HILT CRC

HEAVY INDUSTRY LOW-CARBON TRANSITION COOPERATIVE RESEARCH CENTRE

RP1.011/RP1.011-ARENA M10504/M10522

UPGRADING OF IRON ORE FOR DRI PRODUCTION USING PRODUCTS FROM SEAWATER RO BRINES

PROJECT OVERVIEW

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Curtin University | Government of Western Australia | mriwa | proxa future focused | Fortescue | The University of Adelaide | Roy Hill | BG&E Resources

MOTIVATION – REDUCTION OF SCOPE 3 EMISSIONS

Blast furnace route

1.9 ton CO_{2e}/t hot metal*

Impurities reporting to slag lead to increased waste

Impurities reporting to metal lead to higher production costs

EAF-DRI(gas)

0.9 ton CO_{2e}/t hot metal*

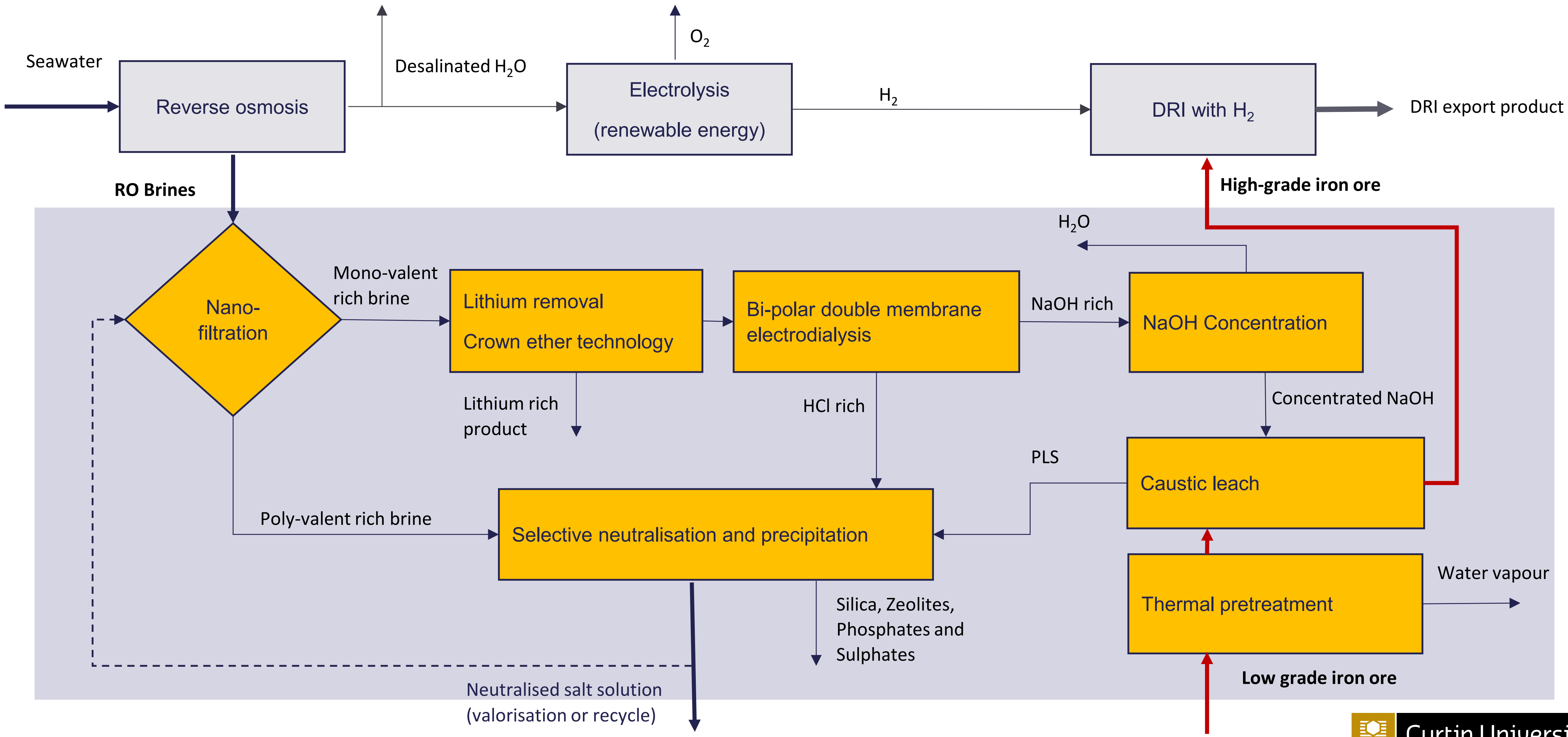
EAF-DRI(H_2)

