Modelling Deployment of Enhanced Geothermal Systems in Western Canada

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ABSTRACT

The Cascade Institute modelled costs for developing Enhanced Geothermal Systems (EGS) to generate electricity at four nominal project locations with representative geothermal gradients in Alberta, British Columbia, the Northwest Territories, and Saskatchewan.[1] First-of-a-kind cost estimates were developed for EGS power projects targeting reservoirs at 3 km, 4 km, 5 km, and 6 km depths under present and future innovation scenarios. This study fed these estimates into Navius Research's gTech and IESD energy-economy models[2] to test EGS deployment in each province. We find that EGS can play a small but meaningful role under present policy and costs. However, with strategic innovation, EGS can play a major role as costs fall, particularly if western Canada is committed to a net-zero grid. In all cases, deployment of EGS power reduces power prices and expands gross domestic product (GDP).

BACKGROUND INFORMATION

Geothermal power harnesses the Earth's naturally occurring heat to generate baseload electricity. This heat is accessed by drilling wells into underground reservoirs and circulating water to drive turbines at the surface that create electricity.

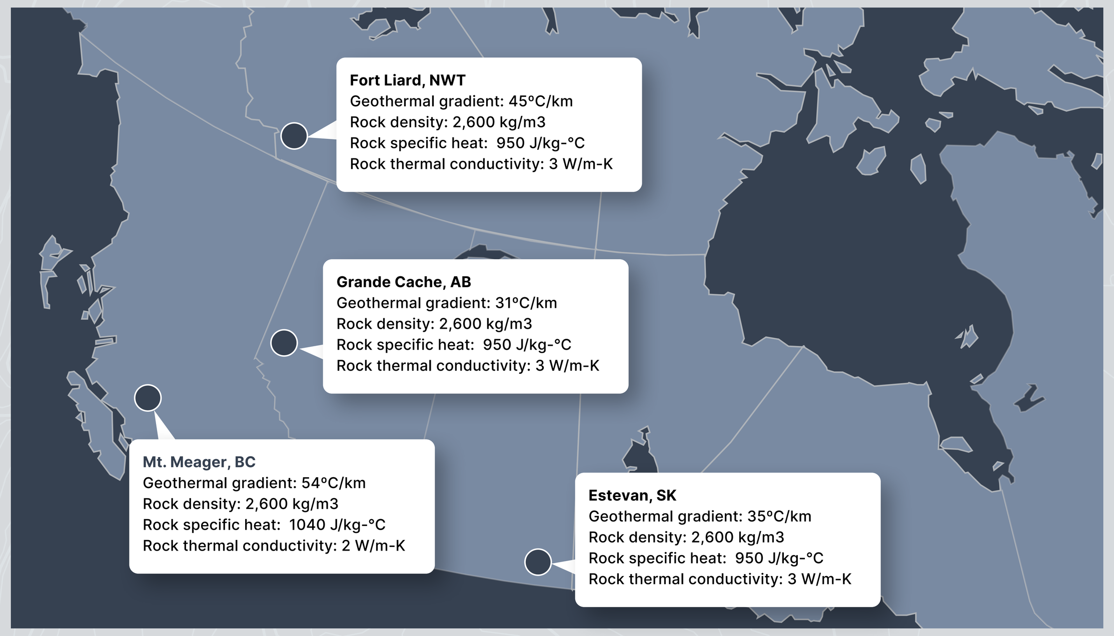
Conventional geothermal requires porous bodies of hot rock that already contain water (natural aquifers). This significantly limits the potential for deployment. However, EGS expands the potential for deployment by creating networks of fractures in the rock to enhance its natural porosity and improve the flow of water.

The potential role of conventional geothermal and EGS in Canada's energy future is poorly understood due to the site-specific nature of the resource. Subsurface conditions—such as temperature gradients, reservoir permeability, and drilling depth—vary widely from place to place. Areas with hotter geothermal gradients tend to be cheaper to develop because, if all other things are equal, these sites will produce hotter water with higher energy content.

As a result, the costs involved in developing a geothermal power project are highly variable and cannot be easily generalized by a single capex estimate. Consequently, geothermal power is underrepresented in Canadian energy models. This variability presents a challenge for modellers, energy planners, and policymakers.

