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MOVE THE WORLD FORWARD MITSUBISHI HEAVY INDUSTRIES GROUP

Ministero dell'Ambiente e della Sicurezza Energetica

Convegno: "*Estrazione di Litio da brine geotermiche: potenzialità*"
Auditorium MASE, via C. Colombo 44 – 00147 ROMA
Giovedì 27 giugno 2024, ore 9:00

PRODUZIONE DI LITIO DA BRINE GEOTERMICHE: L'ESPERIENZA TEDESCA

Joseph Bonafin

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OUR MISSION

We provide unique, reliable and advanced technologies founded on our core proprietary turbomachinery, with the aim of maximizing the value of renewable resources and energy efficiency.

SINCE 1980

Turboden is an Italian firm and a global leader in the design, manufacture, and maintenance of Organic Rankine Cycle (ORC) systems, highly suitable for distributed generation, which produce electric and thermal power exploiting multiple sources.

INNOVATION IN GEOTHERMAL SYSTEMS

Geothermal is known since decades for power generation. Currently there are about 16 GWs installed worldwide. Expected growth of traditional geothermal application (including flash and binary) is in the range 500 MW / year in the next 5 years (including ORC and flash plants). A real scale up of geothermal application can depend in the future on innovative solutions.

Two levels of innovation

Innovation related to the drilling technique to extract the heat from the underground

- Closed loop (e.g. Eavor → 8 MW Turboden Plant)
- EGS (Enhanced Geothermal Systems) (e.g. Fervo → 120 MW Turboden plant)

Innovation related to the mineral extraction (additional revenue stream due to minerals sale)

- Lithium (Vulcan, others)
- Silica (Geo40, others)

Software

Source: Vulcan corporate presentation

WHO IS VULCAN

VULCAN ENERGY
ZERO CARBON LITHIUM™

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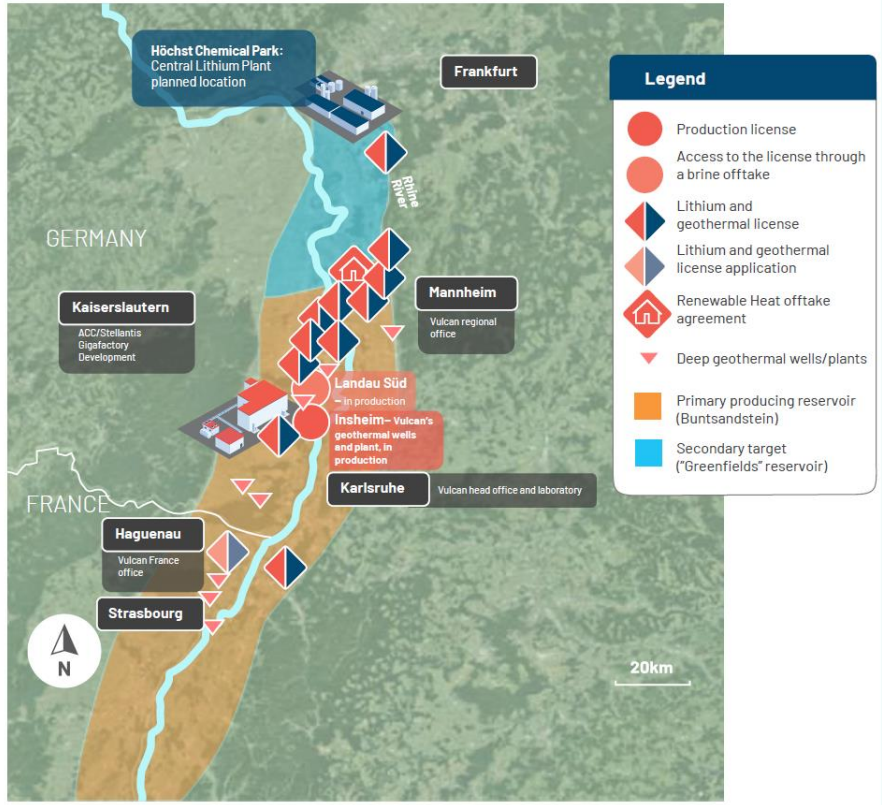
Vulcan is aiming to become the **world's first integrated lithium chemicals and renewable energy producer** seeking to supply the battery electric vehicle industry from Europe, for Europe, with net zero greenhouse gas emissions.

Company created in 2018. Offices in **Perth, Australia, Karlsruhe and Landau, Germany.** Majority of the approx. 370 personnel are on site in **Germany.** Extensive geothermal renewable energy and lithium chemicals expertise.

Vulcan has **offtake agreements with some of the largest battery, cathode and EV producers in Europe.**

STELLANTIS
VOLKSWAGEN GROUP
LG Energy Solution
umicore
RENAULT GROUP

Vulcan's Upper Rhine Valley Brine Field, consisting of **16 licenses for a total area of >1,700 km2**, represents **Europe's largest lithium resource**, with 26.6Mt contained Lithium Carbonate Equivalent.