0.025 ton CO_{2e}/t hot metal*

- DRI production with H_2 set to grow from 8 % to 24 % of global steel production by 2050 (MRIWA Green Steel report, 2023)
- Requires high grade ores, > 67 % Fe grade

*SHAHABUDDIN, 2023, FAN AND FRIEDMANN, 2021

Beneficiation solution for LGIO

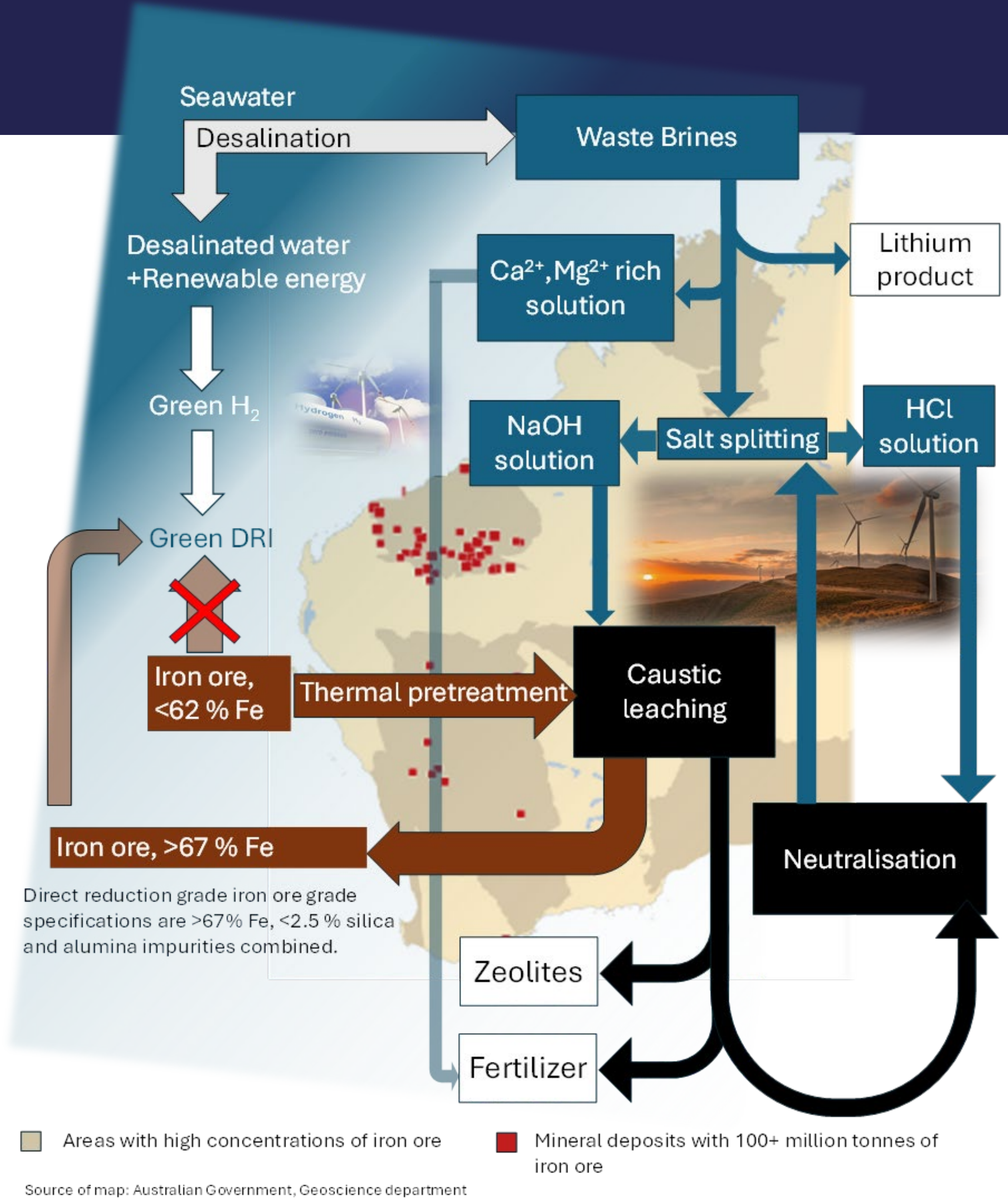


PROJECT CONCEPT

Use renewable energy & reagents from seawater desalination brines to upgrade low-grade iron ores

