen titanates), so it is much more environmentally friendly and doesn't create problematic wastes. Although the LDH sorbents are still being tested and have yet to be implemented commercially, researchers feel they look promising.

Ion exchange

Ion exchange (IX) systems are used across a variety of industries for water softening, purification, and separation purposes. These systems separate ionic contaminants from solution through a physical-chemical process where undesirable ions are replaced by other ions of the same electrical charge. This reaction occurs in an IX column or vessel where a process or waste stream is passed through a specialized resin that facilitates the exchange of ions. When contaminant removal needs are highly specific, such as pulling lithium from geothermal brines, many times IX, especially with chelating resins, is ideal.

Researchers are also developing lithium-imprinted polymer resins for adsorbing the metal. When the lithium ion is adsorbed and desorbed, it leaves behind an imprint that can be used for specific selectivity, since the size, shape, and binding arrangement is recorded and kept on the polymer. To further complicate these studies, lithium recovery by ion exchange can change with a simple adjustment in pH, temperature, or stream composition (and the same goes for other lithium extraction methods), but researchers also believe this method can recover roughly 90% of the lithium present.

The resin's regeneration and binding capabilities are still being tested and recovery rates are expected to increase.

Electrodialysis

Electrodialysis is also a form of ion exchange that can be used to separate out lithium from geothermal brine. It's a membrane process that uses positively or negatively charged ions to allow charged particles to flow through a semipermeable membrane and can be used in stages to concentrate the brine. It is often used in conjunction with RO to yield high recovery rates.

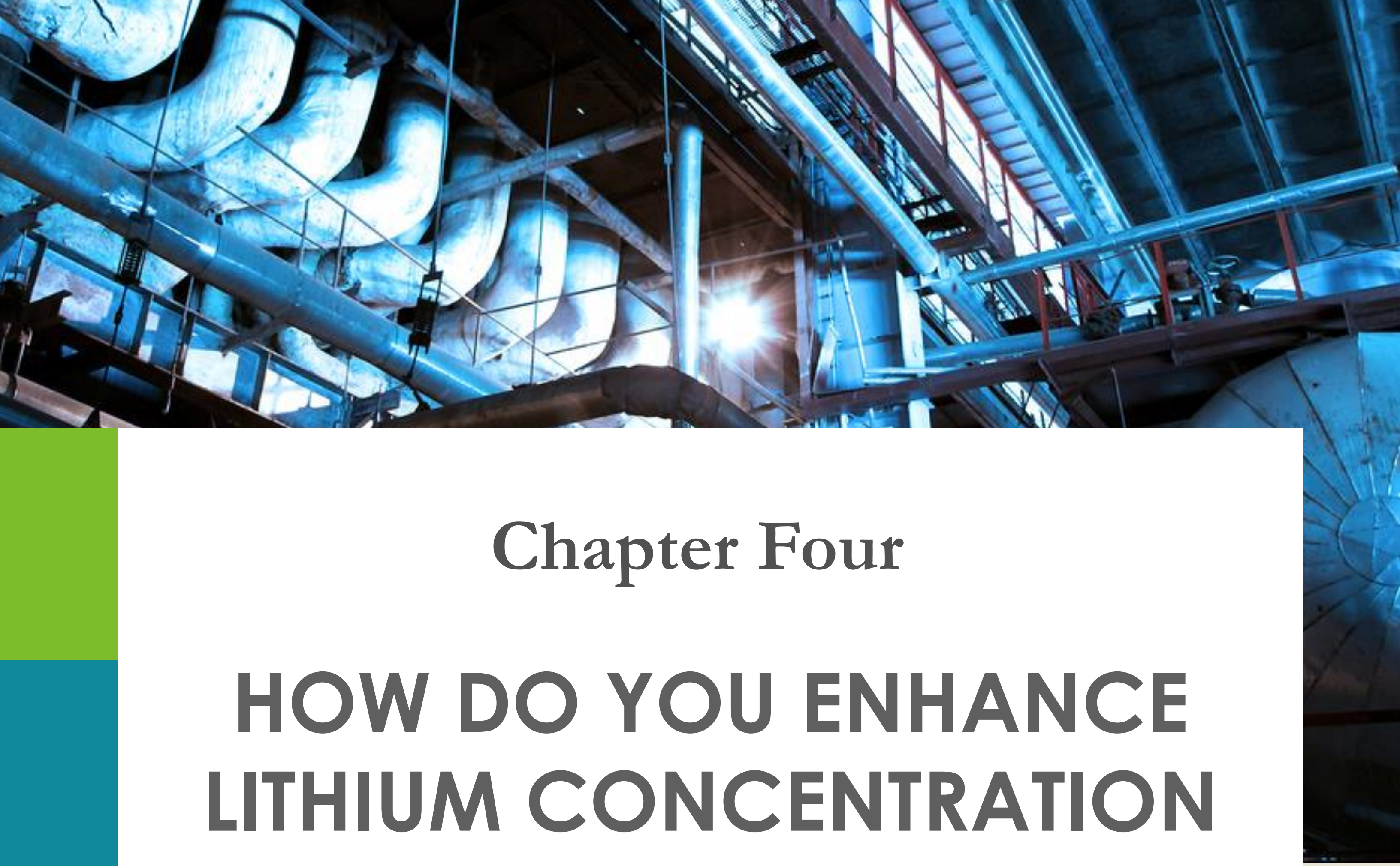
At the Wairakei geothermal power station in New Zealand, which lies on the Taupo Volcanic Zone, researchers attempted to extract lithium with this process, as outlined in a posted study. The facility first removed silica from the stream and proceeded to test how different voltages, currents, temperatures, and acidification levels affected the ability to extract lithium by electrodialysis. The experimenters tested the fluids in batches using several different types of membranes and found that:

