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**VULCAN  
ENERGY**

Q2 2025

ASX/FSE:VUL



**VULSORB®**

**ADSORPTION-TYPE DIRECT LITHIUM EXTRACTION  
(A-DLE) SUMMARY PRESENTATION**

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**Technical information.** Vulcan has carried out a definitive feasibility study ("DFS") and bridging engineering study ("Bridging Study") for its Phase One Project, the results of which were announced to the ASX in the announcements Phase 1 DFS Results dated 13 February 2023 (DFS Announcement) and Positive Bridging Study Results on 16 November 2023 (Bridging Study Announcement). This presentation may include certain information relating to the DFS and the Bridging Study. The DFS and Bridging Study are based on the material assumptions and parameters outlined in their respective announcements. While Vulcan considers all of the material assumptions to be based on reasonable grounds, there is no certainty that they will prove to be correct or that the range of outcomes indicated by the Bridging Study or DFS will be achieved. This presentation may also include certain information relating to future phases of its Project. Vulcan has not yet carried out a definitive feasibility study for future phases of its Project.

**Funding strategy.** To achieve the range of outcomes indicated in the Bridging Study, additional funding will be required. Investors should note that there is no certainty that Vulcan will be able to raise the amount of funding when needed. It is also possible that such funding may only be available on terms that may be dilutive to or otherwise affect the value of Vulcan's existing shares. It is also possible that Vulcan could pursue other financing strategies such as a partial sale or joint venture of the Project. If it does, this could materially reduce Vulcan's proportionate ownership of the Project.

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Note(s): <sup>1</sup> This slide contains a summary of the applicable disclaimers, the full disclaimer in relation to this presentation is contained in Appendix 1.

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# LITHIUM MARKET AND BACKGROUND TO A-DLE





**“The implementation of direct lithium extraction technologies has the potential to significantly increase the supply of lithium from brine projects (much like shale did for oil), nearly doubling lithium production on higher recoveries and improving project returns, though with the added bonus of offering ESG / sustainability benefits...”<sup>1</sup>**

- Goldman Sachs

<sup>1</sup> Goldman Sachs Equity Research, Direct Lithium Extraction: A potential game changing technology, dated 27 April 2023, < <https://www.goldmansachs.com/pdfs/insights/pages/goldmansachs-research/direct-lithium-extraction/report.pdf> >.



# A NEW WAVE OF LITHIUM IS BUILDING

Defined by low cost, scalable, high-purity, and sustainable lithium production from brines using adsorption-type direct lithium extraction (A-DLE) technology

As the lithium market matures into its next phase of growth, major global companies like Rio Tinto and ExxonMobil are entering into lithium brine.<sup>1,2</sup>

A-DLE is becoming an increasingly appealing method of lithium production due to its **faster time to market, low cost of production, scalability, product purity, and sustainability** credentials.<sup>3,4</sup>

The market share for A-DLE currently sits at 10% of lithium production but is **forecast to grow by 280% over the next 10 years**, representing a compound annual growth rate of 13%.<sup>5</sup>

With the global lithium market heading for a structural deficit before 2030<sup>4</sup>, **global lithium production is expected to enter a new round of capacity expansion**, from which Vulcan is well placed to benefit as one of only a few Western lithium companies with strong in-house A-DLE expertise.



## Direct Lithium Extraction: A Game-Changer for Mining Brines<sup>4</sup>

By Chloe Williment  
October 30, 2024



## DLE: The technologies moving the needle on lithium production<sup>6</sup>

By Jessica Cummins  
22 January 2025



## Rise of DLE will open up new sources of lithium supply this decade<sup>7</sup>

23 July 2024

## Rio Tinto completes acquisition of Arcadium Lithium for \$6.7 billion<sup>8</sup>

6 March 2025



## Equinor takes stake in Standard Lithium Smackover direct lithium extraction projects<sup>9</sup>

9 May 2024

<sup>1</sup> Rio Tinto, Rio Tinto completes acquisition of Arcadium Lithium, dated 6 March 2025, < <https://www.riotinto.com/en/news/releases/2025/rio-tinto-completes-acquisition-of-arcadium-lithium> >.

<sup>2</sup> ExxonMobil, ExxonMobil Drilling First Lithium Well in Arkansas, announced 31 November 2023, < <https://investor.exxonmobil.com/news-events/press-releases/detail/1152/exxonmobil-drilling-first-lithium-well-in-arkansas-aims-to> >.

<sup>3</sup> Compared to lithium extraction from evaporation ponds.

<sup>4</sup> EV Magazine, Direct Lithium Extraction: A Game-Changer for Mining Brines, dated 30 October 2024, < <https://evmagazine.com/articles/direct-lithium-extraction-a-game-changer-for-the> >.

<sup>5</sup> Benchmark Minerals Intelligence, Lenders' Market Reports Part 1: Project Positioning & Part 2: Market & Supply Chain Overview, dated 7 October 2024.

<sup>6</sup> The Australian, DLE: The technologies moving the needle on lithium production, dated 22 January 2025, < <https://www.theaustralian.com.au/business/stockhead/news/dle-the-technologies-moving-the-needle-on-lithium-production/news-story/69be75e2d753c7f078ee25faf0cb5ab4?btr=4a7a85412cc25b5820c27eb1b82846be> >.