Lionheart is the **first commercial project (Phase 1).** Target to generate 24.000 tpa of Lithium Hydroxide Monohydrate (LHM), and >300 GWh of electricity and >250 GWh heat per year. COD targeted in late 2026. **Turboden 28 MW ORC design and procurement ongoing**.

LITHIUM CARBONATE NATURAL RESERVES IN GERMANY (PHASE1)

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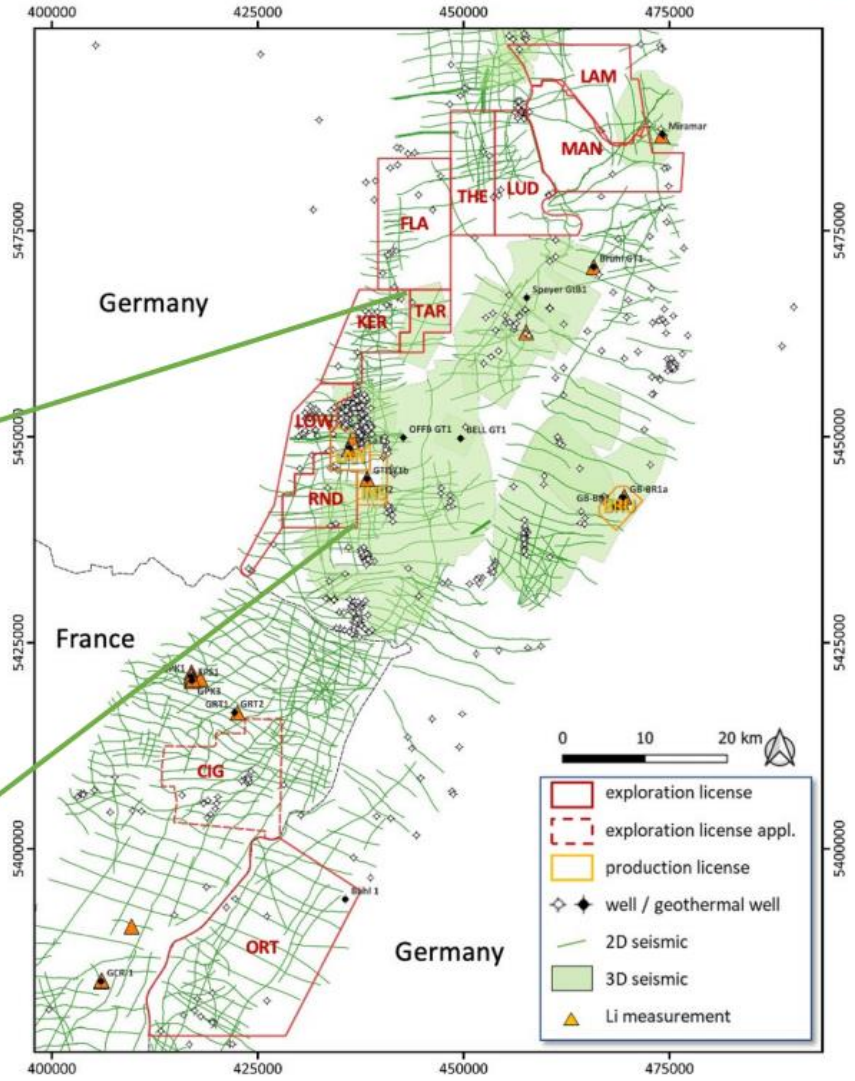
- Detailed reservoir engineering and production simulation study conducted to achieve maximum "sweep" of lithium across the field.
- Planned well placement and brine flow rates optimised for sustainable lithium production over a long project life.
- Production simulation includes existing production wells within Phase One area and incorporates large database of well and seismic data.
- Simulation reviewed and audited by independent lithium brine specialists and O&G industry reservoir engineering experts[2].
- Phase One: 0.54Mt LCE Proven and Probable Reserves centered around production wells in core of the URVBF field.

Lionheart: INS, LAN, RND		
Reserves Classification	Lithium grade	Economic Reserves Volume at Wellhead Reference Point
	mg/l Li	tonnes LCE
Proved	181	196,353
Probable	181	153,546
TAR-KER		
		tonnes LCE
Probable	181	189,070

Phase One[1] Mineral Reserves Estimation

[1]Phase 2 Reserves currently not updated since 2021 PFS, to be updated during current Phase 2 feasibility studies
[2]Refer to Competent Person Statement.



