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Sustainable Process for Li Production

Cheaper, faster, flexible and water friendly

Lithium Seminar Chile

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Talking Points

- Solvay at a Glance
- The challenge for the Chilean Li industry:
  - Increase production and product quality
  - Flexibility on final product
- Revolutionary SX technology – Enabler for cost competitive process
- Conclusions

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Solvay at a Glance – focus on providing sustainable solutions

62 countries
27,000 people
125 industrial sites
21 R&I sites

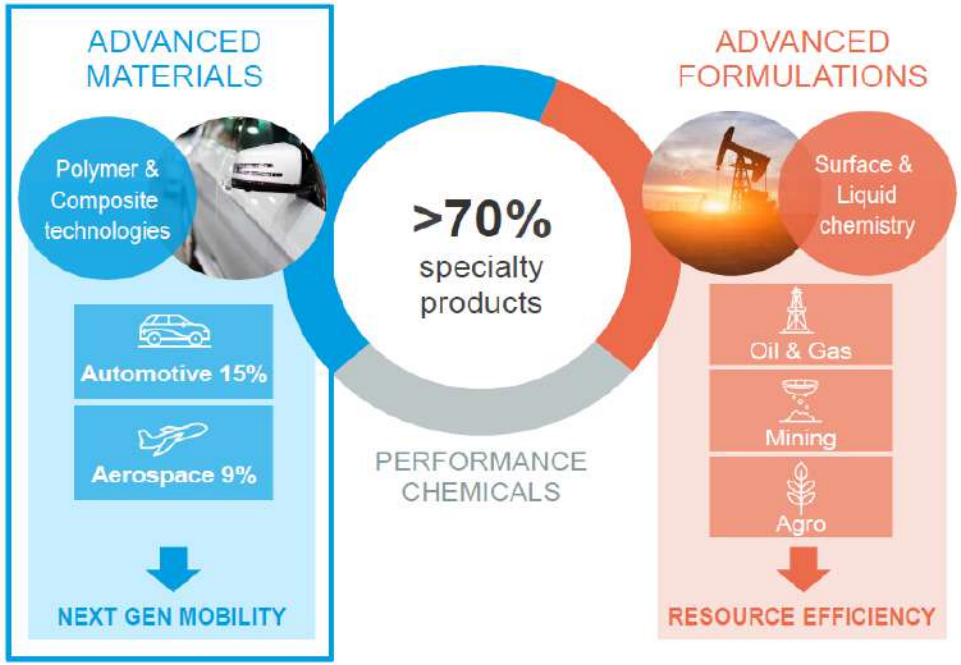
€2.2 bn
underlying
EBITDA
Margin 22%

€10.3 bn
Net sales
50% sustainable solutions

Top 3
Market position[1]

Including discontinued operations

[1]Applicable to ~90% of portfolio



Present in the current process with Soda Ash supply, developing sustainable technology for Li extraction and engaged in recycling and development of next generation batteries.

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The challenge for the Chilean Li industry

Hon. Minister of Mining Baldo Prokurica spoke at XI Lithium Conference – June 11:

- Chile has 58% of Li reserves but is currently the **2nd producer,** after Australia. Production from Atacama's salar is expected to grow from 96 ktons to 223 ktons by 2023
- **Challenges and hurdles ahead** include: water consumption, process yield, production time and dependency on climate conditions

Developing an efficient Li production process, with flexibility on the final product, is critical for Chile's competitiveness in the industry