<sup>7</sup> Benchmark Source, Equinor takes stake in Standard Lithium Smackover direct lithium extraction projects, dated 9 May 2024, < <https://source.benchmarkminerals.com/article/equinor-takes-stake-in-standard-lithium-smackover-direct-lithium-extraction-projects> >.

<sup>8</sup> <https://www.riotinto.com/en/news/releases/2025/rio-tinto-completes-acquisition-of-arcadium-lithium>

<sup>9</sup> Benchmark Source, Rise of DLE will open up new sources of lithium supply this decade, 23 July 2024, < <https://source.benchmarkminerals.com/article/rise-of-dle-will-open-up-new-sources-of-lithium-supply-this-decade> >.



# PLANNED CHINESE RESTRICTIONS ON THE EXPORT OF A-DLE TECHNOLOGY

Vulcan intends to capitalise on restrictions from China on the export of A-DLE technology and know-how, as one of only a few Western companies globally with this technology in-house

A-DLE is a rare, in-demand technology for low OPEX lithium production.

**China is leading the world in A-DLE expertise, however Chinese authorities have started to restrict the export of A-DLE technology and know-how** which may affect large lithium projects worldwide.<sup>1</sup>

**China's Ministry of Commerce has recently announced global export restrictions on key technologies and know-how**, including those related to lithium processing and extraction.

These **restrictions may affect large lithium brine projects worldwide**, with financial institutions imposing stricter guidelines and additional approvals for transactions involving critical technologies.

As one of a handful of Western companies worldwide with the proven technology to extract lithium in-house using A-DLE, **the longer-term implications from China's trade restrictions may open new opportunities for Vulcan** to capitalise upon, using VULSORB®.<sup>2</sup>



## Exclusive: Chinese lithium company halts tech exports as trade tensions build<sup>3</sup>

By Ernest Scheyder and Lewis Jackson  
February 19, 2025 8:01 AM GMT+8

### FINANCIAL REVIEW

## China quietly ramps up its tech trade war with the West<sup>4</sup>

Ryan McMorro, Christian Davies and Kathrin Hille  
Feb 17, 2025 - 1.58pm



## China Imposes Its Most Stringent Critical Minerals Export Restrictions Yet Amidst Escalating U.S.-China Tech War<sup>5</sup>

Critical Questions by Gracelin Baskaran and Meredith Schwartz  
Published December 4, 2024

### FINANCIAL TIMES

## China tightens grip on tech, minerals and engineers as trade war spirals<sup>1</sup>

Ryan McMorro in Beijing, Christian Davies in Seoul, Kathrin Hille in Taipei, John Reed in New Delhi and Zijing Wu in Hong Kong  
Published 16 February 2025



## China proposes new restrictions on exports of lithium processing and refining technologies<sup>6</sup>

David Merriman  
8 January 2025

<sup>1</sup> Financial Times, China tightens grip on tech, minerals and engineers as trade war spirals, dated 16 February 2025, < <https://www.ft.com/content/d48e9a90-ba6a-42bb-9da7-58db89643f86> >.

<sup>2</sup> Discovery Alert, Chinese Lithium Export Halt: Impact on Global Battery Supply Chains, dated 18 February 2025, < <https://discoveryalert.com.au/chinese-lithium-export-halt-impact-on-global-battery-supply-chains/> >.

<sup>3</sup> Reuters, Exclusive: Chinese lithium company halts tech exports as trade tensions build, dated 19 February 2025, < <https://www.reuters.com/technology/chinese-lithium-company-halts-tech-exports-trade-tensions-build-2025-02-18/> >.

<sup>4</sup> AFR, China quietly ramps up its tech trade war with the West, dated 17 February 2025, < <https://www.afr.com/world/asia/china-quietly-ramps-up-its-tech-trade-war-with-west-20250217-p5lcsq> >.

<sup>5</sup> CSIS, China Imposes Its Most Stringent Critical Minerals Export Restrictions Yet Amidst Escalating U.S.-China Tech War, dated 4 December 2024, < <https://www.csis.org/analysis/china-imposes-its-most-stringent-critical-minerals-export-restrictions-yet-amidst> >.

<sup>6</sup> Project Blue, China proposes new restrictions on exports of lithium processing and refining technologies, dated 8 January 2025, < <https://projectblue.com/blue/news-analysis/1100/china-proposes-new-restrictions-on-exports-of-lithium-processing-and-refining-technologies->> >.

