The ELi™ Process – Greener Lithium for Battery Materials

By

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Lithium Hydroxide for the EV Era

The old days – A Niche Material:

- Small volume production, limited installed capacity
- Limited quantities of product suitable for battery cathode
- Use of bulk industrial chemical reagents for two step chemical conversion via lithium carbonate
  - Long distance haulage of bulk materials was relatively insignificant
- The relatively high carbon footprint was not a factor
- Relatively high cost through “double conversion”

The EV Era Needs:

- Large volume production
- Consistent and high purity
- Small carbon footprint
- Lower cost production
  - Protection for producers during lower price phases
  - Lower cost for cathode and battery producers under pressure to reduce battery cost
- Production from both brines and hard rock sources to meet demand growth

Lithium Hydroxide Production

The old days – Chemical Conversion:

Hard Rock

- Li_2SO_4 + Na_2CO_3 = Li_2CO_3 + Na_2SO_4 — Low market value by-product with energy-intensive production
- Li_2CO_3 + $Ca(OH)_2$ = 2 LiOH + $CaCO_3$ — Bulk residue, disposal cost

Brine

- 2LiCl + Na_2CO_3 = Li_2CO_3 + 2NaCl
- Li_2CO_3 + $Ca(OH)_2$ = 2 LiOH + $CaCO_3$ — Bulk residue, disposal cost

The modernized old days:

Hard rock

- Li_2SO_4 + 2NaOH = 2 LiOH + Na_2SO_4 — Low market value by-product with energy-intensive production

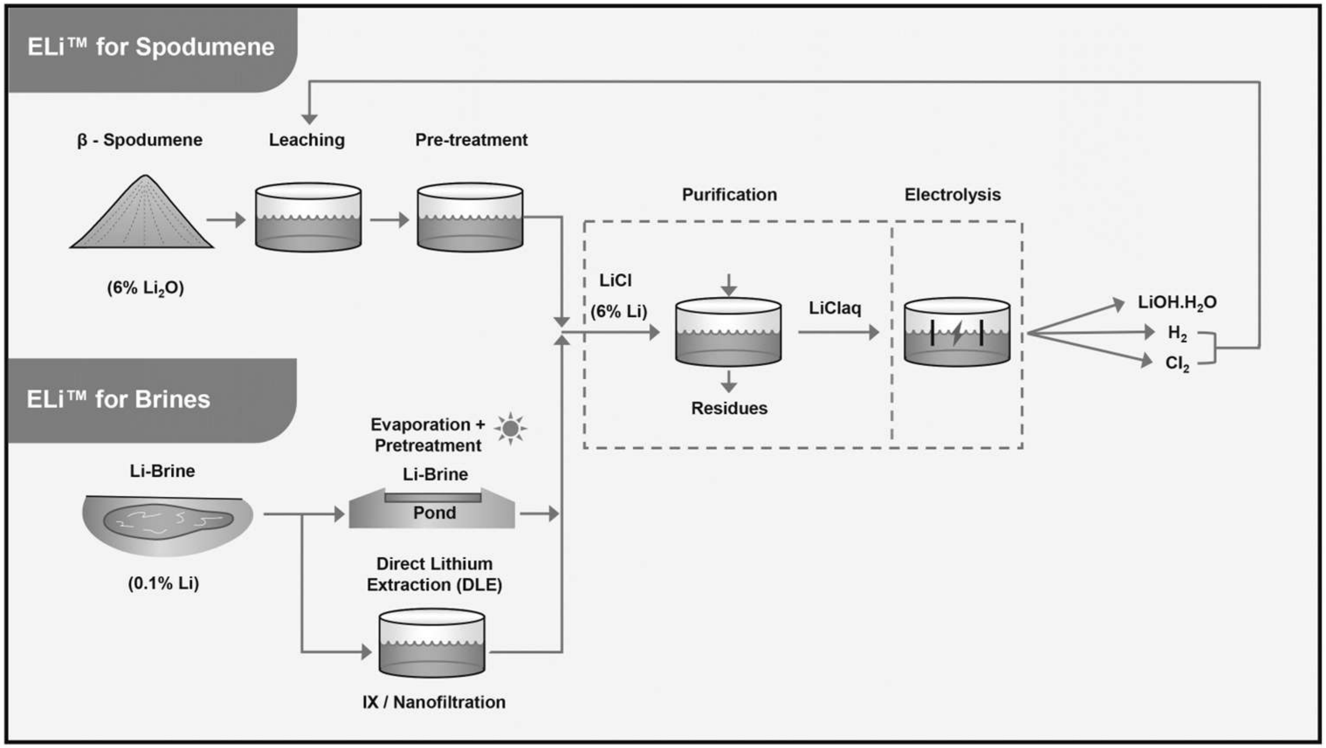
The Modern ELi™ Process:

