Hydrogen export using a powder

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Project summary:

This project involves the research, development and deployment of a new technology to export hydrogen as a powder. The powder is a salt called sodium borohydride that releases hydrogen when added to water. After hydrogen is released a by-product powder remains, called sodium borate, which needs to be regenerated back to its hydrogen-rich form using renewable energy.

The project will focus on:

- The electrochemical production of sodium borohydride powder from sodium borate to provide a circular hydrogen export value chain.
- The research component of the project will feed into the research commercial stage, where a pilot plant will be designed and built in Australia.
- A pilot plant is planned to assess large-scale i) sodium borohydride production directly from renewable electricity, and ii) hydrogen generation from sodium borohydride.

Current hydrogen export options

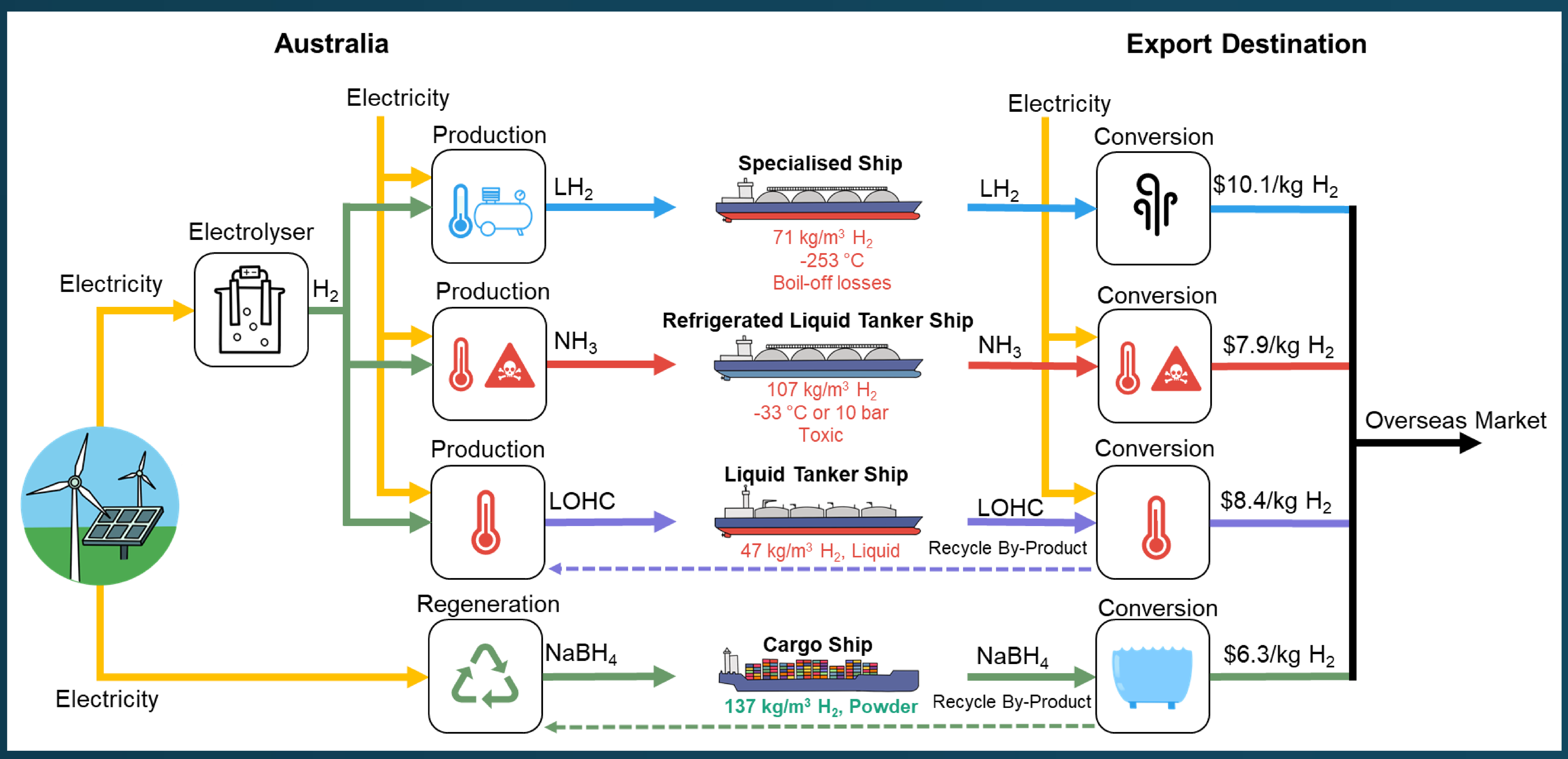

Figure 1: Comparison of different methods of hydrogen export, costs are in AUD and based on 2030 predictions from 'The Future of Hydrogen' report prepared by the International Energy Agency (IEA) using 1 AUD = 0.7 USD as the exchange rate.[1] The cost for $NaBH_4$ is calculated using the same parameters but assuming electrochemical regeneration at 80% efficiency.[2]

