LITHIUM: Emerging Lithium Extraction Technologies - Nemaska Lithium leads the charge

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Background: The lithium industry and batteries

The revolution in battery technologies has caused a sharp acceleration in the demand growth for lithium and the trend is expected to continue. With electric vehicle costs falling and infrastructure improving, demand for lithium from battery applications is projected to increase between 15 to 25 percent per year over the next ten years.

On the supply side, major investment in Australian downstream processing and a shift to lithium hydroxide production are the major trends currently. Within the context of new emerging technologies, expansion of existing operations and more complex routes becoming technically and economically feasible, the lithium industry will continue to evolve.

Producers and technology licensors have invested significantly in the development of newer lithium extraction technologies. Nexant provides a brief analysis of the emerging technologies and a more in-depth case study looking at Nemaska Lithium, a company that has developed a technology utilizing electrolysis and has recently completed a financing package worth US$849 million for development of its mine and lithium hydroxide monohydrate plant.

What are the technologies currently being developed and at what stage of development are they?

Nexant has identified seven brine technologies and six mineral technologies that have not yet been commercialised but that are at advanced stages of development and in some cases, the commercial plant design is underway. Based on information in the public domain, we expect the technologies developed by Eramet, Rincon, MGX Minerals, Nemaska Lithium and Bacanora Minerals to be the closest to commercialization.

Figure 1: Development Stage for Each Emerging Technology (Q3, 2018)

Technology holder	Laboratory testing	Laboratory scale	Pilot plant design	Pilot plant scale	Commercial plant design	Commercial plant scale
Brine						
K-UTEC AG				◆		
Tenova Bateman			◆			
Eramet					◆	
POSCO				◆		
Rincon					◆	
MGX Minerals					◆	
Standard Lithium			◆			
Mineral						
Lepidico			◆			
Lithium Australia			◆			
Nemaska					◆	
Neometals		◆				
Bacanora					◆	
Rio Tinto				◆		

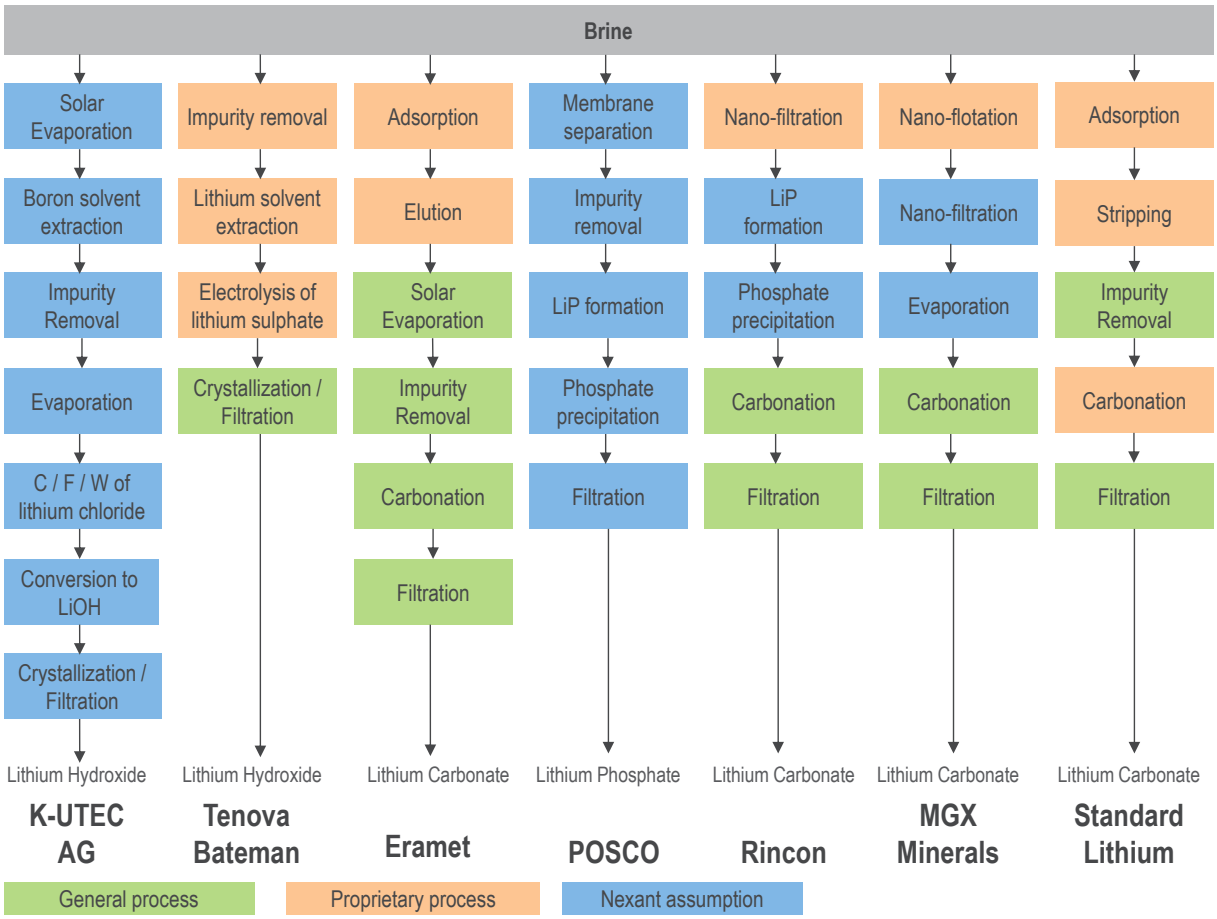
What are the major characteristics of emerging brine technologies?

