H2Uppp Public-Private Partnership between K-UTEC AG Salt Technologies and GIZ

"Brine-to-Value: Valorization of Reject Brine to Enhance Ecological and Economic Process Sustainability"

From Desalination Waste Stream to Specialty Fertiliser: A Scoping Assessment for Northern Chile

- Preliminary Results -

About the Public-Private Partnership (PPP)

Chile's growing green hydrogen industry will increasingly rely on desalinated seawater, particularly in water-stressed regions. However, desalination generates reject brine that can pose environmental risks and increase the costs of hydrogen production if not properly managed.

The public-private partnership (PPP) between GIZ and K-UTEC aims to address this challenge by developing a sustainable "Brine-to-Value" approach. The project explores the recovery of valuable salts and other by-products from reject brine, potentially reducing environmental impacts while creating additional economic value. Through a technical and economic pre-feasibility assessment, the PPP will identify a scalable and replicable solution that can support the sustainable development of green hydrogen and other water-intensive industries in Chile.

Why Reject Brine Matters for Green Hydrogen

Green hydrogen produced from seawater desalination is central to Chile's Hydrogen Strategy and economic growth. The country hosts more than 80 registered green hydrogen projects, with the largest concentration (around 32%) in the Antofagasta region (H2 Chile, November 2025). Approximately 85% of planned capacity depends on seawater reverse osmosis (SWRO) — a technology that, for every litre of freshwater delivered, also produces around 1.5 litres of hypersaline waste brine.

At a 3 GW alkaline electrolyser — the reference scale used in this study — the associated desalination plant generates roughly 5.3 million tons per year of reject brine. Under current practice, this stream is discharged to the sea. Growing scientific and regulatory pressure, particularly within the Atacama Desert coastal corridor where dilution capacity is limited, is making this approach

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increasingly difficult to justify[1]. At the same time, the cost of brine disposal is rising and is expected to be subject to formal regulation under Chilean law in the foreseeable future.

The Brine-to-Value project, a Public–Private Partnership between K-UTEC AG Salt Technologies and GIZ under the H2Uppp Programme, asks whether this waste stream can be converted into marketable products — reducing the environmental burden of desalination while generating revenue that improves the overall economics of green hydrogen production.

What the Scoping Study Found

A systematic evaluation was conducted across three dimensions: methods of brine concentration, salt product routes, and co-product strategies. Eight process configurations were assessed using a multi-criteria matrix covering technology readiness (TRL), capital and operating costs, process complexity, environmental footprint, and market alignment (see Table 1).

Concentration: Solar Evaporation as the most viable Option

Under the Atacama Desert's climatic conditions — low precipitation, high solar radiation, and persistent wind — solar evaporation emerged as the most suitable and economically competitive primary concentration method. Commercially available proven mechanical evaporation alternatives (multi-effect distillation, mechanical vapour compression, membrane distillation) were excluded from the preferred route due to uncompetitive capital intensity and extended payback periods. Additional waste heat from the electrolyser cells (approximately 1,060 MW available at 60–80°C for a 3 GW plant) offers the prospect of accelerating evaporation rates and potentially reducing the required pond area of approximately 2 km² by 40 to 80 per cent by increasing the average water temperature by 10–30°C.

Product Route: A Laboratory Breakthrough

Three main fertiliser product routes were compared: Muriate of Potash (MOP), Sulphate of Potash (SOP), and Langbeinite ($K_2SO_4 \cdot 2MgSO_4$), a multi-nutrient fertiliser. The key technical finding was the demonstration that the potassium-containing mixed salts - "Kainite-type mixed salts (KTMS)" - formed during the solar evaporation of the RO reject solution can be converted into Langbeinit in a well-controlled process with short residence times at elevated temperatures. This produces a Langbeinit intermediate, which, after mechanical separation of NaCl and drying, can be marketed as a saleable product. No chemical reagents are required for this process.

[1] a) Gobierno Regional de Atacama (2023) *Actualización Plan Regulador Intercomunal Costero de Atacama*. Santiago: Strategic Environmental Assessment; b) Comisión de Evaluación Ambiental de Antofagasta (2026) *Resolución de Calificación Ambiental – Plan de Reducción de Extracciones en el Salar de Atacama*. Antofagasta: Novandino Litio.