2LiCl + $2H_2O$ + e = 2LiOH + Cl_2 + H_2 (synthesised into 32% HCl)

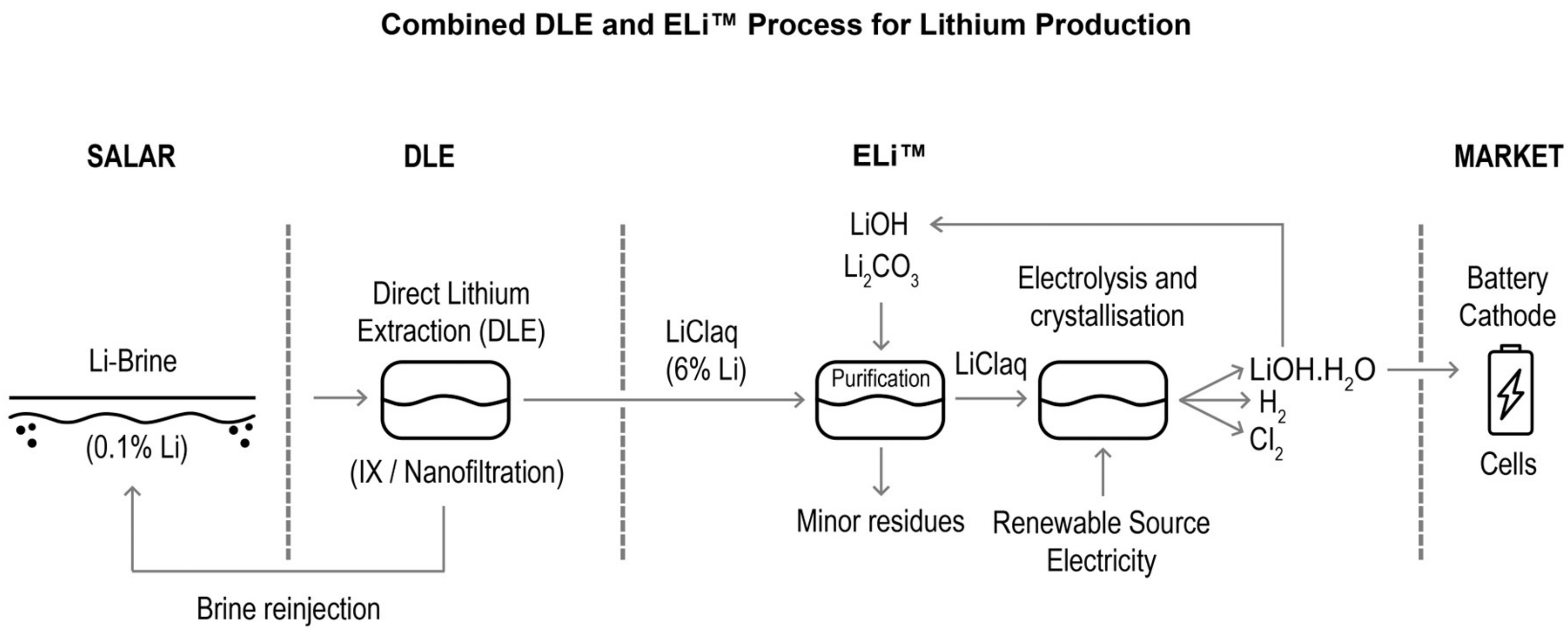
- **Suitable to convert spodumene concentrates and sub-surface lithium brines**
- **Low carbon electricity**
  - **Has increasing availability**
  - **Further reduction of carbon footprint**
- **No bulk industrial chemical reagents**
  - **Minimises heavy transport costs**
  - **Reduces carbon footprint associated with production of reagents and transport of reagents**
  - **Reduced pressure on the reagent supply chains**
- **Minimised waste materials and disposal**