# COMMERCIAL A-DLE LITHIUM PRODUCTION IS RAPIDLY EXPANDING GLOBALLY



ARGENTINA - RIO TINTO HOMBRE MUERTO A-DLE PLANT



CHINA - EVEBATTERY A-DLE PLANT



ARGENTINA - ERAMET CENTENARIO-RATONES A-DLE PLANT



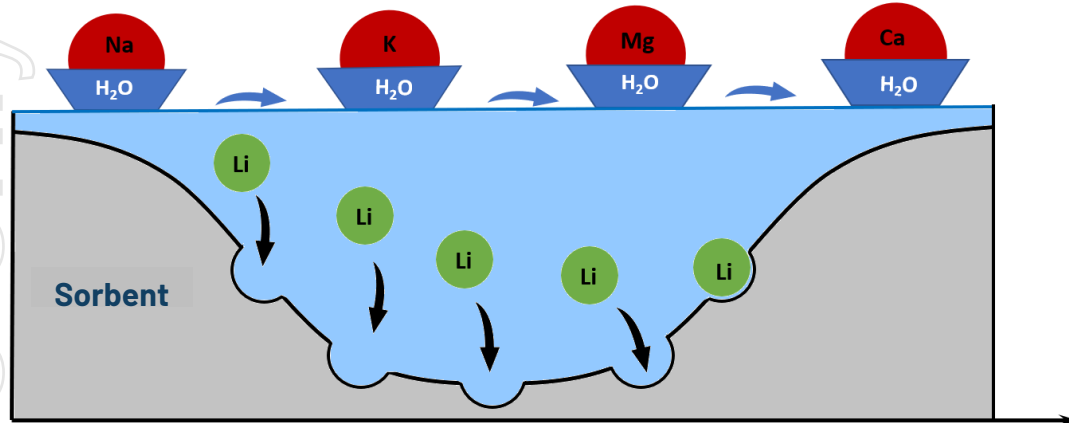
CHINA - ZANGGE MINERAL A-DLE PLANT

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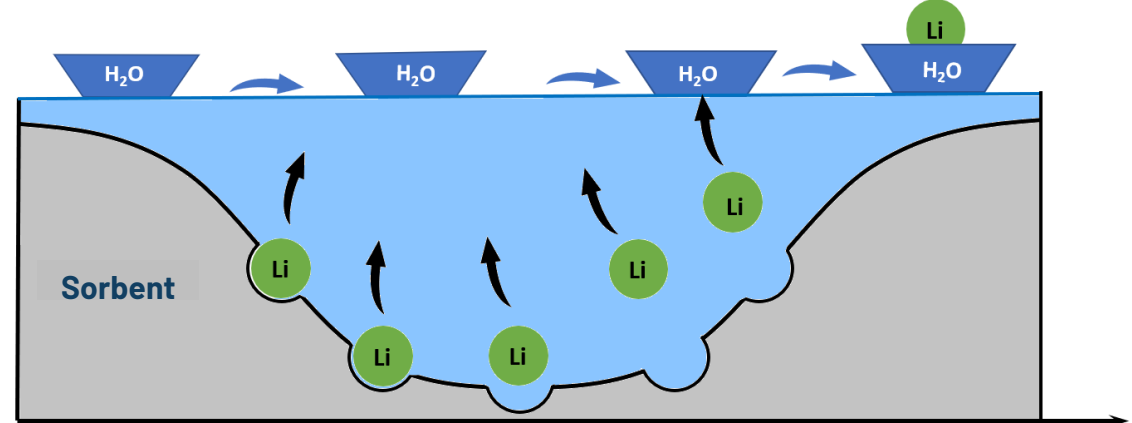
# VULSORB®: LITHIUM EXTRACTION USING A-DLE - HOW IT WORKS<sup>1</sup>

The A-DLE process uses specifically designed sorbents to selectively remove lithium chloride from brine

Step 1: Lithium chloride chemically binds to the adsorbent



Step 2: Lithium chloride stripped, washed, and discharged from the adsorbent



- Brine has a high salinity – it contains ions of various sizes and electric charges.
- Water molecules surrounding the ions make up a hydration shell.
- Small lithium ions require a double hydration shell to stabilise their electric charge in the solution.
- In brines with high salinity this is not possible due to the competition for water molecules with the other ions.
- Thus, lithium chloride adsorbs to the surface of the sorbent material.
- During loading, lithium chloride is adsorbed on the sorbent while all the other ions stay in the brine.

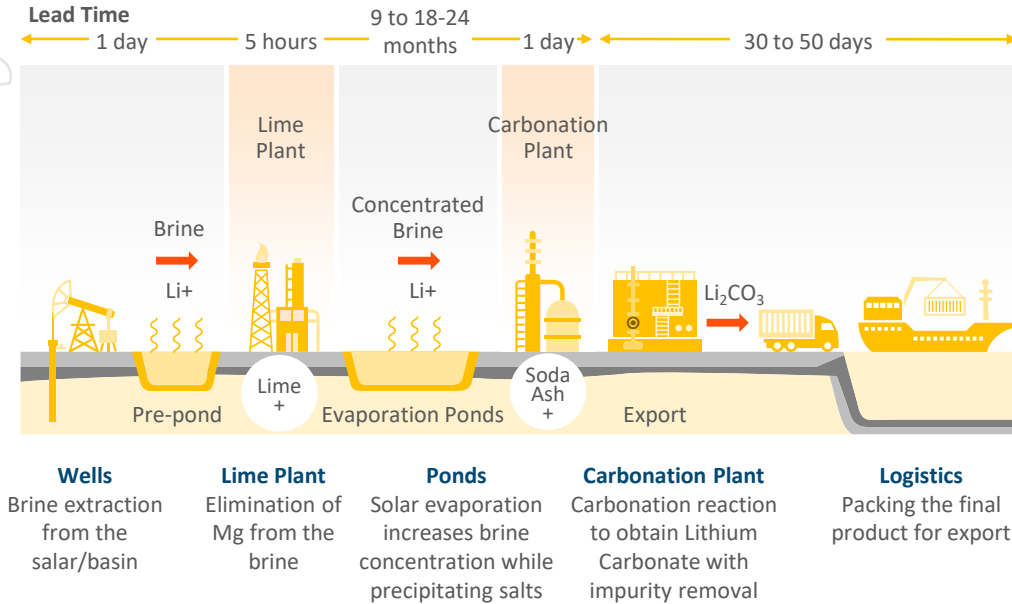
- When the loaded sorbent is washed with water, an excess of free water molecules becomes available to the lithium ions.
- Formation of a double hydration shell is an energetically favoured process, which drives the desorption of the lithium chloride from the surface of the sorbent material.
- This process is called elution and the collected wash water that contains the lithium chloride is called the eluate.
- Eluate has a high concentration of lithium chloride and low concentration of impurities, enabling conversion to lithium hydroxide monohydrate (LHM).