Support potable water production by eliminating brine disposal costs and impacts
Recover valuable by-products from brine and leachate

No need to purchase large amounts of reagents
Using what nature offers
Process development towards a Circular Economy



AIM:

PROPOSE AND DEVELOP THE FLOWSHEETS AND MASS AND ENERGY BALANCES AND CONCEPT LEVEL EQUIPMENT SIZING TOWARDS HYDROMETALLURGICAL UPGRADING OF IRON ORES

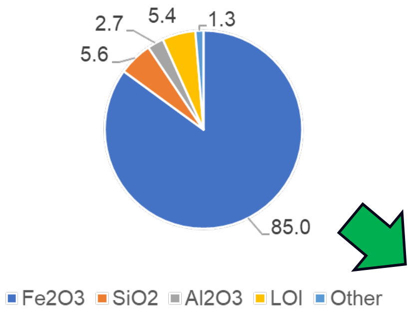
Key Activities

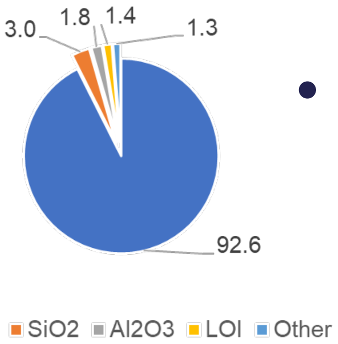
Leaching of iron ore	Reagent manufacture	By-product generation	Thermochemical and process simulation	Techno-economic evaluation
• Literature review • Initial leaching tests • Investigate process variables	• Literature review • Concept confirmation • Testing on mock brines	• Literature review • Proof of concept zeolite production • Proof of concept phosphate production	• Build a flowsheet concept • Determine initial assumptions for each unit • Mass and energy balance • Investigate alternatives	• Assign cost estimates to conceptual flowsheet • Evaluate the profitability of different flowsheet alternatives

Key Successes

Leaching of iron ore

- Literature review
- Leaching tests
- Investigate process variables





- Four of the five low-grade iron ore samples were upgraded hydrometallurgically to high-grade iron ores with calcined Fe grades above 65 %. Two of the five ores were upgraded to above 66 %.
- Thermal pretreatment was shown to change goethite mineralisation into hematite for both projects. The hematite is stable during leaching providing a low LOI hematite-rich product.
- Silica and alumina removal during leaching appears to be increased by fast thermal pretreatment (RP1.08), while conventional thermal pretreatment at around 15 °C/min appears to reduce the removal of these impurities.
- The behaviour of phosphorous and alumina is dependent on the ore sample mineralogy and may vary significantly.
- Calcined Fe grades above 65 % were obtained using a lower caustic concentration of 1.5 M NaOH rather than 5 M.
- Long residence times in the leach reactor at high temperatures and with high NaOH concentrations promote the re-precipitation of alumina silicates and shorter leach times have shown better results.