Nexant has identified seven emerging brine technologies that are currently under development for extraction of lithium. There are several recurring themes for the development of these technologies:

- Remove the requirement for solar evaporation thus increasing the production capacity of lithium production plants and mitigating the risk of impact of the local climate on production
- Improve final lithium compound purity for a lower initial investment and at a lower operating cost
- Reduce the environmental impact of lithium brine mining

Another important area of research has been in the development of technology to process brines with a high ratio of magnesium or other impurities to lithium. Using current processing technology for these brines, lithium yields would be low from solar evaporation and operating costs from reagent use would be very high. Although it is the biggest lithium resource in the world, the Salar de Uyuni has a high content of magnesium making it uneconomic to extract by current methods. In April 2018, the Bolivian government took the decision to advance the development of the deposit by reaching a deal with ACI Systems and K-UTEC Salt Technologies. If it is proven technically and economically feasible, the exploitation of the Salar de Uyuni would add a significant supply of lithium to the world markets.

Figure 2: Overview of Emerging Brine Technologies



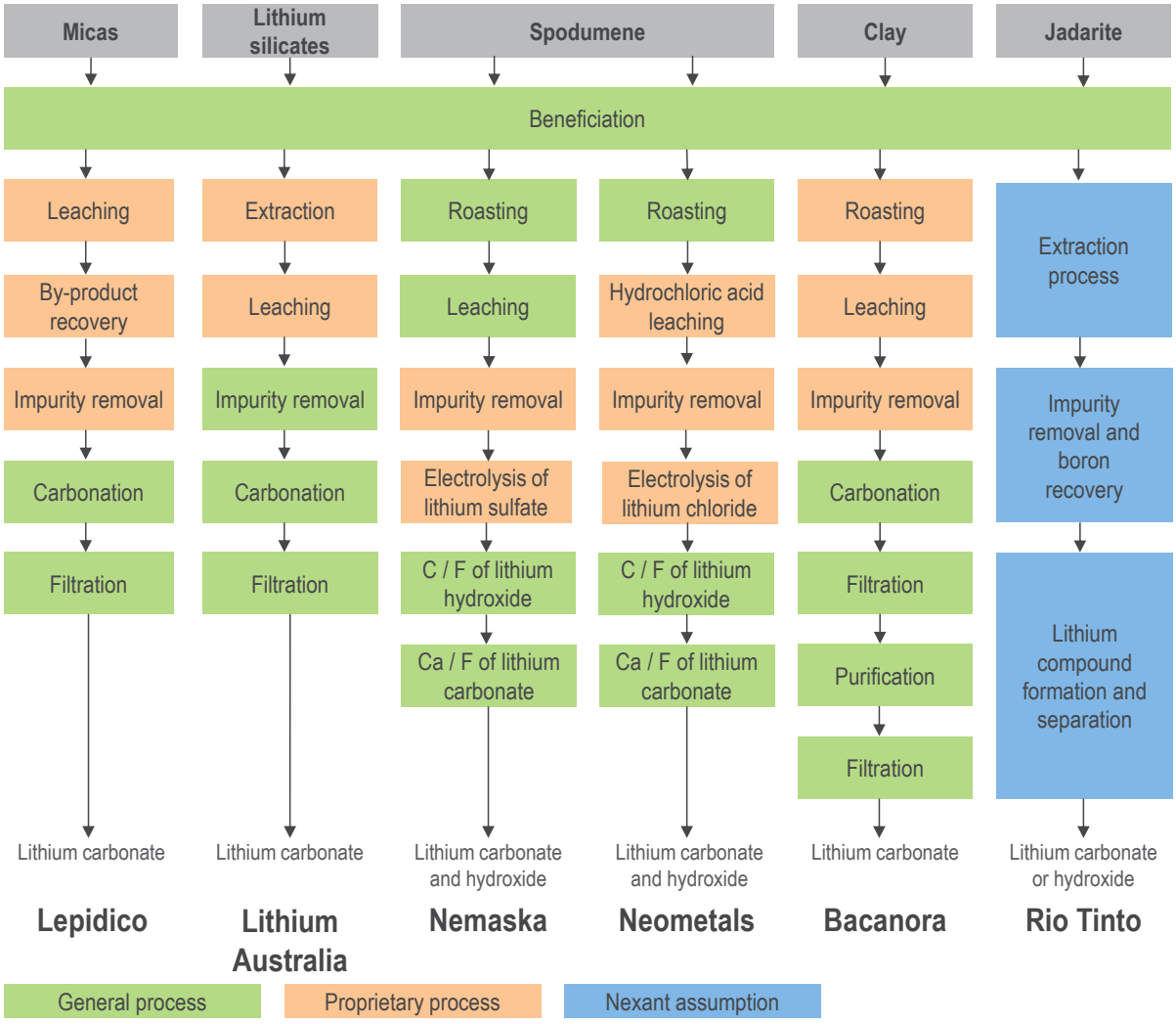
(1) C / F / W – Crystallization, filtration, washing
(2) LiP – Lithium phosphate
(3) Does not include product preparation stages (drying, packaging)

What are the major characteristics of emerging mineral technologies?

For hard rock resources, Nexant has identified six technologies under development. One key theme for these technologies is their focus on the processing of newer and more complex lithium deposits such as lepidolite, clay and jadarite. This is a direct result of the growth in demand for lithium from battery applications, which incentivises the development of extraction methods for new resources. While these technologies are still not proven commercially, success for one holder would allow for expansion to other deposits and diversification of lithium supply.

The processes by Nemaska Lithium and Neometals focus on the development of electrolysis technology to extract lithium. Both use slightly different leaching methods, Nemaska electing for the conventional sulphuric acid roasting method while Neometals utilises hydrochloric acid. The development of electrolysis for lithium extraction has been done to reduce the costs from reagents. In areas with low cost and reliable electricity, electrolysis would be a cost competitive route to producing lithium hydroxide and lithium carbonate compared to conventional routes using reagents.