Hydrogen export using sodium borohydride powder

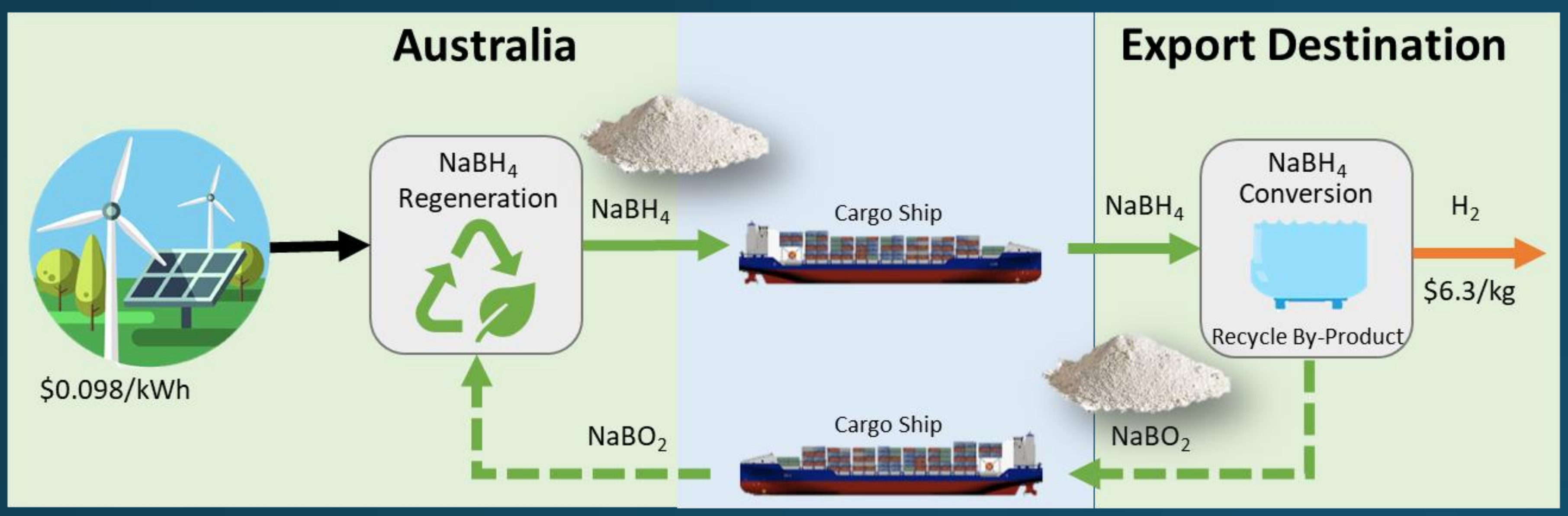

Figure 2: Schematic of planned hydrogen export process using $NaBH_4$ powder. The price of hydrogen at the export destination includes all aspects (production, transport both ways, conversion) and is based on 2030 predictions from 'The Future of Hydrogen' report prepared by the IEA using 1 AUD = 0.7 USD as the exchange rate.[1]