Source: Vulcan corporate presentation

FROM EVAPORATION PONDS TO DLE DEVELOPMENT

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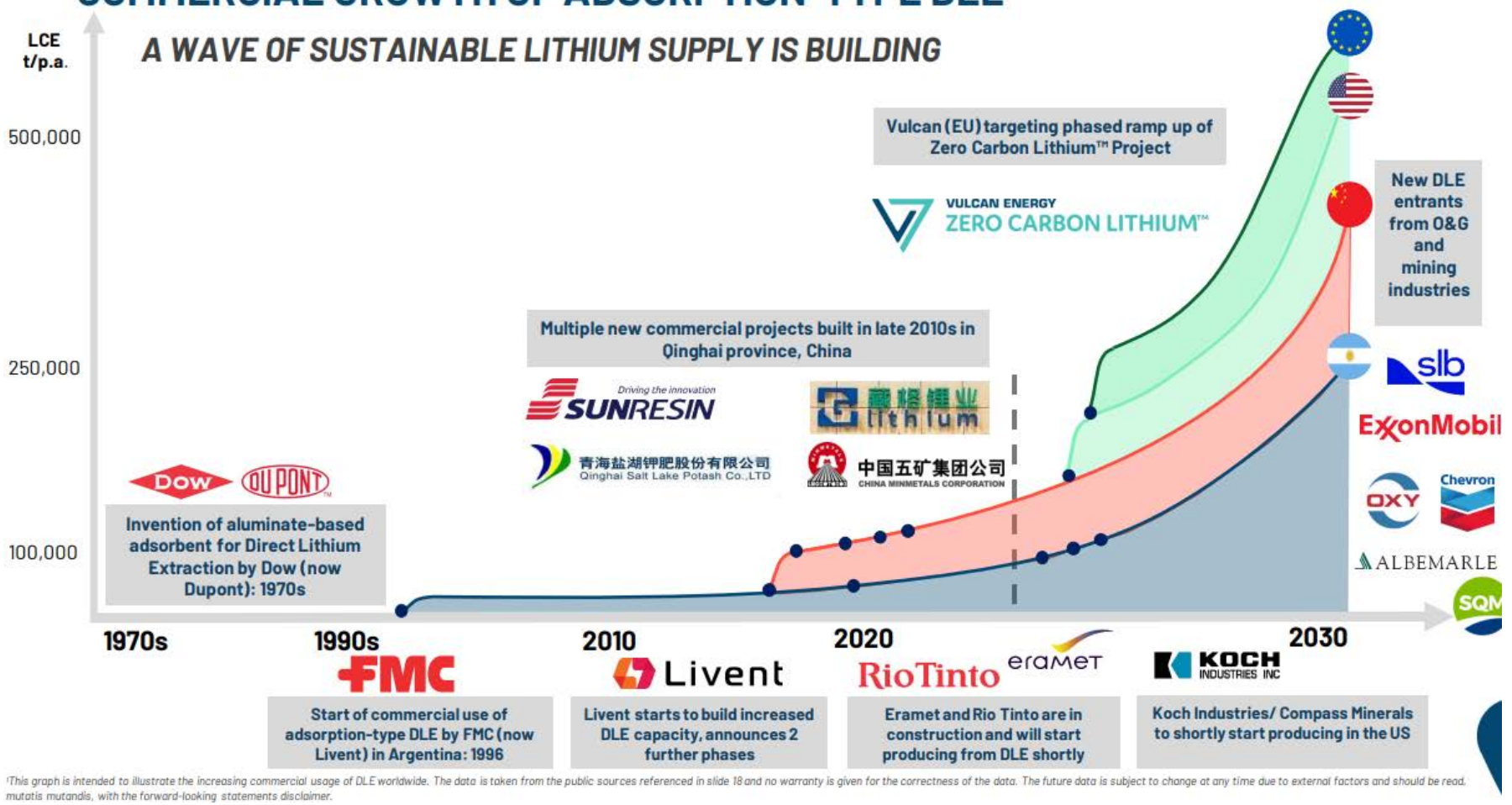
Legacy method:

- Use of evaporation ponds, **high water consumption** and lengthy (18 month) **process** vulnerable to climate/weather disruption
- **Low lithium recovery**, extent depends on Mg/Li ratio
- Complex process, multiple precipitation steps
- **Significant chemical reagent consumption**, and therefore **large CO_2 footprint**



[1]This graph is intended to illustrate the increasing commercial usage of DLE worldwide. The data is taken from the public sources referenced in slide 18 and no warranty is given for the correctness of the data. The future data is subject to change at any time due to external factors and should be read. mutatis mutandis, with the forward-looking statements disclaimer.