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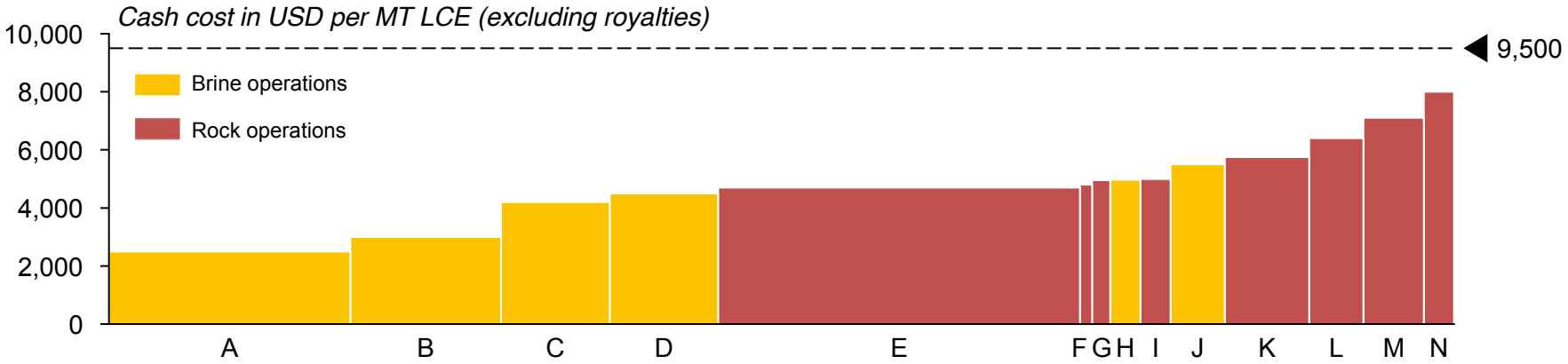
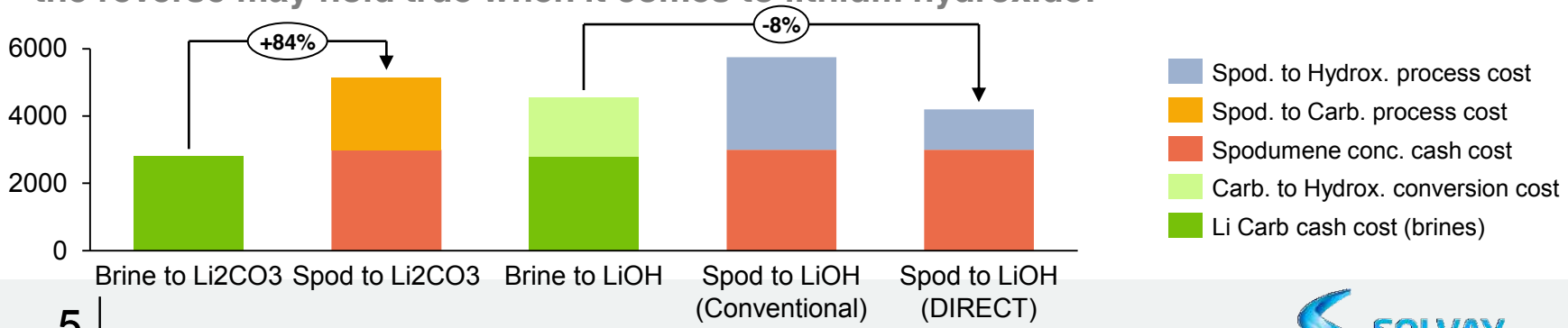
The lithium hydroxide conundrum

While brine producers have lower costs than rock producers on lithium carbonate,



the reverse may hold true when it comes to lithium hydroxide:



Sources: Deutsche Bank, Benchmark Minerals, Solvay, Reed Resources

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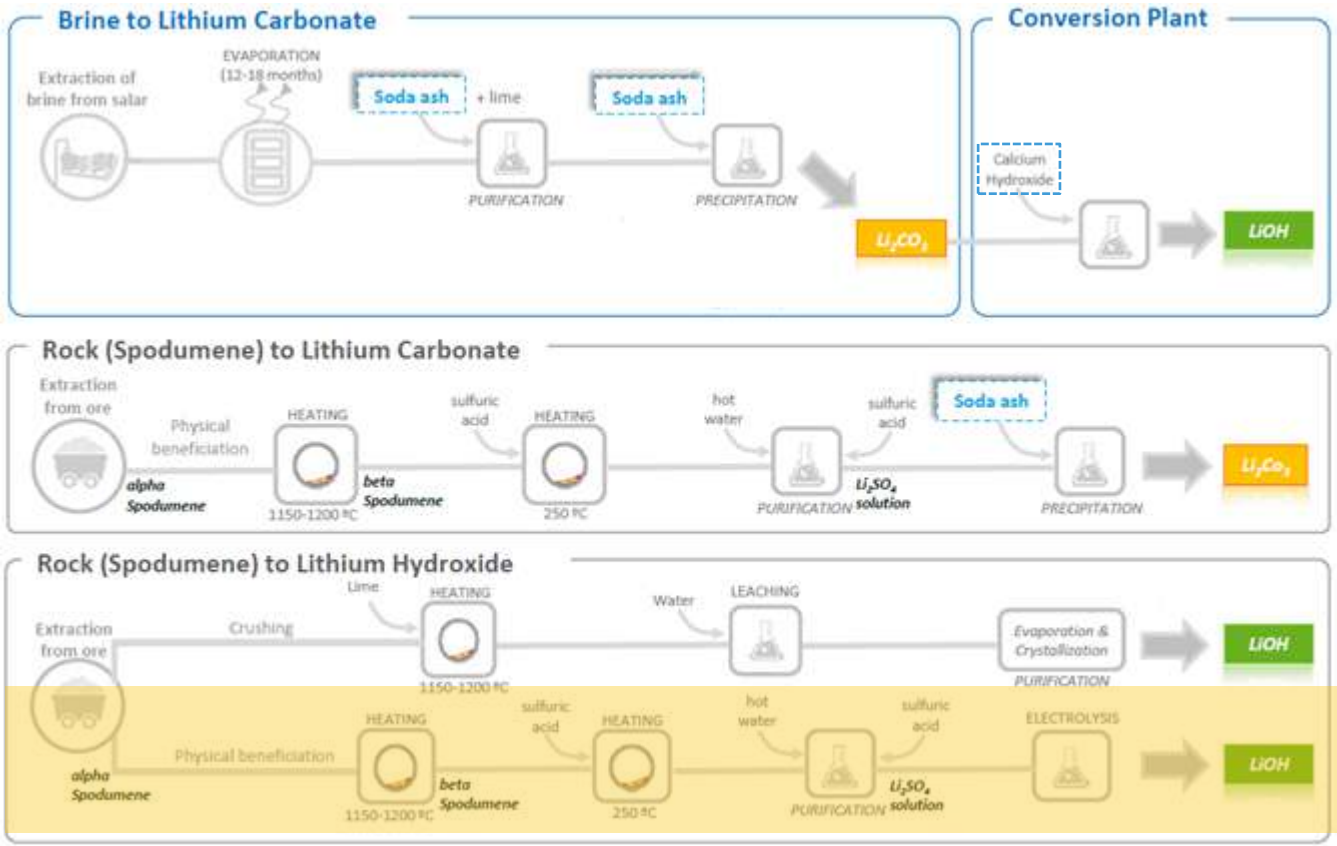
Process-wise…



Estimated OPEX (excluding royalties)