Regeneration of spent powder

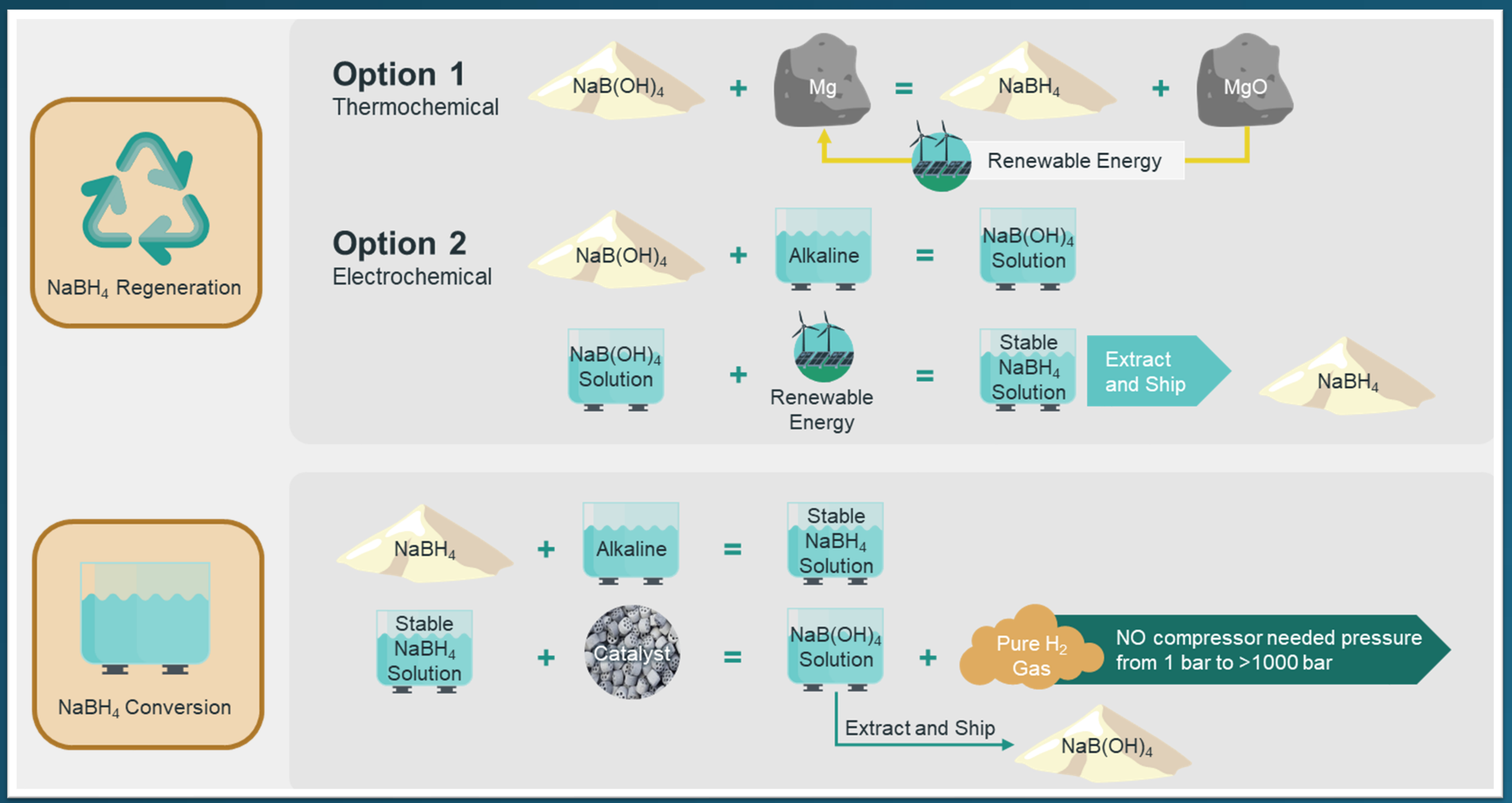

Figure 3: Options for regeneration pathways of $NaBH_4$.

Project deliverables

Research components (March 2024 to May 2027)

- Component 1: Optimisation of electrochemistry at increasing scale
- Component 2: $NaBH_4$ processing
- Component 3: High pressure hydrogen generation[2]

Research commercialisation components (August 2027 to May 2029)

- Component 4: Design a pilot-scale production plant (Facility 1)
- Component 5: Design a pilot-scale plant for hydrogen gas release (Facility 2)
  - Note that Facility 1 and 2 are located in the same pilot plant
- Component 6: Construct and commission the two facilities in the pilot plant
- Component 7: Optimise the two facilities in the pilot plant

The research program will directly feed into the research commercialisation program (pilot scale) to enable testing of critical chemical production and processing sub-systems in conjunction with cost optimisation protocols. The pilot plant will contain both key elements of the $NaBH_4$ technology:

Facility 1: Electrochemical production of $NaBH_4$ from $NaBO_2$ in water and solvents, followed by processing and drying of the $NaBH_4$ powder. On a commercial scale this facility will be in Australia and powered by renewable energy.

Facility 2: Hydrogen generation from $NaBH_4$. The hydrolysis of $NaBH_4$ is enabled using a stable catalyst in a well-known process to release hydrogen on demand. Hydrogen gas will be separated from the $NaBO_2$ by-product, which will be processed and dried, ready for shipping. On a commercial scale this facility will be in an export location.