ELi™ – A New Technology Solution to an Old Problem

Flowsheets for processing spodumene and for processing sub-surface brines



Where ELi™ fits into the Lithium Brine Production Chain



The Starting Point

- **Brine compositions are highly variable**
  - **Typical impurity concentrations and ratios vary salar to salar**
  - **Vary between brine and spodumene sources**
- **Purify to a higher degree than conventional lithium processes**
- **Minimise lithium losses associated with impurity removal**

Typical Sub-surface Brine after pre-treatments

(mg/L)	Li	Ca	Mg	B	Sr	Si
Before	33,000-49,000	3,400-6,500	8,600-13,000	3,500-5,400	30-40	20-40

The “Aha” Moment

Membrane electrolysis directly converts lithium chloride to hydroxide and eliminates transport & use of bulk reagents

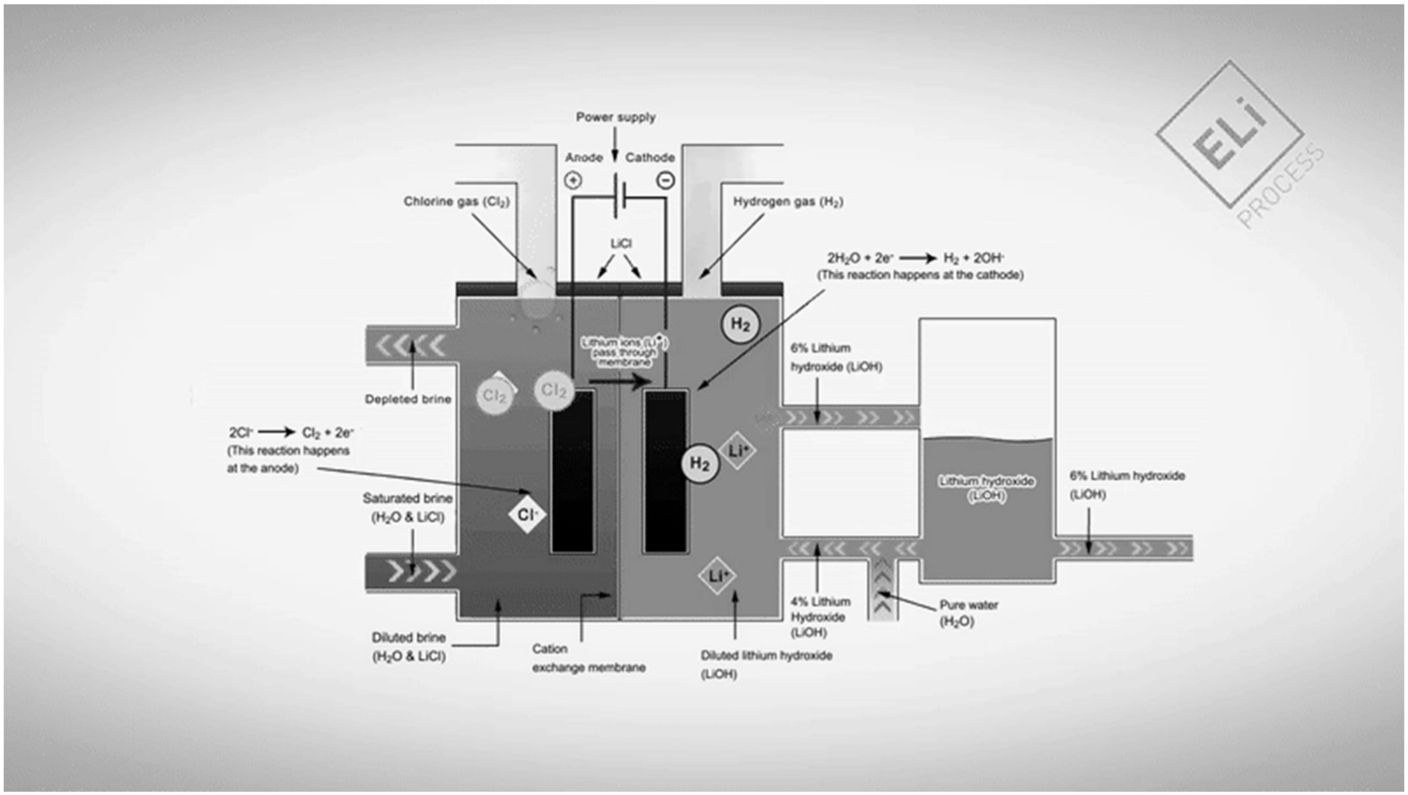
Process	ELi™	Conventional Processes
Bulk Lime	No	Yes
Bulk Soda Ash	Minimal	Yes
Power	Yes (renewable)	Yes
Gas/oil	Yes	Yes