~ $ 4,700 / MT LCE

~ $ 5,200 / MT LCE

~ $ 5,700 / MT LCE

~ $ 4,200 / MT LCE

Sources: SNL, Benchmark Minerals, Roskill, Solvay, Reed Resources

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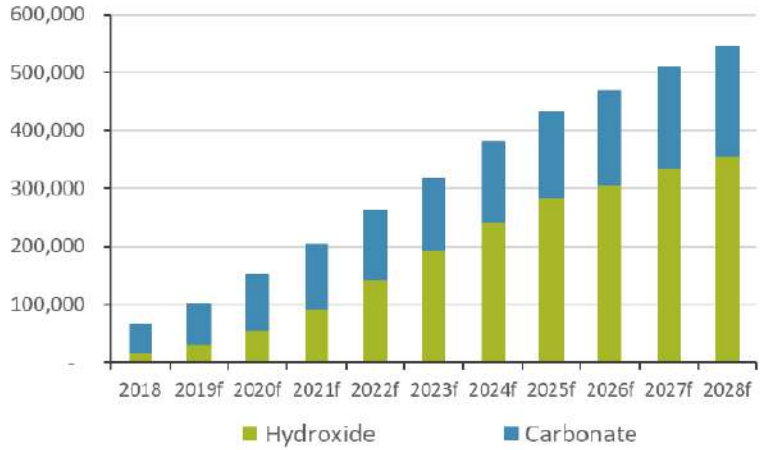
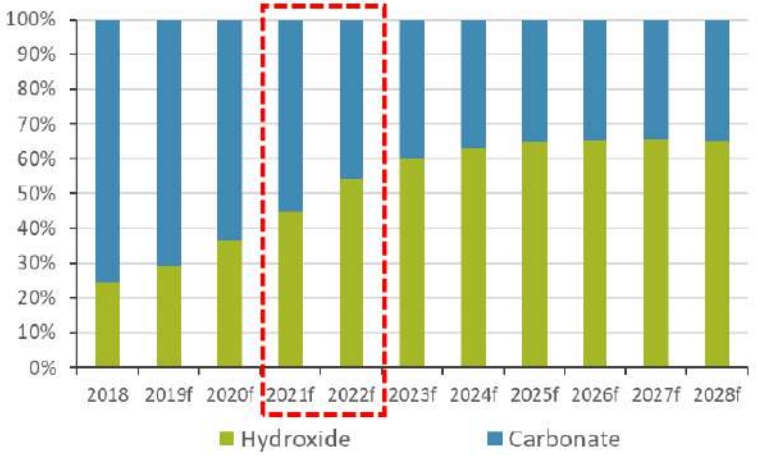
Future Lithium product demand for EV batteries - LiOH

Li compound demand from EV batteries, 2018-2028f



Li compound demand ratio of EV batteries, 2018-2028f



- EV carbonate demand is set to increase x3.8, but reliance on carbonate for batteries will reduce
- Hydroxide is the **underlying product demand story** forecast to increase 20 fold by 2028, from around 16,000t LCE in 2018

- Hydroxide demand is directly reliant on the mass manufacture and uptake of EVs
- As battery technology transitions to higher nickel cathodes, **hydroxide will become the essential lithium feedstock over carbonate by 2022**

Source: Roskill

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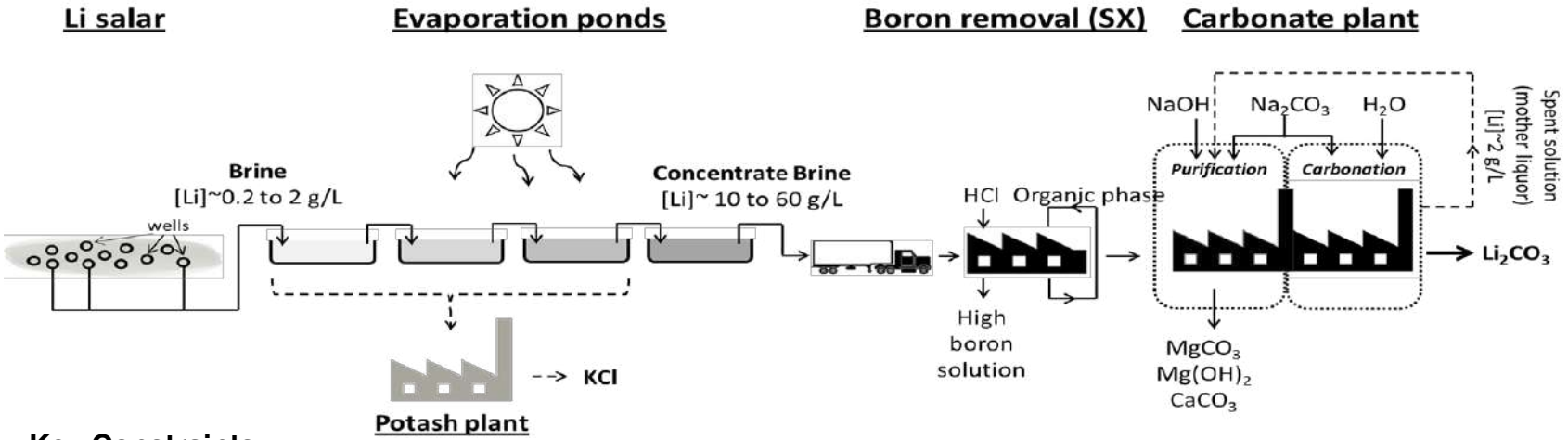
CONVENTIONAL EXTRACTION PROCESS – Li from BRINE