- acidification levels affected extraction (pH from 2 to 4 proved most beneficial)
- increasing the current improved extraction rates, but also limited membrane use

- heating the diluate didn’t seem to increase extraction, as it was expected to

- multi-stack systems might yield higher extraction rates

Their conclusion was that more testing needs to be done before this method can be scaled up to its full potential, especially when it came to using higher currents and voltages, which caused irreversible damage to the membranes.



Chapter Four

HOW DO YOU ENHANCE LITHIUM CONCENTRATION AND RECOVERY FROM BRINE STREAMS?

LITHIUM AND BRINE STREAMS

How to enhance lithium recovery and concentration

Lithium is a **highly reactive alkali metal that offers excellent heat and electrical conductivity**. This metal is also used to manufacture glass, high-temperature lubricants, chemicals, and pharmaceuticals. However, because of its high reactivity, pure elemental lithium, as mentioned prior, is not found in nature but instead is present as a constituent of salts or other compounds. Also, remember that most commercial lithium is available in the form of lithium carbonate, which is a comparatively stable compound that can be easily converted to other salts or chemicals.

Extracting and processing lithium can depend heavily upon the source; lithium exists in different concentrations and states alongside other valuable metals and minerals, which will vary depending on where the lithium is found. Many methods and technologies for extracting and processing lithium can be inefficient or costly and many difficulties than can arise while managing these often-problematic brine streams.

There can be many variables when discussing this topic and the scenarios and methods can get a bit complex, so this portion of the ebook will look at some of the more typical ways to "**enhance lithium concentration and recovery from brine streams**" that are widely used today. Please also keep in mind that many of these methods can be used for extracting AND concentrating lithium, and sometimes in conjunction with each other to yield even better results.

Adsorption

One of the methods researchers continue to pursue include using sorbents to **adhere to the lithium for selective removal**. Lithium ions attach to the sorbents while unwanted ions are washed away. This can be used to extract lithium from geothermal brines, waste brines, or seawater.