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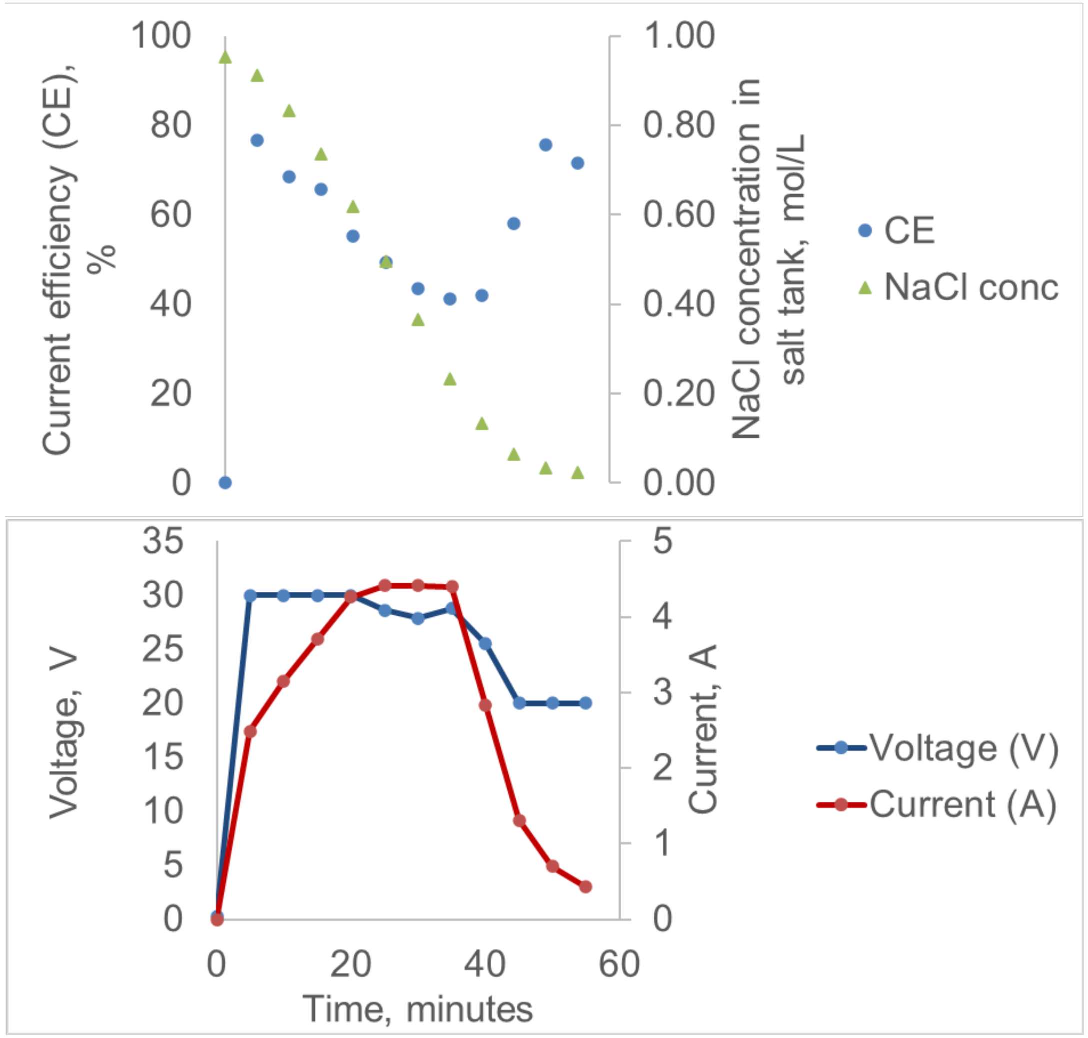
Key Successes