ZERO CARBON LITHIUM

2. AIMING FOR LOWEST WATER AND LAND FOOTPRINT IN LITHIUM INDUSTRY

Engineered to have industry-leading environmental performance: our core mission

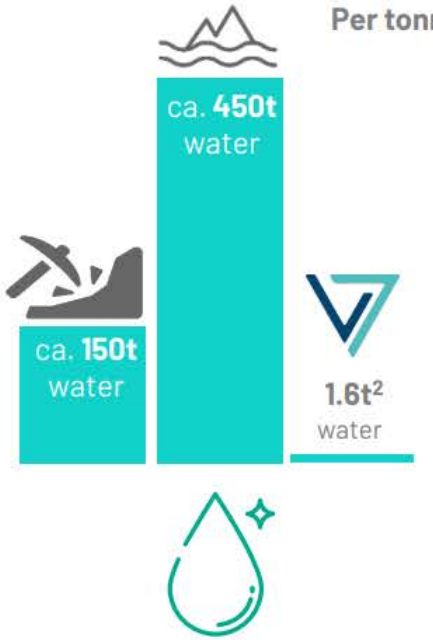
Hard rock mining
~60% of world lithium production

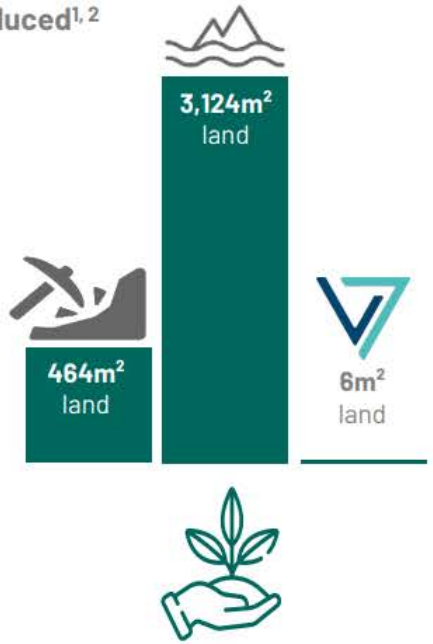
Evaporation ponds
~40% of world lithium production

Zero Carbon Lithium™

Vulcan draws on naturally occurring, renewable geothermal energy to power the lithium extraction process and create a renewable energy by-product. This uses **no fossil fuels** in the process, requires **very little water** and has a **tiny land footprint**.

Per tonne of LHM produced[1, 2]