Some methods require an acidic solution to wash the sorbent, which can leave your facility with problematic waste, but some recently formulated sorbents that require diluted lithium chloride for rinsing are touted as being more environmentally friendly. As this method is tested and made more efficient, recovery rates could increase.

Reverse Osmosis

Reverse osmosis, or RO, is using high osmotic pressure is used to push permeate through a semipermeable membrane while trapping and filtering out any contaminates larger than the pure water that passes through to the lower-pressure side. RO leaves you with pure water and a highly concentrated reject stream that is either used or discarded, depending on the separation and concentration needs of the facility.

In the case of using RO for concentrating lithium, it is often used as a means of providing a higher concentrated stream, such as a concentrate dilute lithium bicarbonate solution to near saturation for downstream lithium carbonate production or prior to evaporation and is usually used as part of a stepwise process or larger treatment train when it comes to concentrating lithium.

Ion exchange

When contaminant removal needs are highly specific, such as pulling lithium from geothermal brines, wastewater brines, or seawater, many times IX chelating resins are typically ideal. IX systems can be used to remove selected contaminants from the stream so lithium can be extracted more efficiently, and these systems can also be used to extract the lithium itself.

In general, using IX to recover and concentrate lithium is done more or less by:

- removing divalent metal ions with cation IX resins
- removing sodium and potassium with a specialty IX resins

- recovering lithium as a precipitate of lithium carbonate

Since sodium and potassium, along with other metals and minerals, can be present is higher concentrations than lithium, it is often recommended that these be removed first to improve lithium recovery rates. Although there are countless other methods for selecting lithium for removal, these general steps, however they are carried out, are typically pursued with selective removal methods such as IX.

Electrodialysis

Electrodialysis is also a form of ion exchange that can be used to separate out and concentrate lithium. It's a process that uses positively or negatively charged ions to allow charged particles to flow through a semipermeable membrane and **can be used in stages to concentrate the brine**.

This process can be complex to get just right; minor variations in acidification levels, current strengths, temperature fluctuations, and membrane configurations could greatly affect the rate at which lithium can be extracted and concentrated.

Precipitation

Some methods for extracting and concentrating lithium from brine use precipitation as a means for isolating the metal. Using precipitation will usually require several steps, as you need to precipitate and isolate the lithium (usually in the form of lithium chloride), and further separate it out.

For example, a study done by the Bureau of Mines was able to yield a 99% recovery of lithium with precipitation. First, they treated brine samples with a lime slurry to increase the pH. Next, they used filtration technologies to remove iron, manganese, lead, and zinc. The resulting lithium/aluminum precipitate was then dissolved, separated, and evaporated out in a series of mixing, rinsing, and filtration steps.

Evaporation

Lithium brine recovery by evaporation is typically a straightforward but lengthy process that can take anywhere from several months to a few years to complete. Brine is distributed among evaporation ponds for a period of months or years until most of the liquid water content has been removed through solar or wind evaporation. Facilities usually operate several large evaporation ponds of various ages and may extract other metals (e.g. potassium) from younger ponds while waiting for the lithium content to reach a concentration optimal for further processing. In some cases, and as mentioned prior, RO is used to concentrate the lithium brine to speed up the evaporation process.

Once the brine in an evaporation pond has reached an ideal lithium concentration, the brine is pumped to a lithium recovery facility for extraction using the pretreatment, chemical treatment, filtration, and lithium production steps mentioned in chapter one.

Chapter Five

HOW MUCH DOES IT COST TO EXTRACT LITHIUM FROM GEOTHERMAL BRINE OR CRUSHED ORE?

LITHIUM EXTRACTION COST FOR YOUR PLANT

Pricing, factors, etc.

Extracting lithium from geothermal brines and crushed ore **requires a complex family of technologies and systems**. If your facility has been exploring new ways to extract this valuable metal, you're probably wondering, "**How much does it cost to extract lithium from geothermal brine and crushed ore?"**

Estimating the cost of a lithium separation and polishing system is complicated, in part due to the many factors and variables that play a key role in system design. This chapter describes **what some factors affecting the cost of lithium extraction systems are** and how they might apply to your facility's processes.