<sup>1</sup> Vulcan Energy Resources, (May 2021) Zero Carbon Lithium presentation, dated May 2021, < <https://vul.live.irmau.com/site/PDF/6d00e2f3-6431-43c0-8222-7ccad698889e/ZeroCarbonLithiumCorporatePresentation> >.

# VULSORB®: LITHIUM EXTRACTION VIA PONDS VS. A-DLE

A-DLE offers enhanced recovery and faster time to market (reducing from years to hours) compared to legacy processes

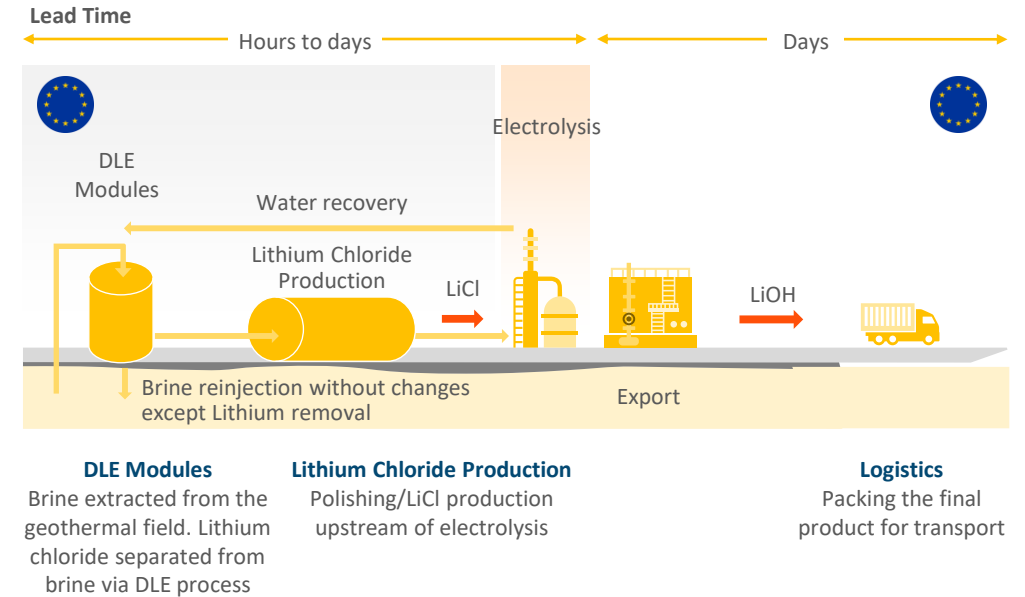
## Legacy pond process<sup>1</sup>



## Attributes of legacy pond-chemical reagents process

- High water consumption and large land area required.
- Lengthy process (up to 24 months) makes it vulnerable to climate and weather disruptions.
- Low lithium recovery, extent depends on Mg/Li ratio.
- Complex process, multiple precipitation steps.
- Significant chemical reagent consumption, and therefore large CO<sub>2</sub> footprint.

## A-DLE & electrolysis process<sup>1</sup>, using VULSORB®



## Attributes of VULSORB® A-DLE process

- Much quicker time to market and proven sustainability credentials (compared to ponds) - carbon neutral, significantly less water usage, and significantly smaller land footprint..
- Vulcan's naturally heated geothermal brine is optimised for A-DLE selectivity post-energy sales (60-75°C), which yields cost and sustainability advantages.
- Highly selective lithium extraction (95% efficiency), producing high purity lithium chloride concentrate.
- Lower operating cost and less waste.

<sup>1</sup> Benchmark Minerals Intelligence, Lenders' Market Report Part 1: Project Positioning, dated 7 October 2024.