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Table 1

Criterion	MOP / SOP Routes	Langbeinite Route ✓
CAPEX (est.)	€26–49 M	~€28 M
Payback period	9–11 years	~7-9 years
Process complexity	Medium to high	Low
TRL	9 (industrial standard)	4–5 — pilot validation required
Chemical reagent use	Higher (flotation)	None
Market fit (LatAm)	Moderate (MOP commodity)	Strong — niche product
Environmental footprint	Moderate to high	Lowest among assessed options

The Selected Route and Its Economic Case

On the basis of the scoping assessment, the Langbeinite Route via solar evaporation was recommended for advancement to pre-feasibility study. The selection rests on four mutually reinforcing grounds: the lowest CAPEX among value-adding alternatives (~€28 M), the shortest payback period (~7-9 years), the simplest process flowsheet, and the strongest fit with fertiliser markets in Chile and broader Latin America.

At the 3 GW reference scale, the process is estimated to yield approximately 15 kt/a of fertiliser-grade Langbeinite alongside approximately 380 kt/a of solid NaCl-rich by-products. Operational expenditure is estimated at approximately €1.4–2.4 M/a. Sodium chloride, though the largest volumetric by-product (Chile's bulk NaCl export price is approximately USD 21/t), does not constitute the primary revenue driver; it is stockpiled as waste. Depending on market demand, higher-quality grades of NaCl salt could also be produced as needed, for which prices of up to 95 USD per ton can be obtained in Chile[2]. Langbeinite, by contrast, commands a price in Chile of approximately USD 550–600/t CIF, reflecting its multi-nutrient profile — potassium, magnesium and sulphur in a single, chloride-free application, ideal for viticulture, avocado cultivation, or fruit and berry cultivations.[3]

[2] Global Product Prices, Chile - Salt - price, January 2026, https://www.globalproductprices.com/Chile/salt_prices/?utm_source=copilot.com

[3] MAWEB (2026.). Current Fertilizer Prices Per Ton – Latest Market Rates, https://maweb.org/current-fertilizer-prices-per-ton/?utm_source=copilot.com; ANUTO (2026), Global Fertilizer Price Benchmarks: A 2026 Marketplace Analysis of Agricultural Inputs, https://anuto.net/signals/global-fertilizer-price-benchmarks-a-2026-marketplace-analysis-of-agricultural-inputs?utm_source=copilot.com;

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Chile is a net importer of potassium, magnesium and phosphate fertilisers. The supply disruptions of 2022–2023, linked to the exclusion of Russian and Belarusian potash from Western markets, have strengthened domestic interest in alternative supply chains. Export-oriented sectors such as avocado, grapes and blueberries are both chloride-sensitive and magnesium-demanding. Furthermore, they represent a natural market segment for a locally produced Langbeinite.

State of Development and Next Steps

Current Technology Readiness Level: TRL 4–5

The Langbeinite formation has been validated at laboratory scale. However, the integrated process has not yet been demonstrated. Pilot testing is underway at K-UTEC's Technical Centre in Sondershausen, Germany. Results will determine whether the mass balance assumptions used in the economic model require adjustment and will select the design parameters for a subsequent detailed feasibility study.

The pre-feasibility study (this project's current phase) is addressing the following in parallel: process flowsheet and mass/energy balance at reference scale; environmental and social impact screening under Chilean EIA requirements; regulatory mapping across Chile's mining, environmental and water codes; and a risk register covering technical, financial, regulatory and social dimensions. Particular attention is given to the legal status of reject brine under Chilean law. Reject brine is not yet definitively classified as either an industrial residue or a mineral substance, and the resolution of this question has material consequences for permitting strategy.

Indigenous consultation requirements under the International Labour Organization (ILO) Convention No. 169 concerning Indigenous and Tribal Peoples in Independent Countries apply to the Antofagasta region, where Chango, Likan Antay and Aymara communities are documented. These obligations are treated as a substantive regulatory requirement, not a procedural formality, and are integrated into the project's social acceptance and permitting assessment.

Broader Significance

The Brine-to-Value strategy, if validated, offers a replicable framework applicable to the estimated 85% of planned global green hydrogen capacity located in water-stressed, desalination-dependent regions.

The Langbeinit process has the potential to be one of the most robust approaches in the emerging field of brine mining. This is due to the combination of a simplified single-stage production process,

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the elimination of environmentally problematic and chemical-intensive flotation separation, the use of waste heat from the electrolysers as process heat, and, last but not least, the supply of a high-quality, chloride-free potassium-magnesium sulfate fertiliser to the regional agricultural market.

Whether it proves commercially viable at scale depends on the outcomes of ongoing pilot work, regulatory clarity, and the evolution of fertiliser market prices — all of which will be addressed in the detailed feasibility study that will follow this pre-feasibility phase.

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