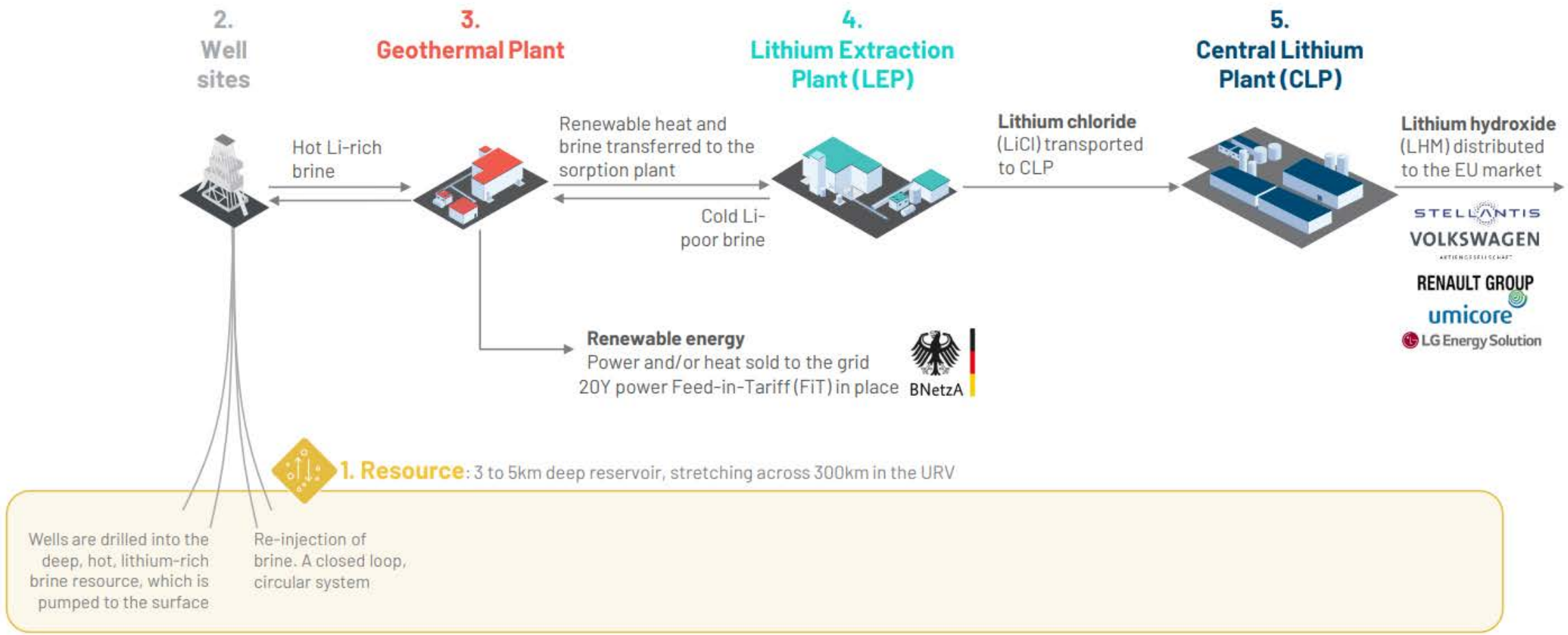


- Adsorption-type DLE needs heated brine to work.
- Current DLE producers use gas to heat the brine. Vulcan uses geothermal brine that is already naturally heated. Excess heat is used to generate renewable energy.
- Vulcan uses process equipment to concentrate lithium, instead of concentration ponds. This speeds up production time and reduces water usage. Incumbent producers are also switching to process equipment concentration.
- Vulcan's proximity to lithium hydroxide conversion also reduces carbon footprint, relative to current producers.

1 Industry peer data generated from Minviro Life Cycle Assessment (see Vulcan ASX announcement, 4 August, 2021)
2 Vulcan Energy's DFS, 13 February 2023
The Company's environmental credentials set out in this slide (and elsewhere in this Presentation) are based on the Company's Studies. There is no guarantee that the Company will be able to achieve the targeted metrics.

VULCAN PHASE 1 PROJECT

Phase one	300GWh power 250GWh heat	LiCl concentrate for 24,000tpa LHM equivalent	24,000tpa LHM



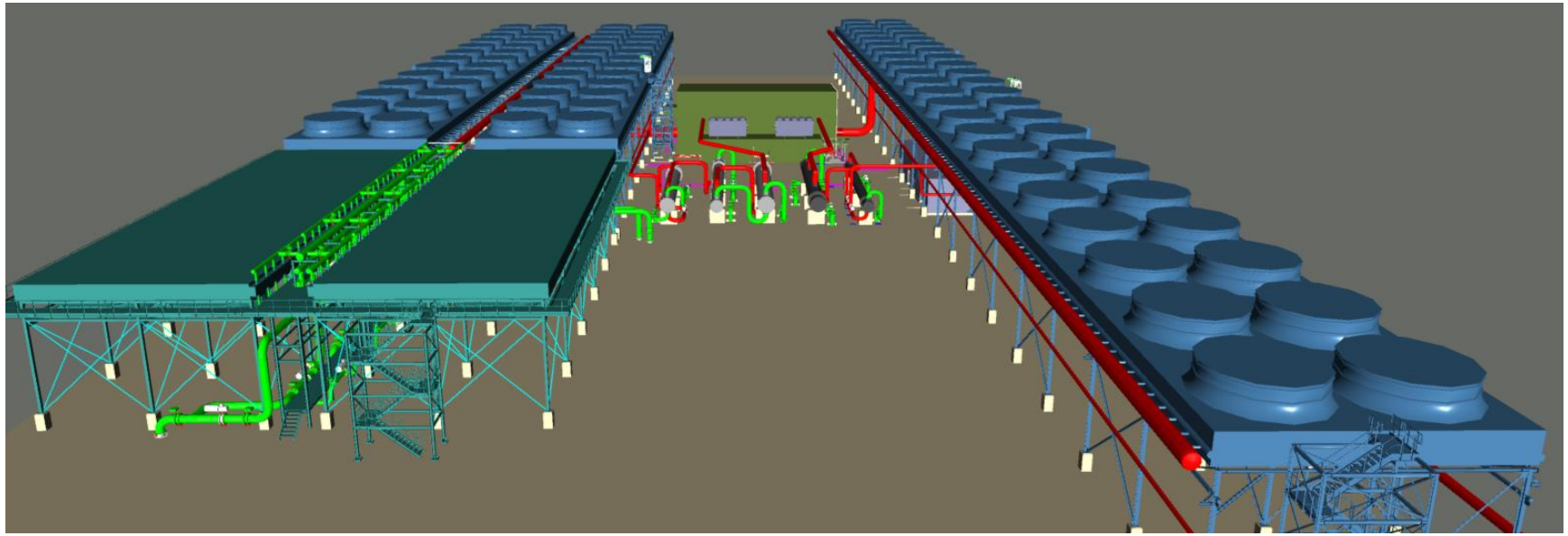
LIONHEART – TURBODEN ORC FEATURES

Project capacity: 28 MW gross

Turboden solution: 1 ORC generator with 2 turbines, with air cooled condensers.