What steps are included in a lithium extraction system?

Clarification and filtration

Each lithium extraction process has a unique polishing step that will depend on the product being manufactured (**whether it's lithium carbonate, lithium sulfate, or lithium hydroxide**).

These steps will also vary based on the type of feed stock being used, such as **ore or liquid brine**.

But, for the most part, after all the primary and crude removal of unwanted metals yields a brine that can be secondarily processed, **clarification and filtration are typically the first steps of lithium processing** to remove physical impurities from a lithium-saturated brine.

There are many ways to do this; however, **using clarification followed by filtration is generally the preferred way to begin the lithium extraction process**. It's also common for companies to opt for the simplicity of lagoon settling before running their brines through high-end membrane filters next, and increasingly, these high-end filters are candle filters or membranes capable of removing unwanted particles down to less than one micron.

Ion exchange and brine softening

The second step to extracting lithium is typically an ion exchange process called brine softening to further remove calcium, magnesium, iron, and other unwanted metals from the brine solution. This technology is very similar to the technology used for brine filtration in the chlor-alkali industry with specialized chelating resins designed to pull metals out of brine solutions in a merry-go-round, three-vessel configuration.

Evaporation and high-pressure membranes

After these steps, the facility should be left with a solution that is highly concentrated with lithium (whether in the lithium carbonate, lithium hydroxide, or lithium chloride state). At this point, typically there is either an **evaporation or high-pressure membrane** step that takes the lithium to a higher concentration and, depending on the product being manufactured, this can even be **a two-step process with high-pressure membranes first and evaporators second**.

End-of-process polishing and posttreatment

Lastly, the brine will enter a polishing system where **an electrochemical cell separates the lithium from the brine**. From here, any required posttreatment options are done so according to the facility's end-product goals.

The main factors of lithium extraction system cost

Brine contaminants

One of the main factors affecting the types of technologies required for your facility's brine-extraction system includes **the different types of rare metals and earths that are present**. Certain metals and elements can require processing steps to be added, as extracting lithium can be complicated by certain metals, such as zinc or lead.

If these are present in the stream, the facility might have to remove these impurities first, lithium second.

Other front-end contaminants, such as silica, sulfates, iron, calcium, magnesium, hardness, suspended solids, etc., can also make it more difficult to get the brine into a condition where it can be polished and used for the separation/concentration ends of the process. So, again, these will need to be removed prior to extracting and concentrating lithium.

Lithium concentration

Another big factor is the concentration of lithium in the stream. If lithium is not at a high enough concentration in the liquid stream, then the cost to concentrate it up increases the overall cost per kilo of lithium substantially. Sometimes this can be to the point where it doesn't make it worthwhile to recover the lithium in the first place. **The higher the concentration of lithium, the less amount of ore and brine processing your facility is required do, which also reduces secondary wastes and overall cost**.

Flow rates

In general, **the higher the flow rate of your lithium extraction and polishing systems, the bigger the equipment and the more the capital cost will be**. Systems are also usually customized for lithium extraction because the applications are unique on every project.

Other important factors to consider when pricing the cost to extract lithium

- ***Up-front planning***; Developing the concepts, designs, and regulatory requirements for your project is the first step to planning your lithium extraction system. The cost of engineering for this type of project can typically run **10–15% of the cost of the entire project** and is usually phased in over the course of the project, with most of your investment being allocated to the facility's general arrangement, mechanical, electrical, and civil design.

- ***Space requirements***; When planning for a lithium extraction system, the size of your system will affect your cost, and the footprint is usually large, so keep in mind that sometimes **your plant location can affect the cost of your system**. For example, if your plant is located in a place that is very expensive when it comes to space, you might want to aim for a smaller footprint, if possible.

