

Geothermal-Assisted Hydrogen Production with ORC Cogeneration from Repurposed Oil and Gas Wells in Alberta

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BACKGROUND

Alberta’s suspended oil and gas wells can be repurposed. Unused wells present an opportunity to extract geothermal energy and limit new drilling. PEM electrolysis requires a lot of electricity; therefore, the cost and carbon intensity of hydrogen are tied to electricity prices. GAHP-IR integrates geothermal heat, PEM electrolysis, and ORC cogeneration. Heat recovered from geothermal energy displaces grid electricity usage. This may reduce costs and carbon emissions associated with hydrogen production.

RESEARCH QUESTION

To what extent can geothermal heat extracted from repurposed suspended oil and gas wells reduce electricity demand and the levelized cost of green hydrogen production, while delivering benefits, compared with conventional PEM electrolysis?

OBJECTIVES

- Evaluate the geothermal potential of suspended oil and gas wells.
- Develop an integrated system, a geothermal-PEM-ORC system, through the GAHP-IR Model.
- Determine reductions in specific electricity consumption for geothermal temperature cases for best-performing scenarios.
- Determine LCOH through each scenario using representative Alberta electricity prices.
- Conduct a sensitivity analysis (one parameter at a time) for the most influential cost drivers across the input parameters.

METHODOLOGY

GAHP-IR FRAMEWORK ASSESSMENT & DECISION-SUPPORT WORKFLOW		
1. Resource & Infrastructure Assessment Candidate suspended well & site data	2. Geothermal Resource Assessment Estimate geothermal temperature and resource potential	3. Temperature Classification 90 °C/120 °C/ 150 °C
4. Geothermal Integration & Hydrogen Production Thermal integration, ORC (where applicable, PEM, compression)	5. Technical Performance Net grid electricity demand (kWh/kg H ₂), Energy efficiency, System Output	6. Integrated Assessment TEA LCOH (CAD/kg H ₂) Costs, cash flow, economic indicators Scenario comparison
7. Environmental Assessment Carbon Intensity (kg CO ₂ e/kg H ₂) Cradle-to-gate assessment Environmental benefits	8. Sensitivity Analysis Identify key drivers and uncertainties Evaluate impact of parameter variations Assess robustness of results	9. Decision Support Output Scenario comparison GAHP-IR feasibility decision Prioritize next steps

GHAP-IR Feasibility Decision
Identify the optimal integration strategy and quantify technical, economic, and environmental benefits to support investment and development decisions

LIMITATIONS

- Steady-state modeling, no field-scale pilot validation
- Used representative geothermal temperatures and published or assumed cost data
- LCA Boundary: Used cradle-to-gate, excluding hydrogen storage, transportation, distribution, and end use.
- Well integrity, site-specific geology, permitting, and detailed ORC design were not verified for a specific site.