Key Constraints :

- Residence time (~18 months)
- Weather dependency
- Water balance
- Footprint
- Low yield process (~50%)

For 1 kg LCE produced: 1 kg lost in ponds + 1500 L water disappear in the clouds

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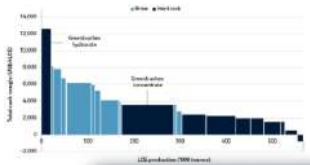
The Challenge

Find an alternative process that is:

- **FAST**
- **LOW COST**
- **WATER FRIENDLY**
- **FLEXIBLE**



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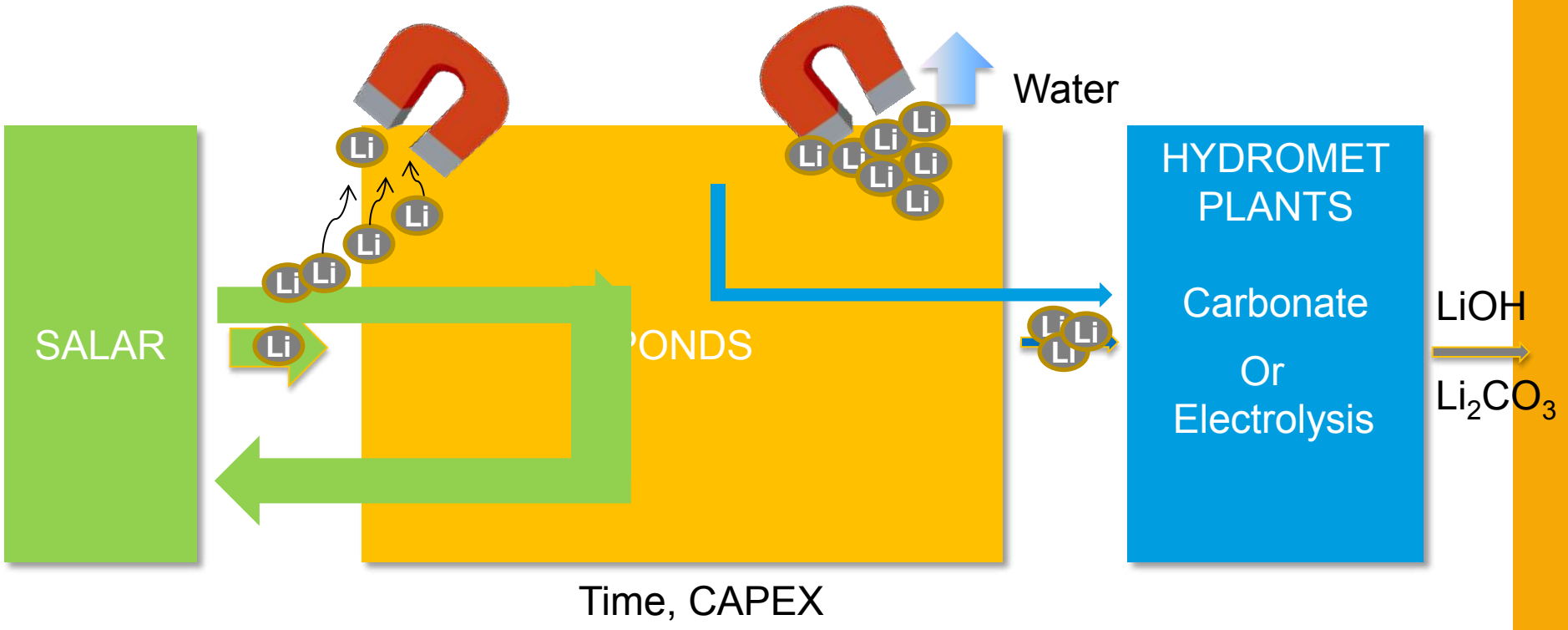
Let's look at an alternative approach