# VULSORB®: WELL-POSITIONED WESTERN A-DLE SUPPLY CHAIN

China dominates A-DLE technology; limited western options currently exist






## Global lithium projects that use, or plan to use, proprietary A-DLE technology

Company	Project	Project location	A-DLE adsorbent provider	Origin of adsorbent
Rio Tinto	Fénix / Rincon		Proprietary <sup>1,2</sup>	
Eramet	Centenario-Ratones		Proprietary <sup>1</sup>	
Vulcan Energy	Lionheart (Phase One)		Proprietary 	

## Selection of global lithium projects that use, or plan to use, A-DLE adsorbents from third-party providers

Company	Project	Project location	A-DLE adsorbent provider	Origin of adsorbent
Tibet Summit Resources	Angeles		SunResin <sup>1</sup>	
Lanke Lithium	Yiliping Lake		SunResin <sup>1</sup>	
Zangge Lithium	Chalkhan Lake		SunResin <sup>1</sup>	
Jintai Lithium	Mahai Lake		SunResin <sup>1</sup>	
Tibet National	Qinghai		SunResin <sup>1</sup>	
Yiwei Lithium	Qinghai Salt Lake		SunResin <sup>1</sup>	
Various juniors	e.g. Cleantech, Anson etc.		SunResin <sup>1</sup>	
Equinor / Standard Lithium	South West Arkansas (Smackover) <sup>3</sup>		Lanshen / Koch <sup>4</sup>	
ExxonMobil	Exxon Lithium Brine (Smackover) <sup>5</sup>		n.q.	n.q.
EAU Lithium	Salar de Coipasa / Pastos Grandes		Vulcan Energy <sup>6</sup> 	
Rosatom (via Uranium One Group)	Uyuni		Rosatom (via Uranium One) <sup>7</sup>	

## Main global A-DLE technology providers

Company and origin of technology	
	SunResin <sup>1</sup>
	Lanshen (via Koch Technology Solutions) <sup>1,8</sup>
	Vulcan Energy 
	Rosatom <sup>7</sup> & Axion <sup>9</sup>

+ Vulcan is tracking dozens of other A-DLE project developers

n.q. = not quantified / information is not publicly available.

<sup>1</sup> Goldman Sachs, Direct Lithium Extraction: A potential game changing technology, dated 27 April 2023, < <https://www.goldmansachs.com/pdfs/insights/pages/gs-research/direct-lithium-extraction/report.pdf> >.

<sup>2</sup> Rio Tinto to invest \$2.5 billion to expand Rincon lithium project capacity, dated 12 December 2024, < <https://www.riotinto.com/en/news/releases/2024/rio-tinto-to-invest-2-5-billion-to-expand-rincon-lithium-project-capacity-to-60000-tonnes-per-year> >.

<sup>3</sup> Standard Lithium, Arkansas Smackover Project, < <https://www.standardlithium.com/projects/arkansas-smackover> >.

<sup>4</sup> Standard Lithium, Standard Lithium Successfully Commissions First Commercial-Scale DLE Column in North America, dated 24 April 2024, < <https://www.standardlithium.com/investors/news-events/press-releases/detail/170/standard-lithium-successfully-commissions-first> >.

<sup>5</sup> ExxonMobil drilling first lithium well in Arkansas, aims to be a leading supplier for electric vehicles by 2030, dated 13 November 2024, < [https://corporate.exxonmobil.com/news/news-releases/2023/11/13\\_exxonmobil-drilling-first-lithium-well-in-Arkansas](https://corporate.exxonmobil.com/news/news-releases/2023/11/13_exxonmobil-drilling-first-lithium-well-in-Arkansas) >.

<sup>6</sup> EAU Lithium, Brine samples enroute to Vulcan in Germany for testing with VULSORB® technology, < <https://eaum.investorhub.com/activity-updates/brine-samples-enroute-to-vulcan-in-germany-for-testing-with-vulsorb-technology> >.

<sup>7</sup> Global Flow Control, Uranium One to Develop Bolivia's First DLE Plant, dated 12 September 2024, < <https://globalflowcontrol.com/newsroom/uranium-one-to-develop-bolivia-first-direct-lithium-extraction-dle-plant/> >.

<sup>8</sup> Koch's adsorbent originates from China following its long-term agreement with Lanshen, < <https://www.kochtechsolutions.com/2023/10/02/koch-technology-solutions-reaches-lithium-selective-sorption-media-exclusivity-agreement-with-xian-lanshen-new-material-technology-co-ltd/> >.

<sup>9</sup> bnamericas, Revolutionizing lithium production: Russian firm's breakthrough DLE technology explored, dated 21 November 2023, < <https://www.bnamericas.com/en/interviews/the-proposal-of-russian-company-axion-for-direct-extraction-of-lithium-in-chile> >.

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# VULSORB® A-DLE TECHNOLOGY



# VULSORB®: HIGH-PERFORMANCE A-DLE TECHNOLOGY WITH A WESTERN SUPPLY CHAIN

- ✓ **Superior extraction rate:** > 95%.
- ✓ **High adsorption capacity:** ~3 g/l, porous structure of the extraction material enables high surface area and adsorption capacity
- ✓ Main inputs for operation: heat and salinity, naturally occurring in many brines. **Lowers cost and CO<sub>2</sub> footprint of operation:** no acid/base required for loading/unloading.
- ✓ **Highly selective:** adsorbent chemical structure is selective towards lithium ions due to its small radius; ions such as magnesium, sodium and calcium cannot enter.
- ✓ **Tuned structure:** allows high performance in a wide range of operational temperature - from room temperature to over 70°C.
- ✓ **Western supply chain:** technology is 100%-owned by Vulcan; manufactured in Germany and France.
- ✓ **Limited field of competitors:** main western players with comparable technology position are Rio Tinto / Arcadium and Eramet, with other suppliers are from China
- ✓ **Applicable to all brine types:** VULSORB® has been successfully tested with salars, oil field brines and geothermal brines. Being licensed to developers in the Americas (north and south).