Figure 3: Overview of Emerging Mineral Technologies



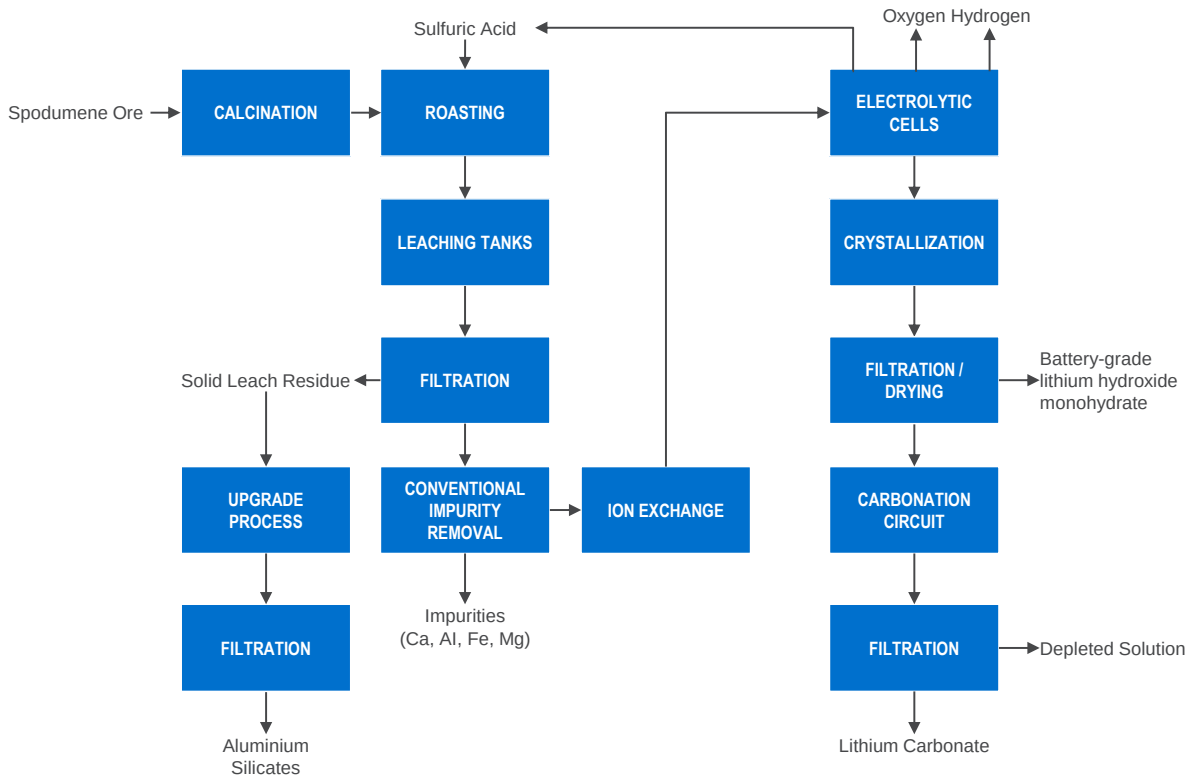
(1) C / F / W – Crystallization, filtration, washing
(2) LiP – Lithium phosphate
(3) Does not include product preparation stages (drying, packaging)

Case Study: Nemaska Lithium

Nemaska Lithium has developed one of the technologies that Nexant believes is the closest to commercialisation. In May 2018, the company announced that it had completed a financing package worth US$849 million for the development of their mine and lithium hydroxide monohydrate plant. Having completed the financing stage, Nemaska Lithium has begun construction at the site. The construction timeline has been estimated between 9 to 12 months in length for the development of the mine and about 18 months for the construction of the lithium hydroxide monohydrate facility. With construction underway commissioning of the plant is expected in 2020.

The company has also secured off-take agreements for the product from their future commercial facility. Five year supply agreements were signed with LG Chem and Northvolt in the summer of 2018 for battery-grade lithium hydroxide monohydrate.