Allows for improved yield and flexibility in the final product

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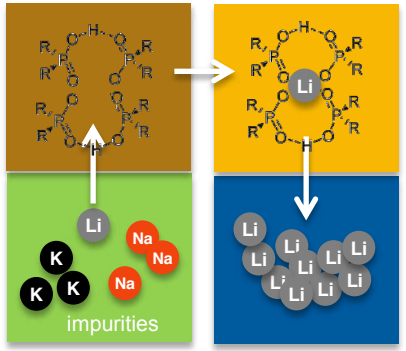
The Li Magnet: CYANEX®936P Extractant

- SOLVAY has developed CYANEX®936P, a phosphorus-based extractant specifically formulated for lithium (Li) which forms a complex with Li at any concentration"
- Reagent was designed in collaboration with Tenova Advanced Technologies, who holds IP rights on LiSX™ technology

$$Li^+_{(aq)} + RH_{(org)} \leftrightarrow RLi_{(org)} + H^+_{(aq)}$$

Extraction Stripping



- Reagent works by chelation, exchanging protons (H+) for metal (Li+), similarly to copper reagents
- Applicable to any lithium feed stream exempt of divalent ions (→ Mg^{2+} and Ca^{2+} must be pre-removed via filtration or precipitation)
- Requires neutralization

tenova ADVANCED TECHNOLOGIES

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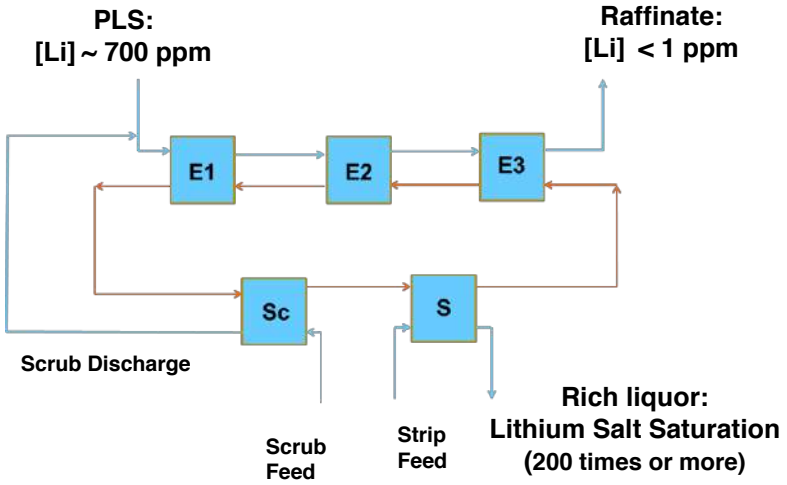
SX process replaces ponds and enables to concentrate until the saturation



- Bench piloting in simple SX circuit demonstrates reagent ability to achieve **99% Li recovery**
- Li can be concentrated in Rich Liquor at **any required concentration**, with only limiting factor being Li solubility in stripping solution (LiCl or Li_2SO_4)