The Enabler – Ultrapure LiCl Feed to Electrolysis

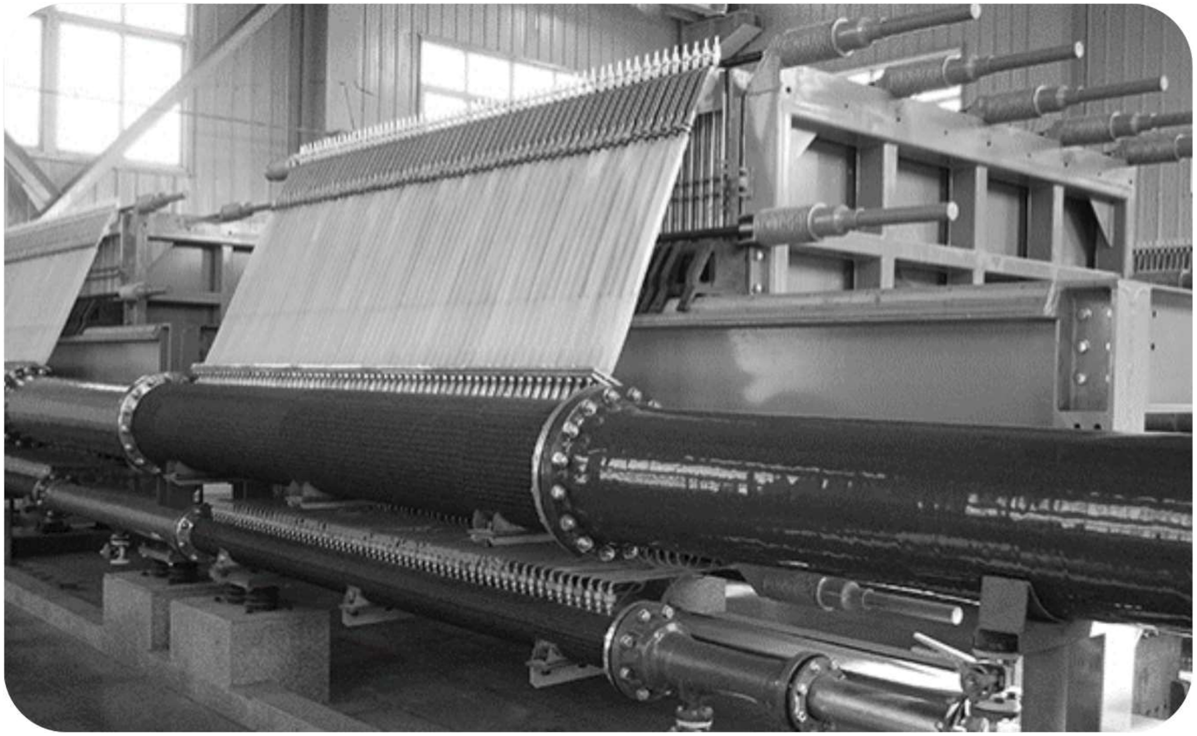
- **Successful brine purification pilot enables efficient electrolysis**
  - **The higher purity the solution, the higher the product purity and the lower the power cost**
  - **Flowsheet successfully piloted**
  - **Previous electrolysis tests were successful on less pure feed**
- **Next piloting phases are long duration electrolysis tests and LHM crystallisation**
  - **Electrolysis tests are evaluating membrane durability and cell hydrodynamics**