## Granular particles

Particle size range	450 - 1,050
Temperature	up to 75°C
Adsorption capacity	3 g/l

# VULSORB®: TESTWORK AND OPTIMISATION

Vulcan has spent years developing, testing, optimising and continuously improving VULSORB®

- ✓ One campaign of 1,000 non-stop cycles, with VULSORB® at ambient pressure.
- ✓ Two campaigns of 1,000 non-stop cycles each, with VULSORB® at brine pressure.
- ✓ Battery-quality LHM produced from Vulcan's optimisation plants.
- ✓ >95% lithium extraction efficiency.

## Full laboratory facilities (Karlsruhe)

- ✓ Technology selected in **scoping work conducted between 2018 and 2020.**
- ✓ **Three years of in-house laboratory testwork successfully performed and completed** between 2021 and 2023.
- ✓ **Technology de-risked on our brine chemistry at multiple well sites** (for salinity, Li content, chemical composition, temperature, etc.).

## Pilot plants (Landau)

- ✓ Vulcan has **conducted tens of thousands of hours of successful in-house pilot plant performance.**
- ✓ **Pilot Plant PP1 has completed over 5,000+ cycles of stable, non-stop operations**, since being commissioned in 2021.
- ✓ **Pilot Plant P1A has completed over 2,000+ cycles of stable operation** since being commissioned in 2022.
- ✓ **Data from pilot plants was used to optimise and improve the engineering design** for the Definitive Feasibility Study and Bridging Engineering Study.

## Optimisation plants (Landau and Industrie-Park Höchst)

- ✓ Representing an investment of c.€60m to date, **Vulcan's optimisation / qualification plants provide further validation.**
- ✓ Strong results achieved with **95% lithium extraction efficiency** from our A-DLE unit.<sup>1</sup>
- ✓ In January 2025, Vulcan announced that it had **produced its first battery quality LHM at the downstream optimisation plant**, by processing high-purity LiCl concentrate using VULSORB®. In doing so, **Vulcan became the first fully integrated, battery-grade LHM producer in Europe, from raw material to final product.**<sup>2</sup>

<sup>1</sup> Company announcement, Equity Raising Presentation, dated 11 December 2024, < <https://api.investi.com.au/api/announcements/vul/e031fc96-6e5.pdf> >.

<sup>2</sup> Company announcement, Production of battery quality lithium hydroxide monohydrate, dated 13 January 2025, < <https://api.investi.com.au/api/announcements/vul/c2d7d3dd-e4a.pdf> >.

# VULSORB®: EUROPE'S FIRST FULLY DOMESTIC LITHIUM CHEMICALS SUPPLY CHAIN

Combined €60m investment by Vulcan in two optimisation / qualification plants



Vulcan's operational lithium extraction optimisation plant ("LEOP")



Vulcan's operational central lithium electrolysis optimisation plant ("CLEOP")

- High-quality LiCl is being produced to spec since June 2024; >95% extraction efficiency.
- Onshored entire A-DLE technology and production supply chain into Germany and France.

- Initial production of battery quality LHM material from CLEOP announced by Vulcan in January 2025.<sup>1</sup>
- Vulcan to start sending battery-quality LHM from CLEOP to offtake partners for pre-qualification testing.

**Operational readiness: train staff and optimise product in a pre-commercial environment, and fast track product qualification**

<sup>1</sup> Company announcement, Production of battery quality lithium hydroxide monohydrate, dated 13 January 2025, <<https://api.investi.com.au/api/announcements/vul/c2d7d3dd-e4a.pdf>>.