Project timeline

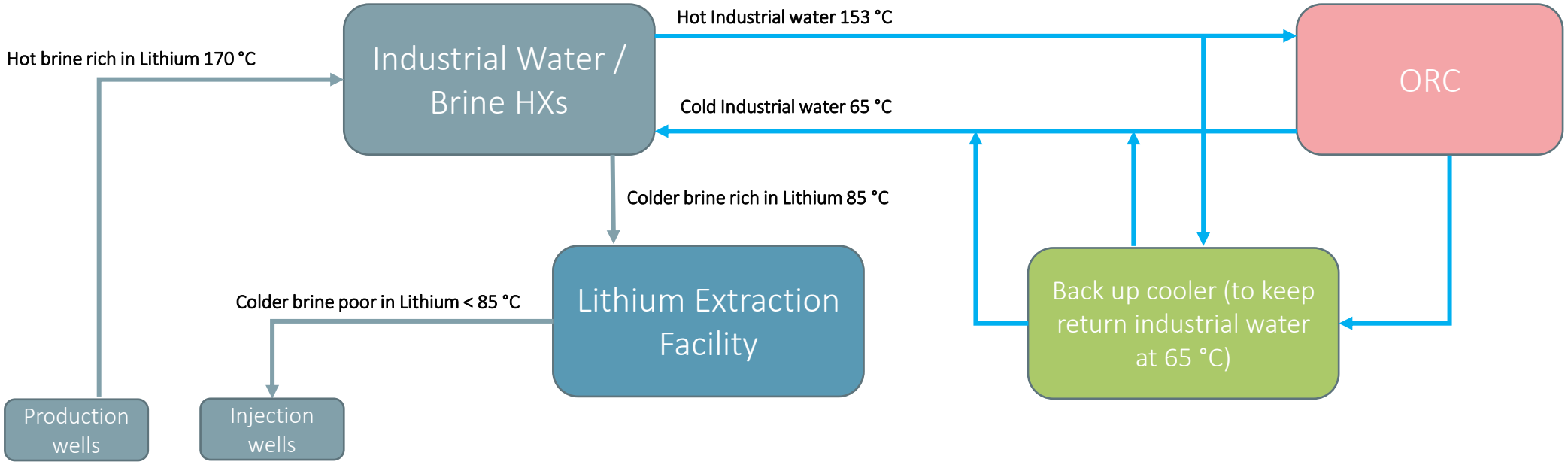
- COD target: Q4 2026



PROCESS SCHEME

The ORC works with the industrial water stream:

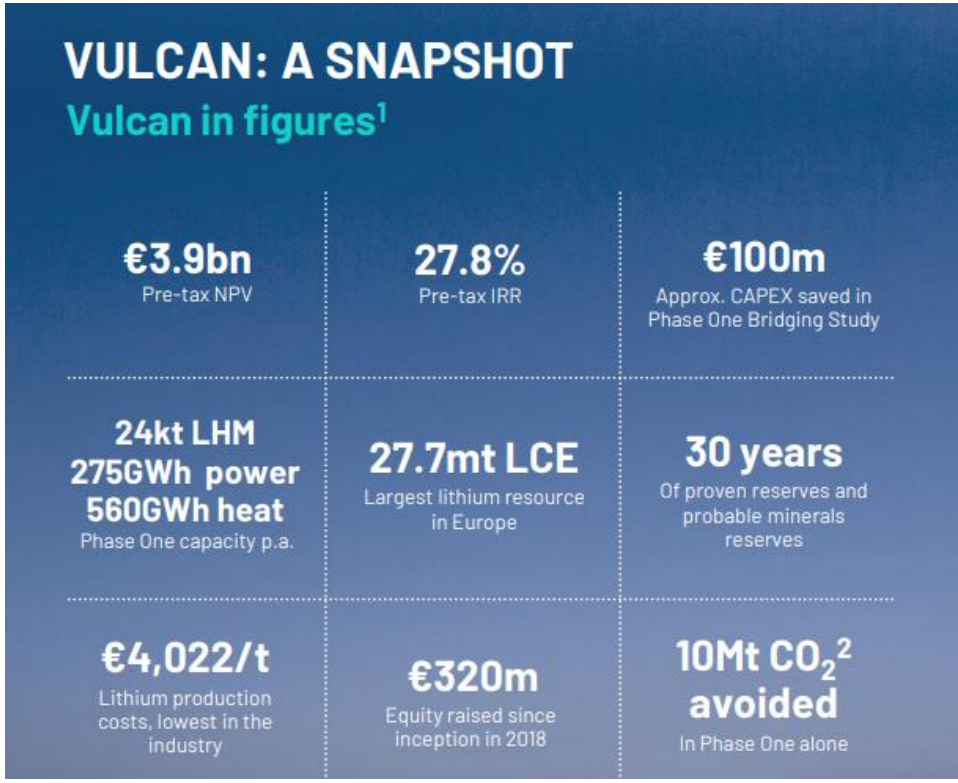
- The Heat exchangers with brine heat the industrial water at 153 °C to feed the ORC.
- The ORC cools the industrial water to 65°C
- The industrial water cools the brine to a temperature suitable for the Lithium extraction process (85 °C)
- The Lithium extraction facility extracts the Lithium before reinjection of the brine to the wells
- If the ORC is shut down or works at partial load, the back up cooler provides the cooling required by the Lithium extraction facility. It can work in by-pass mode, in series to the ORC, or deactivated if the ORC provides enough cooling.