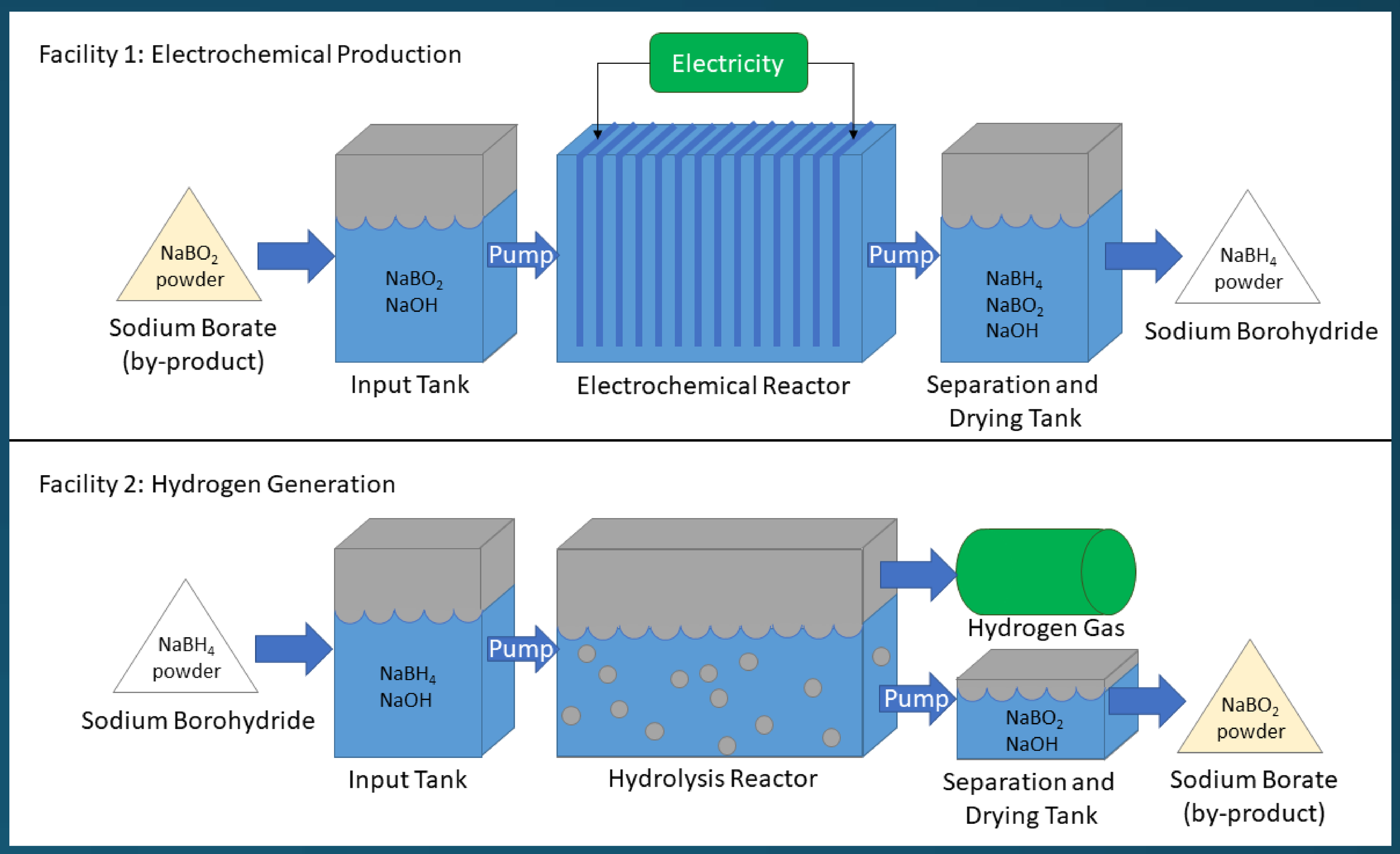

Figure 4: Schematic of pilot plant to be designed, constructed and tested during the final 2 years of the project.

Expected project outcomes

The specific outcomes of the project are:

1. Produce sodium borohydride using the electrochemical method at a low enough cost to export hydrogen competitively.
2. A pilot plant is designed and built that is capable of both producing sodium borohydride and converting it to hydrogen on the multi-kg scale
3. Provide cost validation and technical feasibility for commercial production.

References

[1] *The Future of Hydrogen*, IEA Report, 2019.

[2] A. Ibrahim, M. Paskevicius and C. E. Buckley, Sustainable Energy & Fuels, 2023, 7, 1196-1203.

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Research and funding partners

Curtin University
HSRG Hydrogen Storage Research Group
Velox Energy Materials
ARENA Australian Government Australian Renewable Energy Agency
GlobH2E ARC Industrial Transformation Training Centre for the Global Hydrogen Economy
Australian Government Australian Research Council