(mg/L)	Li	Ca	Mg	B	Sr	Si
Before	62,654	6,260	15,792	7,141	71	52
After (ave)	45,100	< 0.9	< 0.09	< 0.4	< 0.002	1
% removed*	n/a	**> 99.98**	**> 99.99**	**> 99.99**	**> 99.99**	**> 97**

ELi™ Membrane Electrolysis



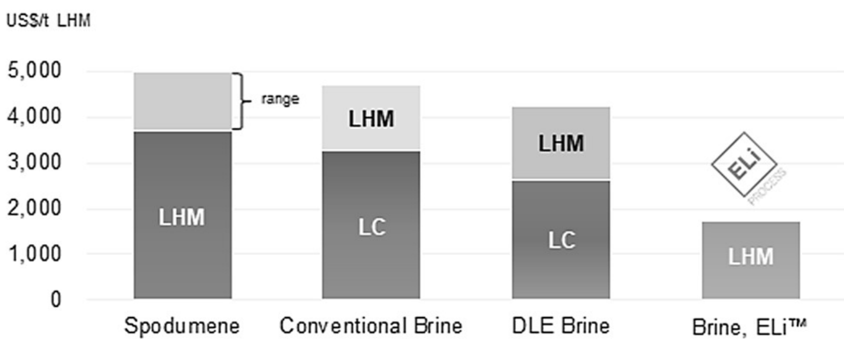
ELi™ Membrane Electrolysis Equipment



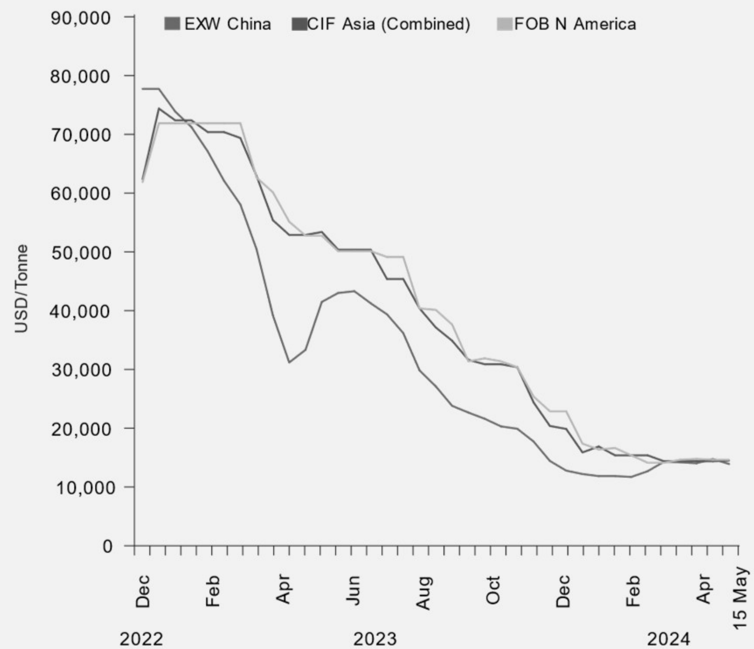
Source: Denora

Low Opex is Compatible with Periods of Low Market Prices

Estimated Opex Comparison (Conversion to LHM)



Source: ALB, E3 Li, PLL, Livent, Management estimated, Class 3 ECS, Benchmark Mineral Intelligence.



