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From Black Gold to White Gold: Saudi Arabia's Ambition in the Global Lithium Market and the Role of Advanced Extraction

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INTRODUCTION

Lithium has emerged as the backbone of the global energy transformation due to its central role in powering electric vehicles (EVs), portable electronics, and large-scale energy storage systems. As nations accelerate toward carbon neutrality, lithium has transitioned from a niche commodity into a strategic industrial resource. The global lithium market is expected to grow more than fivefold by 2030, driven by demand for energy transition technologies and enhanced battery performance metrics.

Saudi Arabia is now actively diversifying toward critical minerals in line with Vision 2030. The national minerals strategy prioritizes lithium exploration and downstream processing to create a full-fledged battery supply chain that supports domestic EV manufacturing, renewable integration, and green hydrogen storage systems. The government's National Industrial Development and Logistics Program (NIDLP) identifies lithium as central to this transformation, ensuring value addition occurs within the Kingdom rather than through raw material export.

Recent efforts, including the Aramco–Ma'aden joint venture, have demonstrated promising progress by combining geological exploration expertise with large-scale industrial capabilities. Research institutions such as KAUST and KACST have contributed innovative electrochemical extraction technologies tailored to Saudi brine compositions. These developments signify a national shift from hydrocarbon-centred to critical mineral wealth, reinforcing the Kingdom's leadership in the evolving global energy economy.

METHODS

This research employs a holistic approach with four analytical pillars that guide the study:
(1) **Geological Prospecting:** Comprehensive mineralogical analysis focused on the Arabian Shield's felsic and granitic massifs, known for pegmatite-hosted lithium minerals. Remote sensing and geochemical sampling data were processed to identify high-lithium anomalies and lithium-bearing minerals above the 0.5 wt.% economic threshold.
(2) **Brine and Waste Stream Assessment**: Desalination brine and oilfield-produced water were chemically profiled to assess lithium concentrations typically ranging from 30 to 120 ppm. Laboratory trials tested hybrid extraction processes that integrate adsorption materials and membrane-free electrochemical separation, achieving selectivity above 85% at magnesium-to-lithium ratios greater than 10:1.
(3) **Techno-Economic Benchmarking:** A financial and energy-based model evaluated refining options, namely lithium carbonate and lithium hydroxide production using renewable-powered electrolysis units. Comparative analysis showed domestic refining costs could be 20–30% lower than global averages when co-located with renewable hydrogen.
(4) **Industrial Integration Modeling**: Industrial systems modeling linked extraction sites to refining and export infrastructure at Yanbu and Jubail. Spatial optimization using cost-distance mapping assessed potential logistics synergies with existing port and power infrastructure, thus supporting scalable deployment scenarios.

RESULTS

Early results underscore both geological and resource potential within Saudi Arabia's industrial regions. Granite-hosted pegmatites in the Arabian Shield exhibit lithium oxide concentrations between 0.6% and 1.3%, consistent with commercial-grade deposits elsewhere. Coupled with brine and geothermal source testing, the findings reveal multiple extraction opportunities across inland basins and western coastal desalination corridors.

Electrochemical extraction prototypes developed by **KAUST laboratories** show high lithium recovery rates (82–90%) while reducing energy consumption and eliminating harmful chemical reagents. These systems function effectively under wide salinity ranges, allowing for modular scale-up in remote desert installations. This flexibility aligns well with the Kingdom's broader sustainability agenda and resource-efficiency principles under Vision 2030.

Integrating refining operations with renewable energy projects significantly reduces process costs and emissions intensity. The proposed Yanbu refinery cluster could produce over 30,000 tons of lithium carbonate equivalent (LCE) annually by 2028, meeting regional industrial demand and positioning the Kingdom as a strategic lithium supplier for Asia and Europe.

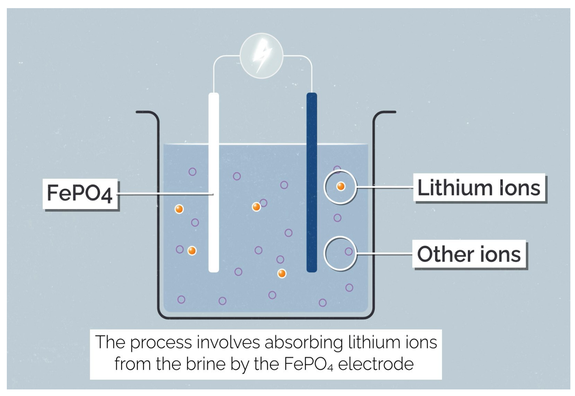


Figure 1. KAUST Lithium adsorption process (Zhen Li et. al, 2024)



Figure 2. Balthaga Lithium Project (EVM, 2023)

Another emerging project is the Balthaga Project, located in the Arabian Shield and covering 1,200km^2 across 13 licensed tenements, is prospective for **lithium and rare earths**. The recent exploration campaign systematically located and sampled targets, collecting 43 rock chip samples which have been submitted for analysis, with results expected to define the next stages of work.

The successful execution of the initial exploration programme is a result of a collaborative earn-in joint venture between EV Metals Group plc (EVM), through its subsidiary Riwaq Al Mawarid for Mining (RIWAQ), and Power Metal Resources plc.

Strategically, this upstream activity is crucial to EVM's broader vision of establishing a fully integrated critical raw materials supply chain in KSA, linking mining to the midstream processing at its planned flagship Lithium Chemicals Plant (LCP) in Yanbu Industrial City, which will produce high-purity battery chemicals like Lithium Hydroxide Monohydrate to support the global energy transition and Saudi Arabia's Vision 2030 goals.

DISCUSSION

Saudi Arabia's lithium initiative reflects a multidimensional strategy anchored in innovation, industrial integration, and global partnerships. The **Aramco–Ma'aden joint venture** serves as a cornerstone of this approach, leveraging resource exploration with sustainability-focused operations. The alignment of lithium projects with the **National Mining Strategy 2030** provides institutional continuity, ensuring that the lithium transition accelerates under a robust legal and investment framework. The nation's comparative strengths lie in:

Energy economics — leveraging low-cost renewable and nuclear power for refining and electrochemical synthesis;

Geochemical diversity — enabling both hard-rock and brine-based extraction;

Research leadership — with KAUST advancing sustainable lithium separation techniques suitable for Saudi brine chemistry.

Key challenges include scaling extraction technology to industrial volumes, developing sustainable water management solutions, and maintaining long-term competitiveness in lithium pricing. However, governmental incentives under the **Saudi Green Initiative** and R&D funding through the **Ministry of Industry and Mineral Resources** are expected to bridge these gaps. By aligning R&D with industrial objectives, Saudi Arabia can integrate critical mineral production into its circular economy vision.

CONCLUSION

This study concludes that Saudi Arabia's transition from an oil-based economic structure to a balanced mineral and energy system positions it as a future leader in global lithium supply chains. Lithium exploration in the Arabian Shield and selective extraction from desalination and oilfield brines represent a transformative path for resource utilization in arid environments.

Emerging electrochemical extraction technologies, supported by renewable energy and advanced materials research, have shown exceptional promise for achieving commercial-grade lithium recovery at reduced costs and environmental footprints. Integrating these efforts within industrial ecosystems like NEOM and Yanbu reinforces economic resilience, promotes carbon neutrality, and secures the nation's role in the global clean energy supply chain.

Saudi Arabia's "white gold" evolution symbolizes not only an industrial diversification milestone but also a vision for sustainable prosperity grounded in science, innovation, and international collaboration.

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