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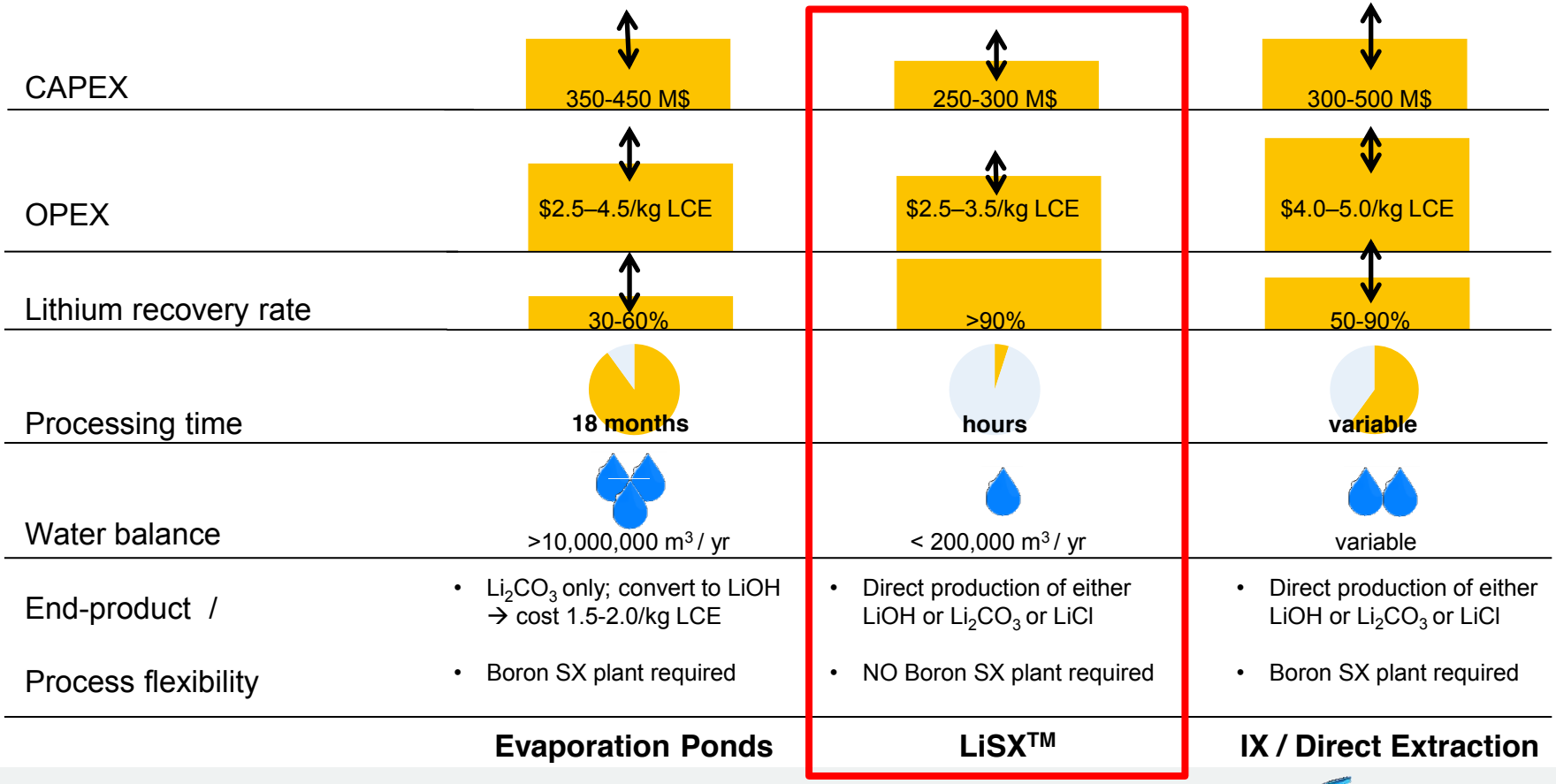
Key process benefits

Average 20ktpy LCE operation



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Conclusions

- Fast-growing demand for critical battery materials such as lithium is disruptive to the supply-side industry.
- Li price increase opened window for hard rock miners, who benefit from industry's growing preference for lithium hydroxide.
- Brine producers need faster, higher-purity, more cost-effective and more flexible production routes; Solvent Extraction is a potential answer.
- CYANEX®936P and Tenova's LiSX™ are game changers, enabling direct production of high-purity lithium hydroxide from brines, at reduced capital and operational costs, faster time-to-market and in a sustainable fashion.
- Our solvent extraction experts are available to provide technical support in regard to laboratory tests, piloting, flowsheet design and validation, demonstration plants and operational ramp-up

Thank you !

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