KEY TAKEAWAYS

The first integrated renewable energy, lithium extraction and lithium hydroxide refining project development, seeking to supply the battery electric vehicle industry from Europe, for Europe is currently under advanced implementation phase by Vulcan.

- **Sustainability credentials:** engineered specifically to be world -first zero Scope 1 fossil fuels, net zero GHG emissions, very low water consumption project.
- **Compelling financial model**, much higher IRR as compared to traditional geothermal projects based on “power or heat and power only”.
- **Turboden is leading the powerplant optimization** and implementation according to German rules and environmental impact minimization.
- **Growth pipeline**: Vulcan’s URVBF consists of a consistent sedimentary geothermal lithium reservoir across 16 licences covering a total area of 1,771 km2 and 300 km long. There are currently 36 geothermal plants operating in Germany and 42 active projects. The federal government aims to reach 100 plants by 2030.



BACKUP

For more information about Turboden please visit

TURBODEN - Sistemi ORC, espansori di gas e grandi pompe di calore

For more information about Vulcan Energy please visit

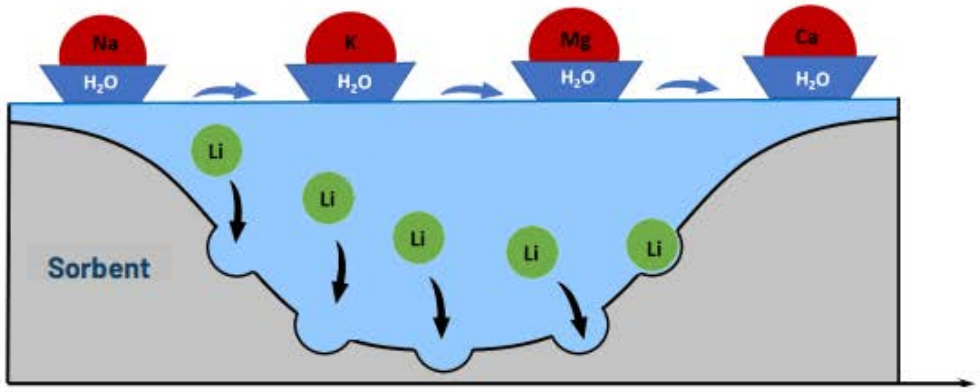
Home - VULCAN ENERGY RESOURCES (v-er.eu)

Corporate Presentations - VULCAN ENERGY RESOURCES (v-er.eu)

DLE PROCESS (BACKUP)

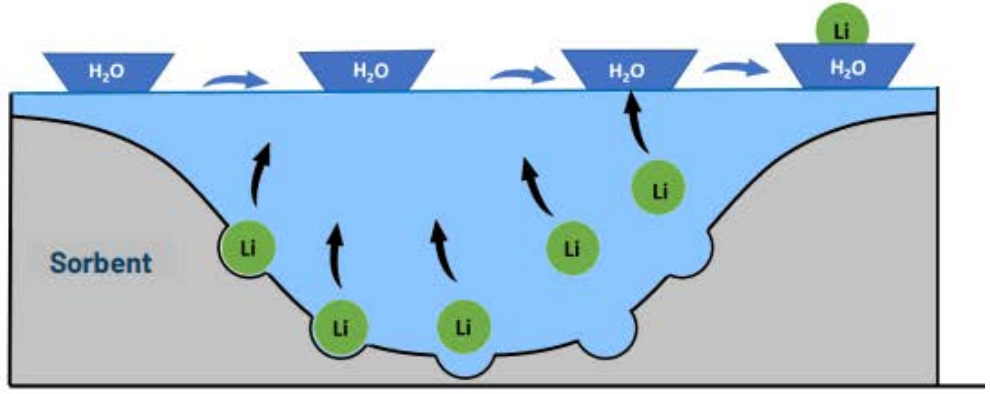
HOW THE ADSORPTION-TYPE DIRECT LITHIUM EXTRACTION PROCESS WORKS

Step 1



- 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.

Step 2



- 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.

