

Overview of Direct Lithium Extraction

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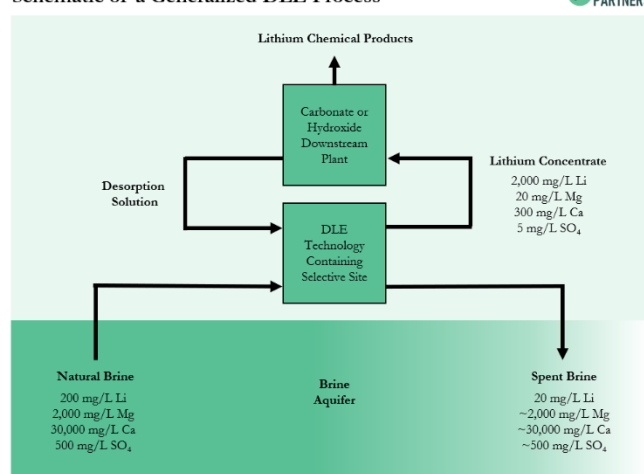
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In the 1990s, the majority of lithium brine extraction operations were built using pure evaporative processes to produce lithium and other chemical products. These operations took advantage of the high lithium/impurity ratios of the “best” brines, and the extreme aridity of the jurisdictions in which they are found. However, after the first major evaporative brine operation constructed to satisfy the growth of the battery industry faced severe product quality issues in the 2010s, a number of slow development timelines & ramp-ups, and questions about water table imbalances in Chile, the future of pure evaporative brine processing is under scrutiny. There are now more projects around the world under development proposing to use direct lithium extraction (DLE) than there are proposing pure evaporative processing.

DLE has been used commercially since 1998 at Livent’s Hombre Muerto operation in Argentina.¹ It is a type of recovery technique in which lithium is removed from a brine to create a high purity lithium concentrate for refining into battery quality lithium chemicals. DLE technologies rely on selective characteristics of an engineered material to remove lithium from brine while leaving other salts in solution. The most commonly claimed advantages of DLE include (but are not limited to):

1. Recovery from brine to concentrate does not necessarily depend on the weather.
2. Up to 90% lithium recovery compared to 30-50% for pure evaporative processes.
3. Lead time to production may be shorter than evaporative processes, improving project economics.
4. Concentration of Mg, Ca, and SO₄ in brine matters less than for evaporative processes.
5. Loss of water in brine may be eliminated or reduced, and freshwater consumption may be reduced.
6. Production of a high concentration and high purity lithium concentrate can be relatively easily processed into battery quality lithium chemicals using “off-the-shelf” technologies.
7. OPEX often claimed below \$6,000/tLCE, cheaper than spodumene mining & processing.
8. Drastically reduced physical footprint required compared to evaporative processes.
9. The potential to unlock unconventional resources like oilfield and geothermal brines in mature industrial jurisdictions closer to cathode manufacturing and near infrastructure.
10. As of Q3 2021, **Jade Cove Partners is tracking 73 different groups** who are developing DLE technologies & processes which could be applied to recovering lithium from different types of resources around the world, including natural brines, mineral leachates, & recycling wastewaters.

Schematic of a Generalized DLE Process



¹ 2020 Livent Sustainability Report.