Source: Benchmark

Commercialisation – Further Piloting and Scale-Up

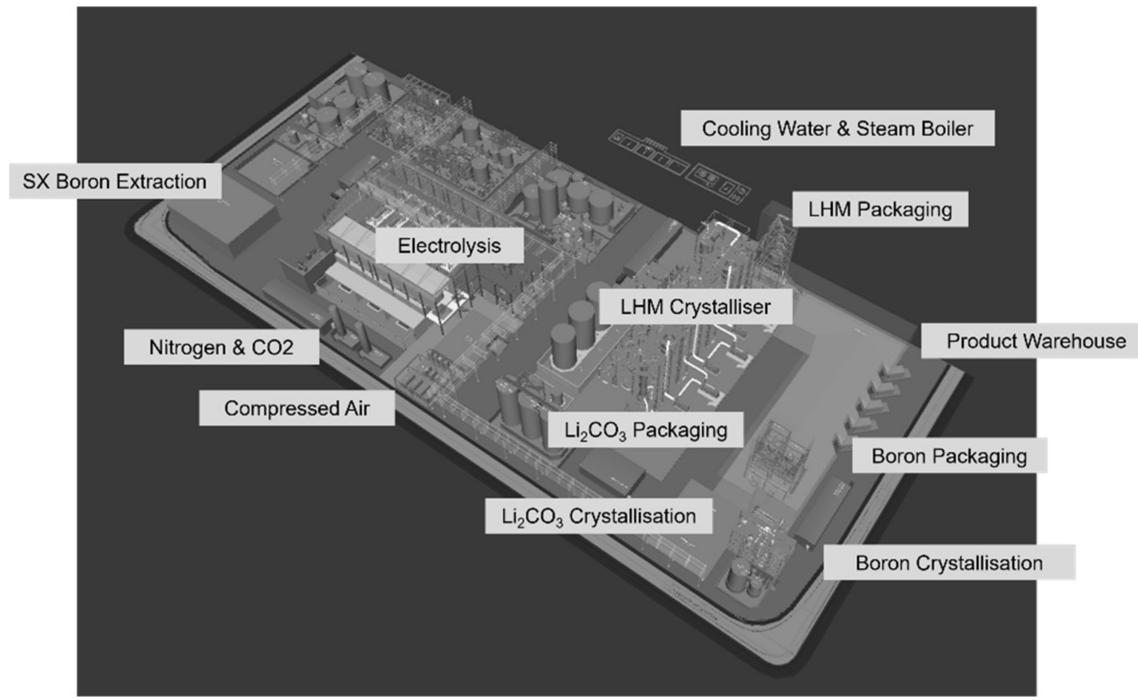
Disciplined, gated approach to reaching commercial operations

Process batch pilot evaluation:

- Performed on a Sth American brine eluate
- Pre-concentration completed and characterized
- Purification completed
- Long-duration electrolysis commencing
- Product crystallisation from catholyte to follow
- Next step is sub-commercial scale continuous pilot

Plant design and estimation:

- Vendor packages were integrated into Engineering Cost Study to AACE Class 3 (+/- 15% accuracy)
- Plant layouts and PFDs completed, brownfields site
- Partial completion of P+IDs
- Capex and Opex estimates completed
- Process LCA on gate-to-gate basis completed, in peer review