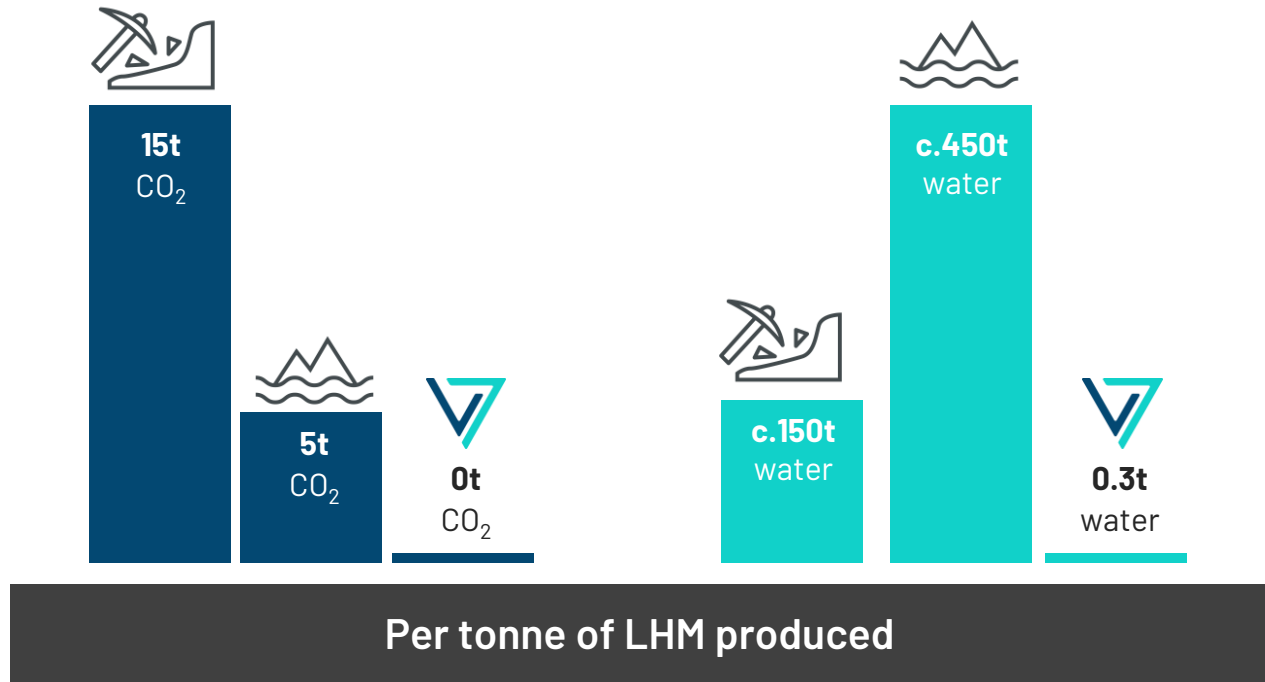
# VULSORB®: SUSTAINABILITY BENEFITS

A-DLE is engineered to have industry-leading environmental performance, significantly lowering the environmental footprint for lithium production

A-DLE can draw on naturally occurring, renewable geothermal energy to power the lithium extraction process and create a renewable energy by-product.

This process uses **no fossil fuels**<sup>2</sup>, requires **very little water**, and has a **tiny land footprint**.

Sustainability benefits of VULSORB® A-DLE technology compared to traditional methods of lithium production<sup>1</sup>



Hard rock mining



Brine evaporation ponds and reagents



VULSORB® A-DLE

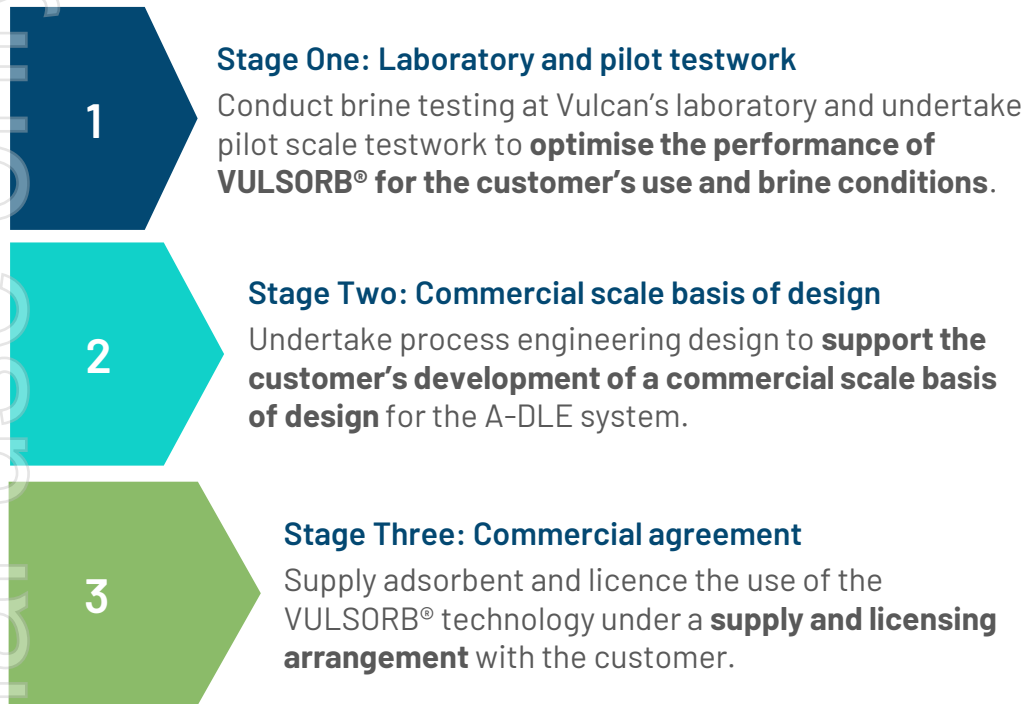
<sup>1</sup> Industry comparison data (CO<sub>2</sub> emissions, water usage) from Minviro's Life Cycle Assessment based on the 2023 Bridging Engineering Study. See also Vulcan's 2024 Sustainability Report, announced on 26 March 2025, < <https://api.investi.com.au/api/announcements/vul/5fd1e45e-3f7.pdf> >.

<sup>2</sup> Using geothermally heated brine as in Vulcan's Lionheart Project.

# VULSORB®: POTENTIAL LICENCING STRUCTURES

Vulcan is aiming to leverage its technology to gain exposure to other projects, by supporting selected partners in other jurisdictions with technology licensing, where there is no competition with Vulcan's own projects

Vulcan's three-step approach for licensing its VULSORB® technology to third parties



Revenues are targeted in the form of a supply and licensing agreement for Vulcan to supply sorbent and license the use of its VULSORB® technology.