Reagent manufacture

- Literature review ✓
- Concept confirmation ✓
- Testing on mock brines ✓

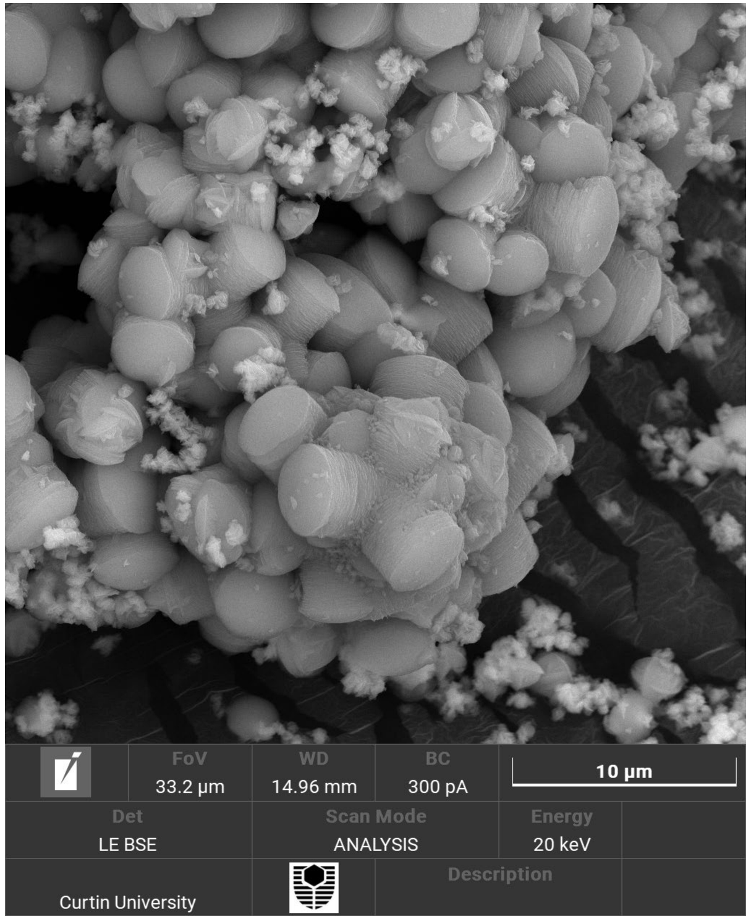


Key Successes

Experimental setup for zeolite crystallization process.

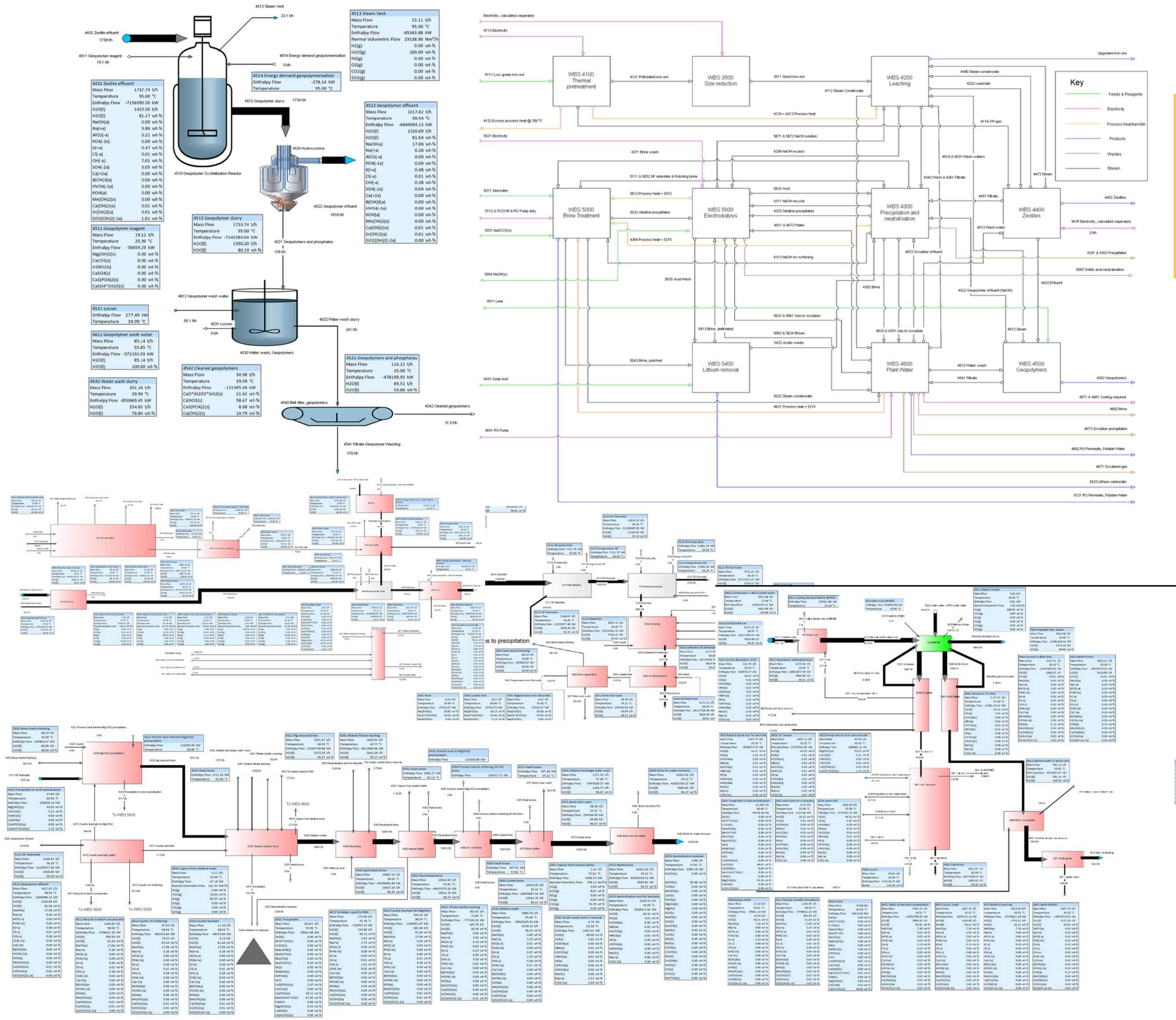
By-product generation

- Literature review ✓
- Proof of concept zeolite production ✓
- Proof of concept phosphate production