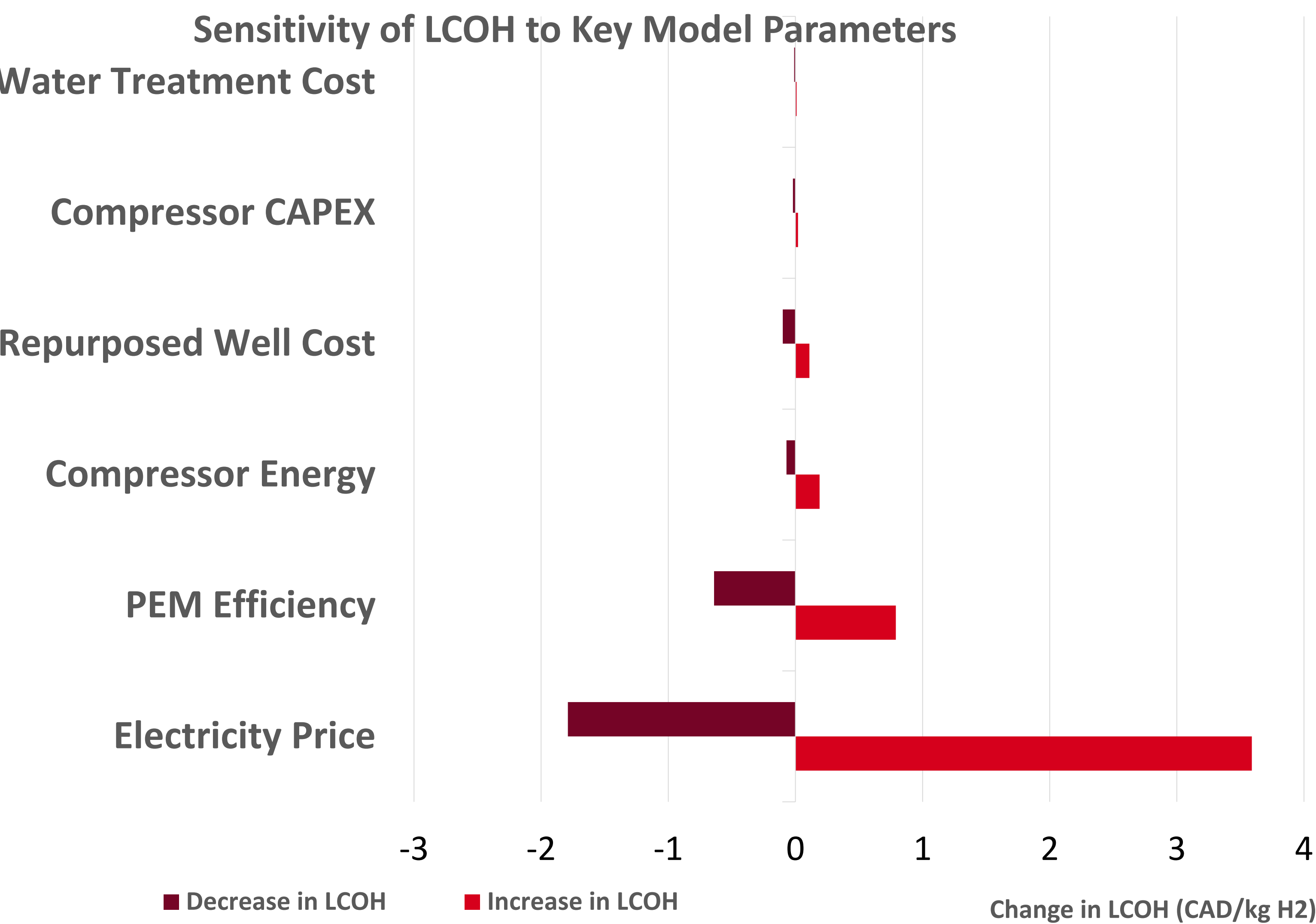
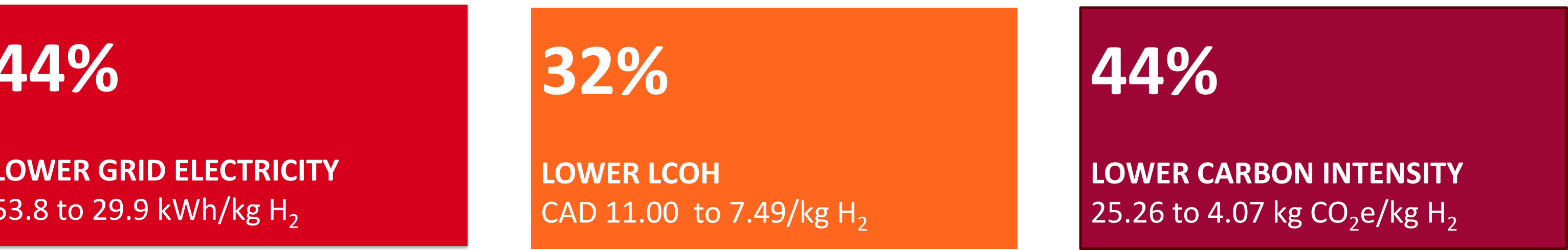
RECOMMENDATIONS

- Conduct site-specific screening, targeting suspended wells with available resources greater than 120 °C
- Demonstrate GAHP-IR with detailed reservoir and ORC modeling, followed by pilot-scale testing
- Expand LCA and commercial assessment with field-measured data and project-specific data
- Optimize key cost drivers including electricity price, PEM efficiency, and ORC performance

SDGs APPROACH



RESULTS



Key Takeaway: Electricity price dominates LCOH sensitivity, followed by PEM efficiency
Reference LCOH: CAD 7.49/kg H₂ (150 °C scenario)

KEY MODEL ASSUMPTIONS

- GEOTHERMAL RESOURCE: 90. 120. 150 °C (Representative operating temperatures)
- PEM ELECTROLYZER: 100 kg H₂/h (65% efficiency)- Design production capacity
- PLANT OPERATION: (85% capacity factor)- Annual operating availability
- ECONOMIC BASIS: 20- year life, 8% discount rate (CAD 0.18/kWh electricity)- Base-case economic parameters

CONCLUSION

- GAHP-IR scales favorably at higher geothermal temperatures, especially with ORC integration
- GAHP-IR using suspended wells offers an attractive opportunity for well repurposing and decarbonized hydrogen production