✓ **Supply agreement**

- **One-off revenue:** supply of sorbent volumes for first fill
- **Recurring revenue:** supply of sorbent volumes for annual replacement (common assumption is 10% of first fill)
- **Recurring revenue:** technical support services for third-party projects

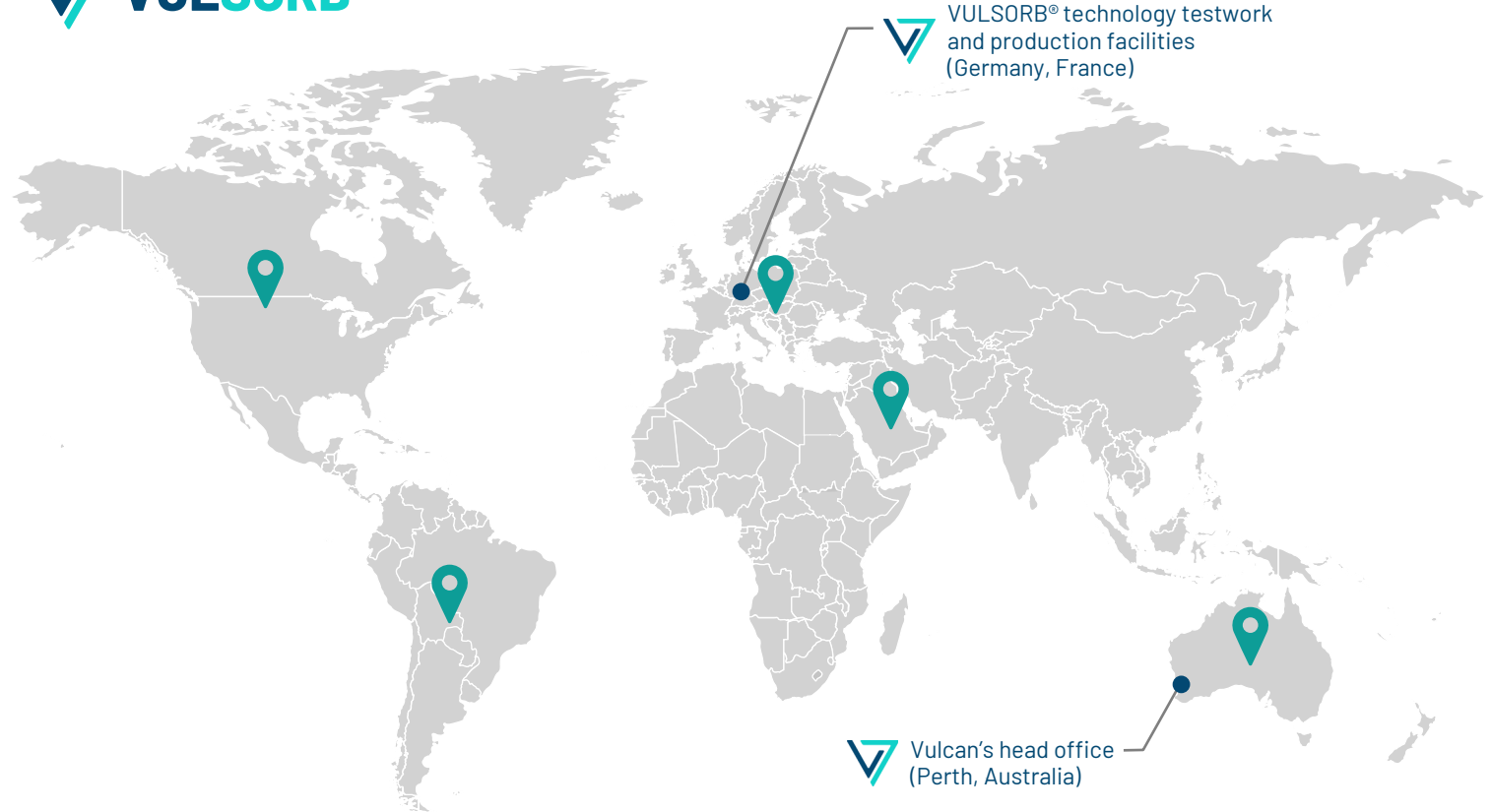
✓ **Licensing agreement**

- **Recurring technology licensing fee:** per project

# VULSORB®: KEY MARKETS

Vulcan has experienced increasing interest from technology agnostic A-DLE partners for VULSORB®

- Vulcan has experienced a material **increase in number of inbound enquiries**, confirming the visibility and market reputation of VULSORB®.
- Vulcan is monitoring a wider **pipeline of potential customers globally**, across:
  - North America
  - South America
  - Europe
  - Middle East
  - Australia
- A **wide geographic spread of lithium in brines** is usually associated with **large-scale energy infrastructure**.
- VULSORB® has been **successfully tested on South American salar brines and North American oil field brines**.
- An increased focus on **scale, cost of production, sustainability and supply chain security** in lithium industry will favour the deployment and demand for VULSORB®.



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# APPENDIX 1: DISCLAIMER CONT.

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