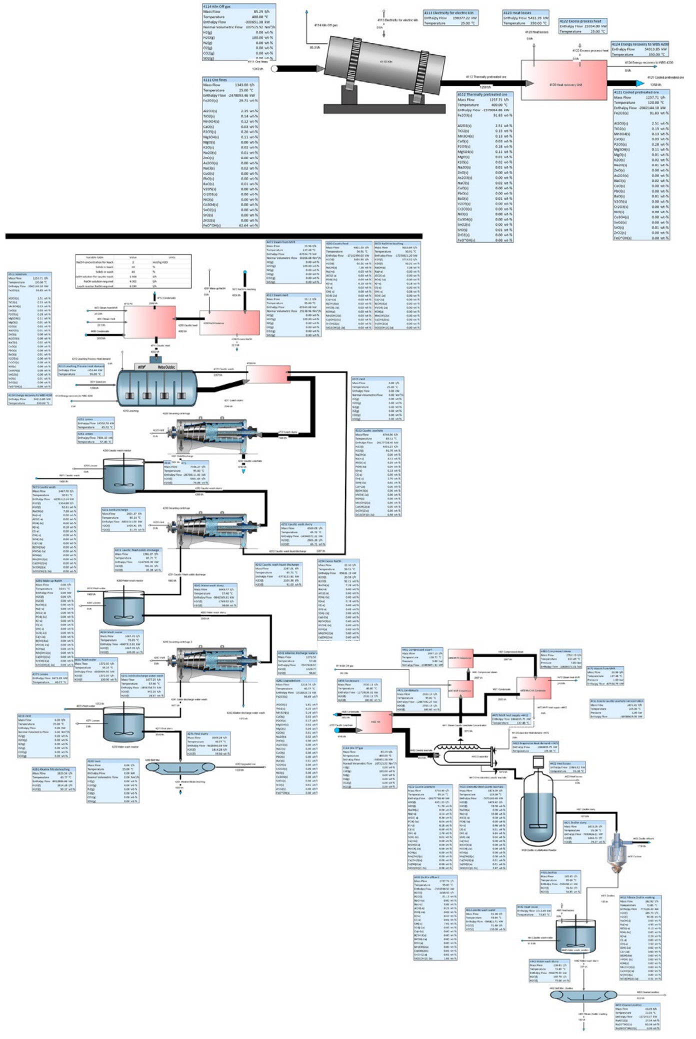
Zeolite crystals from caustic leachate

Key Successes



Thermochemical and process simulation

- Build a flowsheet concept ✓
- Determine initial assumptions for each unit ✓
- Mass and energy balance ✓
- Investigate alternatives ✓