OVER 40 YEARS OF A VIABLE SUSTAINABILITY

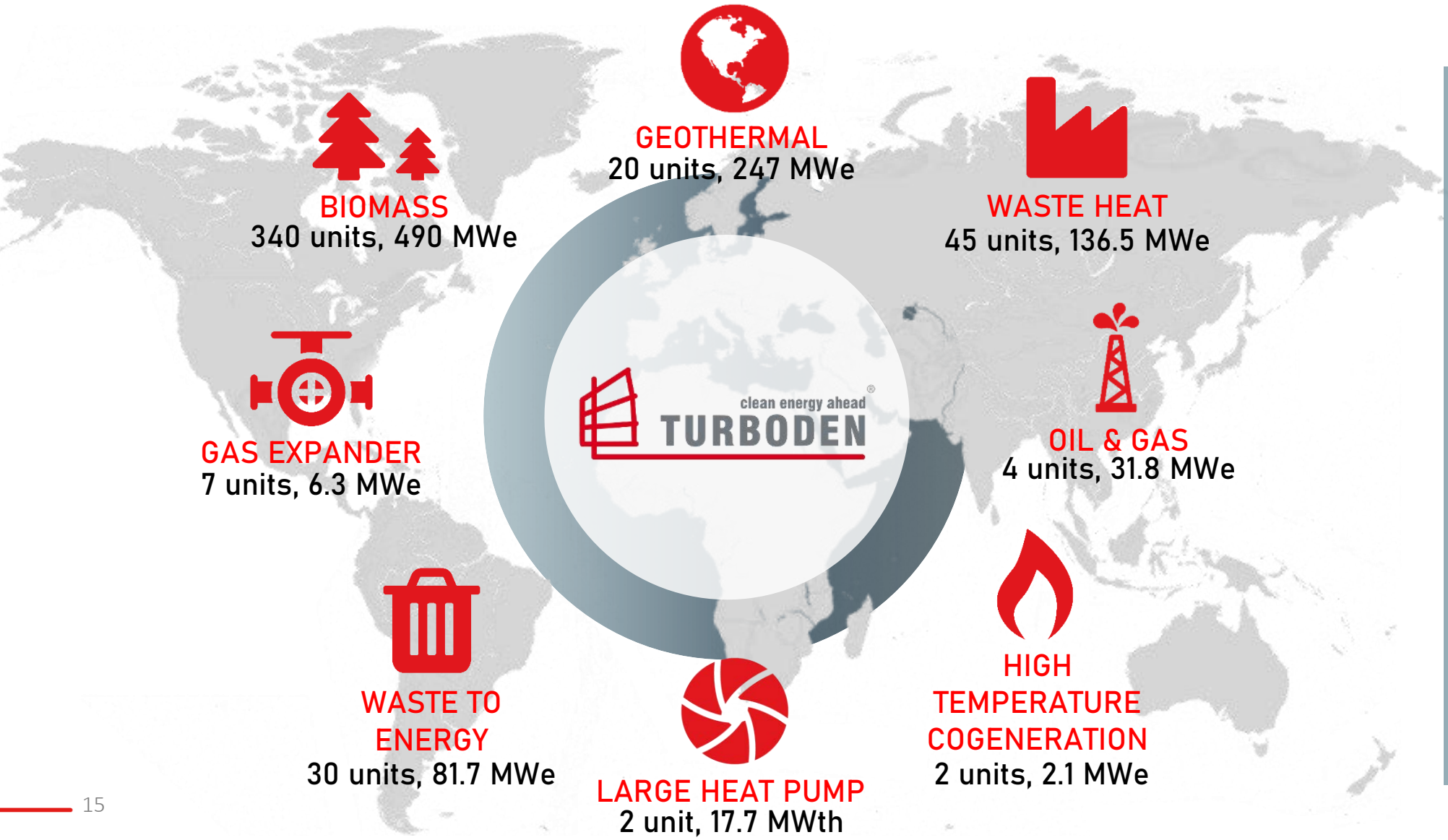
40 YEARS viable sustainability

SINCE 1980

Turboden is an Italian firm and a global leader in the design, manufacture, and maintenance of **Organic Rankine Cycle (ORC) systems**, highly suitable for distributed generation, which produce electric and thermal power exploiting multiple sources.

Thanks to its long experience in the energy efficiency sector, today Turboden expands its solutions offering with **gas expanders** and **large heat pumps**.

GLOBAL AND PROVEN EXPERIENCE



Experience in over
50
countries

With
440+
installations

Power delivered
> 1 GW

Cumulative operation time
20 million
hours

Last update: January 2024
* including two hybrid power plants

MILESTONES

‘60-’70

Prof. Mario Gaia makes experience in the field of ORC within his research group at Politecnico di Milano.

1976

1st ORC prototype.

1980

Prof. Mario Gaia founds Turboden.

1998

1st ORC biomass plant.

‘90-2000

Turboden enters geothermal, waste heat recovery and solar markets.

2000-2009

Turboden becomes leader in Europe with its biomass plants.

2013

MITSUBISHI HEAVY INDUSTRIES, LTD.

MHI acquires the majority of Turboden.

2019

Turboden launches new products, LHP and EXP

2020

40 YEARS

	1990	2000	2010	2020
ORC SIZES AVAILABLE	300 kW	1 - 2 - 4 MW	5 - 8 - 10 MW	40 MW
ORC PLANTS INSTALLED	1	100	220	400+