Figure 4: Illustrative Block Flow Diagram of Nemaska Lithium's Technology

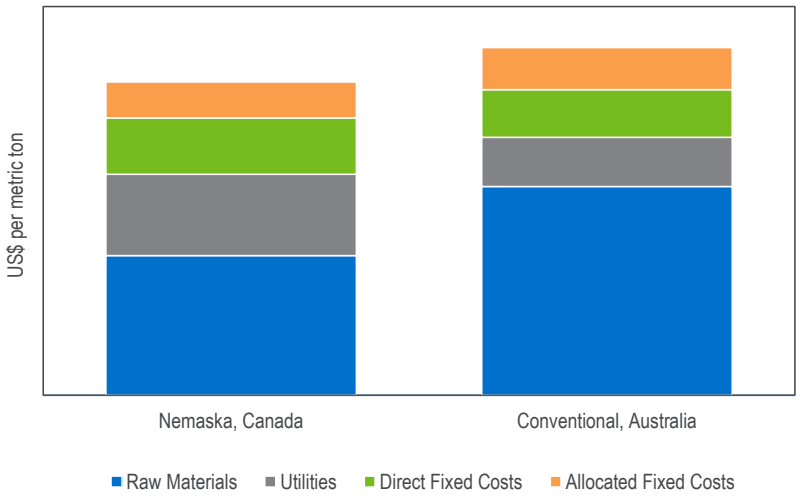


The technology produces both lithium hydroxide monohydrate and lithium carbonate from spodumene concentrates. These concentrates are initially roasted and leached with sulphuric acid to produce a solution of lithium sulphate. Electrolysis is then utilised to convert lithium sulphate directly to lithium hydroxide. The initial process steps are conventional (i.e., calcination, sulphuric acid roast and leach) while those following the impurity removal circuit have been adapted by Nemaska. After crystallisation of lithium hydroxide monohydrate, carbon dioxide can be used to convert the lithium hydroxide to lithium bicarbonate which in turn is heated to produce lithium carbonate.

Can Nemaska Lithium compete against the cost structure of conventional manufacturing processes?

Comparing the cost of production of lithium hydroxide monohydrate via Nemaska's route and the conventional route developed by Tianqi Lithium, we conclude that they are similar when crediting lithium hydroxide on a co-product basis to the Nemaska process. Note that the Tianqi Lithium process is considered here as an archetype of conventional processing and uses caustic soda to precipitate lithium hydroxide. The costs of utilities for Nemaska Lithium are comparatively higher than the conventional route due to the cost of electricity but the main contribution is still raw materials.

Figure 5: Comparison of Nemaska Lithium Cost of Production with Conventional Routes
Cash cost of Lithium hydroxide monohydrate on US$ per metric ton basis, 2018



Source: Nexant, Nemaska Lithium

Electricity is the largest contributor to the processing costs and therefore, the technology's competitiveness is very sensitive to the regional cost of electricity. In Quebec, electricity is relatively low cost and reliable allowing the facility to operate more efficiently and lower on the cost curve. The cost of raw materials is reduced in comparison to conventional methods as reagents (such as caustic soda) aren't required to precipitate lithium hydroxide.

For all the technologies in question, scale-up and commercialisation risks are still apparent but as conventional lithium resources become scarce, new methods of extraction are required over the long-term. Nexant expects Nemaska Lithium to be the first of the technologies to be commercialised but with time, extraction from micas, clays, Jadarite and low quality brines is likely to become the norm.

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"Lithium Extraction Technologies" is one in a series of reports published as part of the 2018 TECH Program.

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Daniel Saxton is an Analyst in Nexant's Energy and Chemicals Advisory business and is based in London, UK. Having joined Nexant in 2017, Daniel has worked on market analysis, feasibility studies, technical evaluations and transaction support projects.

Daniel has developed a deep understanding of the raw materials for the EV battery markets with a focus on the lithium and cobalt markets. At Nexant, he is the author of a study titled "Lithium Extraction Technologies" which provides a detailed and up-to-date analysis of the commercial technologies, emerging technologies, process economics and lithium compound markets involved with this industry. As part of his postgraduate studies, Daniel wrote his dissertation on the cobalt industry which included in-depth studies of its markets, a risk analysis of existing refining technologies and financial modelling of a nickel-cobalt laterite deposit in Australia.

Before Nexant, Daniel worked in an operational capacity for Total at their UK refinery and also as Chemical Engineer for Grupo Familia in Medellin, Colombia. He holds an MEng in Chemical Engineering and MSc in Metals and Energy Finance.

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