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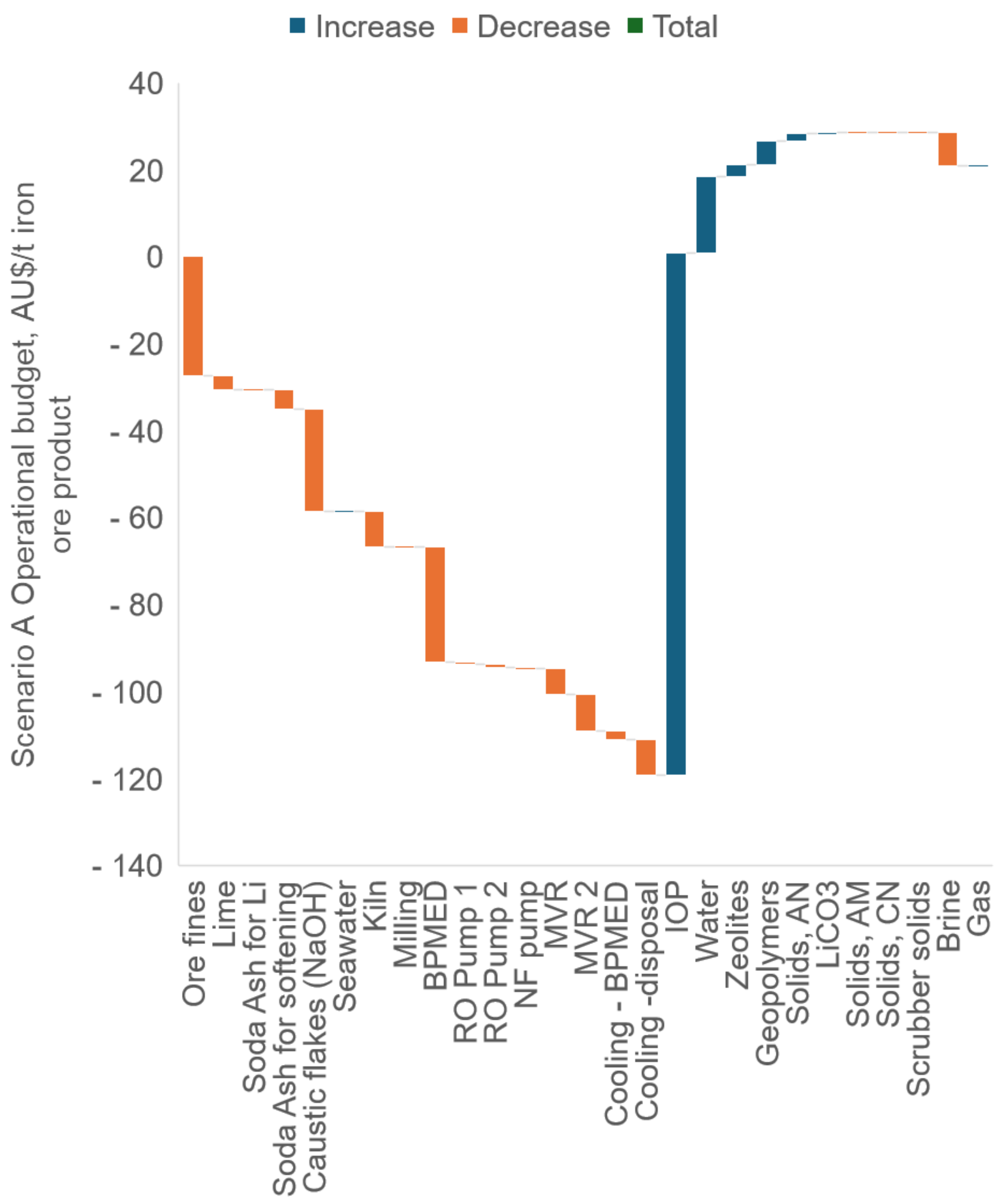
Key Successes