Result – Lowest Opex Conversion & Potentially Lowest CO_2

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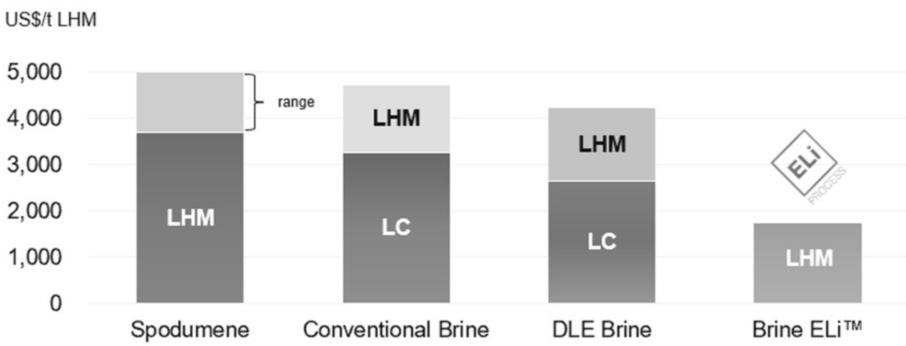
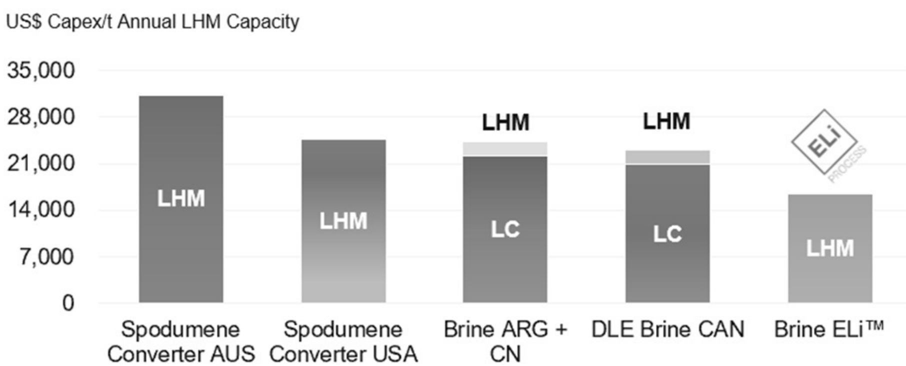


Estimated Capital Intensity (Conversion to LHM)



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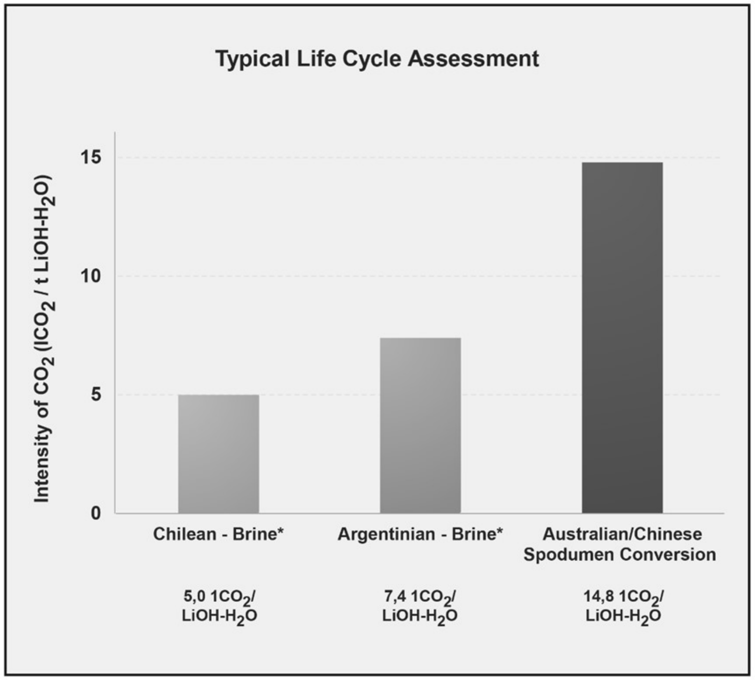

Source: SQM 2024

Sustainable Competitive Advantages for Plant Operators

Commercial operating licence for highly efficient, lithium hydroxide plant utilising our patented processing flowsheet

1 Low Cost	No bulk reagents ensures essential lithium produced at substantial discount to conventional process
2 Low Carbon	Replacement of carbon-heavy traditional bulk reagents
3 License to Operate	Reduces the lithium carbon footprint for EV batteries

- **Commercial deployment of ELi™**
  - Licensing business model, to producers, for royalty payments
  - Partnership model with producers
- **RAM holds 17 granted patents and 14 pending patents worldwide**
  - 4 families of patents covering brine and hard rock processing
- **Major lithium resource production regions**
  - Incl USA, Argentina, Chile, Australia