Engineering and Physical Sciences Research Council Doctoral Landscape Award

PROJECT TITLE: Electrochemical Lithium Extraction (ELITE)

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Project details: The rapid evolution of battery technologies drives global lithium demand, and the UK's 2030 vision seeks a competitive, sustainable battery supply chain to fuel prosperity and net-zero goals. Despite its vast geothermal brine lithium reserves that has potential to meet national demand, the UK's lithium resources remain underexploited. The southwest—rich in lithium, renewables, and emerging battery manufacturing—is an ideal hub for lithium supply development. Conventional evaporation-precipitation methods and direct lithium extraction struggle with low efficiency, modest affordability, and poor sustainability. Li^+-selective membrane based electrochemical lithium extraction (ELITE) system offers a promising solution, leveraging scalability, energy and time efficiency, low costs, and decarbonized lithium production to meet these challenges. The ELITE system uses a Li^+-selective ceramic membrane to drive lithium ions via electric potential across an electrochemical cell. The potential of lithium extraction from brine and seawater, integration with renewable energy sources make this technology promising for low-cost and decarbonized lithium production. However, ceramic membranes, generally used in all-solid-state lithium-ion batteries, face hurdles like low ionic selectivity and conductivity, brittleness, chemical instability, and high production costs. Driving Li^+ migration often requires high voltage, exceeding water hydrolysis thresholds and increasing energy use, while electrolysis of the source solution generates unwanted by-products like chlorine gas. This project aims to develop a cost-effective, high-efficiency ELITE system.

To unlock its industrial potential, this project focuses on achieving the practical application of ELITE systems through three key tasks. First, based on my prior research on garnet-solid state electrolyte, a membrane with high ionic conductivity, robust mechanical and chemical/electrochemical stability, and affordability, will be explored using doping, sintering, thermal spray, and surface coating techniques. Second, by engineering electrochemical reactors with tailored reactions—adding chambers or anode surface protection layers—lithium yield of the ELITE system will be optimized, and by-products minimized.

A range of material enhancements, electrochemical cell modifications, operational strategies will be explored for improved ELITE performance. Third, the ELITE system's durability will be evaluated in Cornish geothermal brine water, progressing from lab-scale tests with simulated brine or seawater to pilot-scale trials with real brine, ensuring practical applicability. Whilst most research projects on this topic are restricted to the use of synthetic Li-bearing brine samples, which do not accurately reflect the complex geochemistry of real brine, crucially this PhD project will benefit from samples which will be supplied from both Cornish Lithium (1km borehole depth) and GEL (5km borehole depth), the latter being UK's deepest onshore borehole. This project outlines theoretical and experimental methods, with strong focus on materials manufacturing and electrochemical measurements, aided by industrial collaboration to credit the wide-spread impact of this pioneering research. The project has the potential to underpin

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the future lithium extraction technology, enhance UK energy security on critical mineral supply chains, driving economic and environmental benefits toward a net-zero future.

Project specific entry requirements: The PhD should have background in Materials, Chemistry, Engineering etc.

Potential PhD programme of study: PhD in Renewable Energy

Department: Engineering

Location: DDM, Penryn Campus

Please direct project specific enquiries to: Please contact: zhenyu.zhang@exeter.ac.uk

Please ensure you read the entry requirements for the potential programme you are applying for.

To Apply for this project please click on the following link - **APPLY HERE**