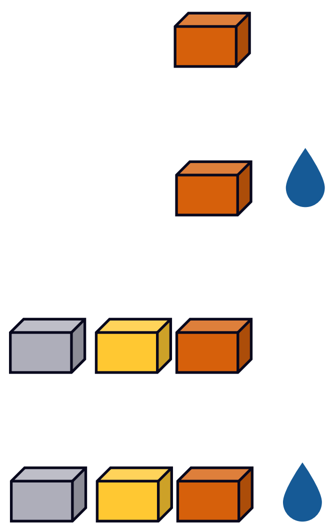


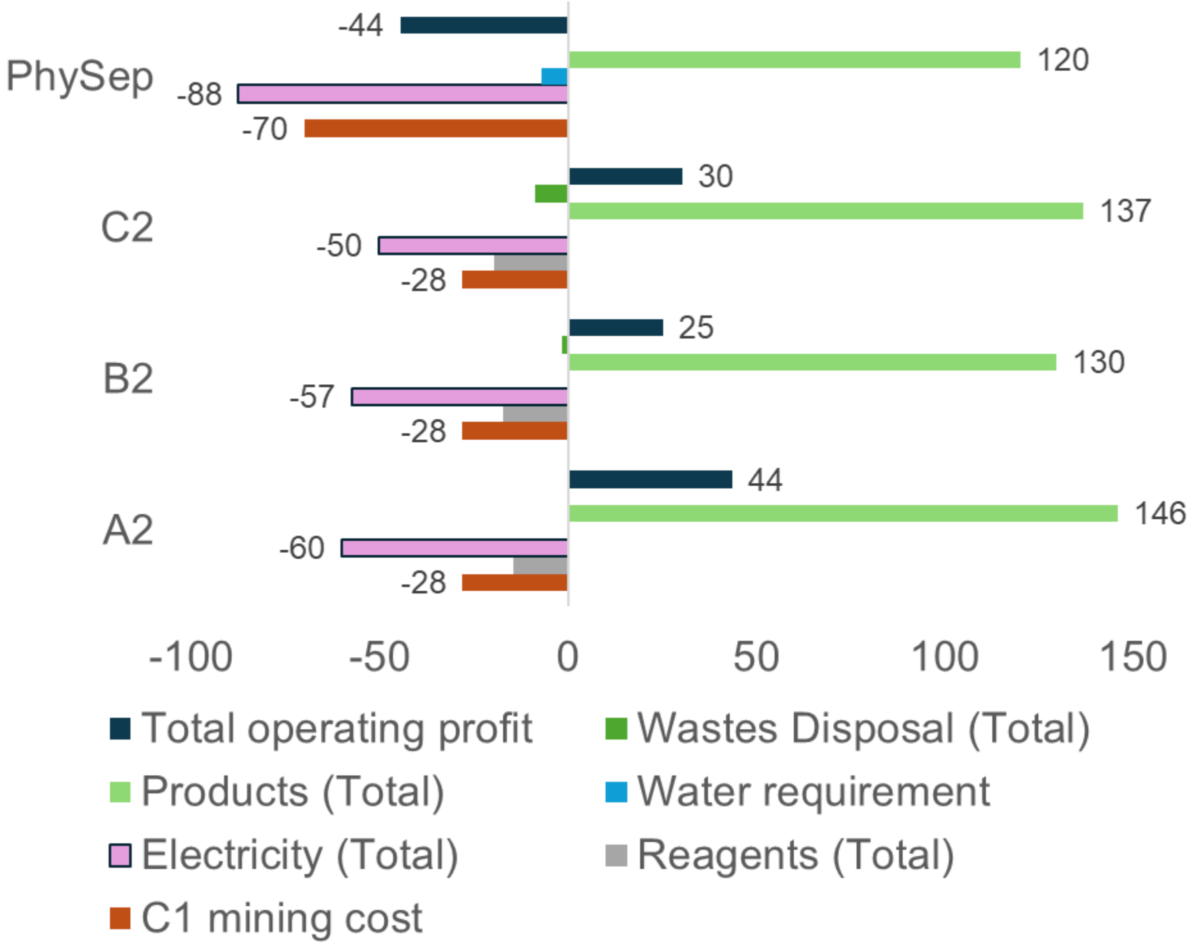
The main costs for the process across all three scenarios investigated are the cost of iron ore, the cost of NaOH to neutralise acid and the cost of electricity for salt splitting. To minimise these costs, the following steps are proposed:

- Investigating substitution or blending of iron ore tailings with low-grade run-of-mine ores.
- Substituting $Ca(OH)_2$ for NaOH to neutralise excess acid
- Obtaining more data on the electricity consumption of salt splitting and optimising operating conditions to minimise electricity consumption.

Key Successes

Main products





Operating budget in AU$/t IOP breakdown for different scenarios using $Ca(OH)_2$ for neutralising excess acid

Techno-economic evaluation

- Assign cost estimates to conceptual flowsheet
- Evaluate the profitability of different flowsheet alternatives

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STEPS TO DE-RISK AND ADVANCE CONCEPT, RP1.011-ARENA

3 - year research program

2 – year commercialisation phase

Lab and mini-plant experiments

Confirm operating windows

Partial integration testing

Build skills in relevant topics

Flow sheet optimisation and techno-economic assessments

Early identification of risks

Direct research to critical aspects

Costing of pilot plant

Identify relevant pilot scale or minimum feasible pilot scale

Determine cost of further development

OUTCOMES

Four out of five samples upgraded to HGIO (>65 % Fe grade, calcined)

Mass and energy balances developed for three scenarios.

Salt splitting performed in the laboratory
Zeolites produced with iron ore as the source of alumina and silica

A positive operating budget confirmed for process flowsheet

Curtin Team

C3MET

Critical Minerals, Metals and Materials for the Energy Transition

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