- ***Installation rates***; Another thing to keep in mind is the installation rates in your area. These also fluctuate by location, so be sure you're aware of the cost to install the system and factor this into your budget. **In areas where installation costs are high you may want to consider prepackaged modules** versus build-in-place facilities.

- ***Level of system automation needed***; When it comes to the level of automation you need for your lithium extraction system, there are two options. The first is a higher level of automation where you won't need an operator present for much of the time. With type of automation, you can eliminate much of the human error associated with running the plant, and although this option is more costly up front (an initial investment in more sophisticated PLC controls and instrumentation), the ongoing labor costs are less. The second option is a lower level of automation with less capital cost, but with added labor, this can end up costing you more in the long run. When deciding whether or not to invest in more costly controls, you need to **consider what works for your company and staffing availabilities**.

- ***Turnkey and prepackaged systems***; If you are able to order your lithium extraction system prepackaged, this will typically save you about three months in construction time at about the same cost or less. A benefit to having your system prepackaged is that the production facilities and fabrication shops that assemble your system are, more often than not, highly knowledgeable about the type of system they are manufacturing. This results in a quick and efficient fabrication versus build-in-place facilities. Sometimes when you hire a field crew, there is a bit of a learning curve that can add extra time and/or cost to a project. Installation costs **will vary, but typically range between 15–40% of the project cost**, depending on the specifics of prepackaging and amount of site civil work needed.

- ***Shipping the system to your plant***; When having your lithium extraction system shipped to the plant, **you usually want to factor in about 5–10% of the cost of the equipment for freight**. This can vary widely depending upon the time of year you are purchasing your system in addition to where your plant is located in relation to the manufacturing facility. When you are looking to purchase your system, check with your manufacturer to see if there is a facility where the system can be constructed closer to you, if not on-site.

- ***Operation costs***; Also keep in mind that particular technology packages cost a certain amount to purchase up front, but you need to also factor in system operating costs over time. For decisions like these, you need to **weigh the pros and cons of initial versus long-term cost investment** in addition to what works for your company and staff. You will likely want to look into having someone develop an operating cost analysis so your company can plan ahead for the operating cost over your lithium extraction plant's life cycle. This might help you consider whether or not you want to spend more on your system initially or over time.

- ***Other possible costs and fees***; When purchasing a lithium extraction system, you might also want to **keep in mind what other hidden costs and fees might be**. For example: Will there be any taxes on the system or additional purchasing fees? What are your possible utility costs to the installation area? Will there be any environmental regulatory fees and/or permits? Any ongoing analytical compliance testing you need to pay for?

Also consider that there will be **costs to treating the secondary waste** produced by the system. With stringent environmental regulations, you will need to either treat the waste for hauling away or solidify with a filter press/evaporator and transport to third party disposal firm.

Also, be sure to ask your system manufacturer about options that might be cheaper to install. They might be able to shed some light on the more installation-friendly systems with suggestions on how to keep your costs to a minimum.

The bottom line

For front-end filtration, plan spending anywhere from $750,000 to $2.5 million depending on the amount of filtration, flow rate, and automation on the filters. The brine IX system will be in the same range. Lower flow rates (around 50 GPM) would be in the range of about **$300,000 to $400,000**, and higher flow rates (500 to 1000 GPM) will be in the range of **$1.5 to $3 million**.

Membrane processes are very customizable, and a 50 GPM high-pressure membrane system to concentrate lithium may be in the **$200,000-$400,000** range, a high-end 1000 GPM system will be in the **$2 to $4 million** range.

A complete operating pilot plant installed and running for a 1/10 scale can cost **$50 million to $150,000 million**. A large integrated facility can be as high as **$500 million to $1 billion** USD.

HOW CAN SAMCO HELP?

SAMCO has over 40 years' experience in identifying appropriate lithium treatment technologies to help lower costs and waste volumes while increasing product quality. For more information or to get in touch, contact us to set up a consultation with an engineer or request a quote. We can walk you through the steps for developing the proper solution and realistic cost for your system needs.

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