Feasibility Assessment of Electro-Thermal Energy Storage Adoption in Alberta's Steam-Intensive Industries for Industrial Decarbonization

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Project Overview

- Alberta's steam-intensive industries, such as oil sands, chemical manufacturing, and pulp and paper, are critical to the province's economy but contribute significantly to greenhouse gas emissions due to their reliance on fossil fuel-based steam generation
- The provincial grid's limited transmission infrastructure has led to frequent curtailment, instances where available renewable generation is not utilized, affecting system reliability and economic returns for producers (NREL, 2014)
- Electro-Thermal Energy Storage (ETES) systems convert surplus renewable electricity into heat for steam generation.
- ETES offers potential for 90-95% emission reduction when powered by renewables.

Questions

- Which industries in Alberta rely heavily on heat or steam?
- Can ETES technically and economically replace fossil fuels in Alberta's steam-intensive industries?
- How do ETES applications align with Alberta's regulatory frameworks for emissions reduction targets and sustainability initiatives?

Interdisciplinary Aspect

- Aligns with the three foundational pillars of sustainability: energy, environment, and economy. Supports several of the United Nations Sustainable Development Goals (SDGs).
- Affordable and Clean Energy: This system facilitates the storage and utilization of surplus renewable electricity for heat generation
- Climate Action: examining how ETES systems can reduce greenhouse gas (GHG) emissions through the decoupling of industrial steam production from fossil fuel combustion when powered by low-carbon electricity, ETES systems have been shown to reduce CO_2 emissions significantly
- Industry, Innovation, and Infrastructure: Evaluate techno-economic parameters such as CAPEX and OPEX. The system is increasingly recognized as a cost-effective decarbonization pathway for industries seeking long-term operational savings and reduced exposure to fuel price volatility.

Methodology

Phase1
Literature Review
ETES technology overview
Operational principles & applications
Industry reports.

Phase 2
Data Collection
NRCan Energy Use Database
Statistics Canada (Table 25-10-0029-01)
AESO statistics.

Phase 3
Data Analysis & Modelling
Identify steam-intensive industries
Techno-economic modelling (CAPEX, OPEX, Carbon Pricing)
Policy/regulatory review & CO_2 abatement.

Results

Industry	Temperature (°C)	Pressure (bar)	Annual Steam Demand (TJ)	Technical Compatibility
Oil Sands (SAGD)	300	100	601,145	Yes
Chemical Manufacturing	250	25	65,529	Yes
Pulp & Paper	180	10	58,071	Yes

Source: Statistics Canada (2023)

ETES Technology	Max Temperature (°C)	Efficiency (%)	Storage Duration (hours)	Technology Readiness Level	Cost (US$/kWh thermal CAPEX)
Molten Salt Storage	565	85	12	9	25-70
Concrete/Rock Storage	400	98	24	7	5
Phase Change Materials	300	80	8	6	25
Thermochemical Storage	1000	75	48	4	50

***Source:* Alberta Electric System Operator (2022)**

Results (Cont'd)

Policy	Type	Impact on ETES	Carbon Price ($/tonne CO2)	Implementation Year	Status
Technology Innovation and Emissions Reduction (TIER)	Regulation	High	95	2020	Active
Renewable Electricity Program (REP)	Program	medium	0	2019	Active
Industrial Energy Efficiency Program	Program	Medium	0	2018	Active

Source: Environment and Climate Change Canada (2023)

Conclusion

- ETES can serve as a viable alternative to fossil fuel-based steam generation, contributing directly to the electrification of industrial heat
- Economically, the viability depends on the favorable electricity prices and low carbon intensity

Recommendation

- A detailed feasibility report should be conducted that will involve direct stakeholders with a real-world application.
- Support and incentivize pilot and demonstration projects for ETES in Alberta's industrial settings

References

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