This study is the first to assess the role of EGS in Canada using granular cost estimates for different sites. Key parameters for modelled EGS costs are shown below in **Figure 1**. Please refer to our *Deep Heat Advantage report*[1] for full detail on the techno-economic analysis methodology.

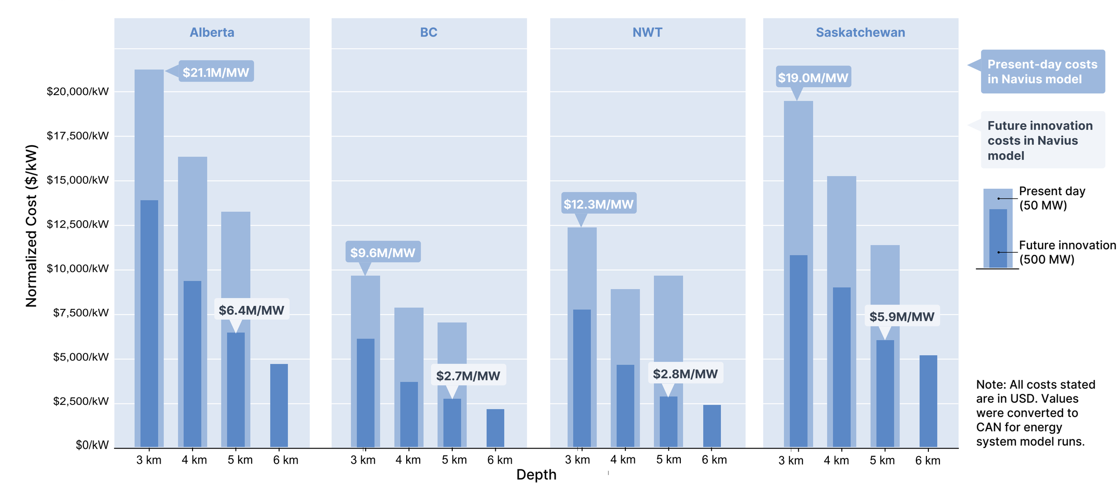
Figure 1: Locations and site characteristics of the four nominal projects in Alberta, British Columbia, the Northwest Territories, and Saskatchewan.



MODEL INPUTS

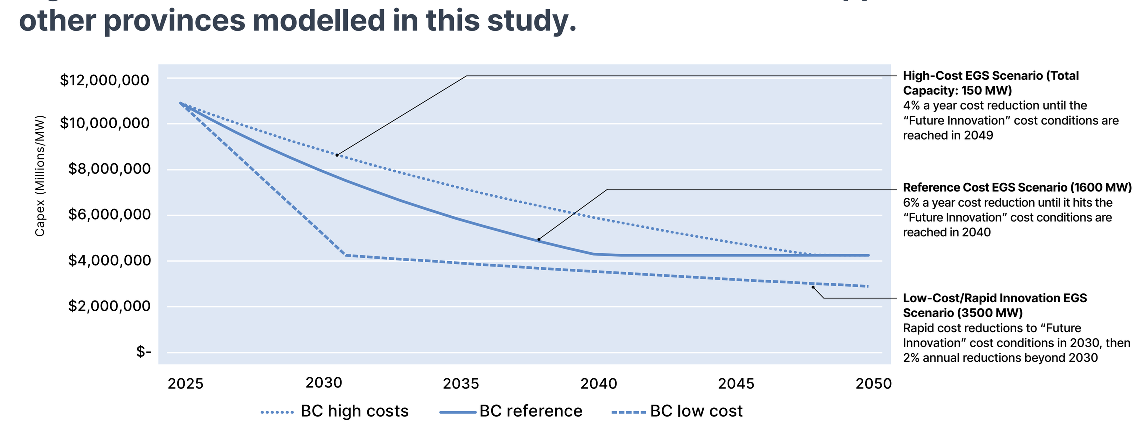
Techno-economic analysis shows that EGS development is already cost-competitive on a LCOE and $/kW basis with other forms of baseload generation. Areas with hotter geothermal gradients (BC and NWT) can be developed more inexpensively. In a *future innovation* scenario, based on progress that is already made by EGS developers in the marke$t, costs become even lower.

Figure 2: Normalized CAPEX costs for EGS project development.



EGS deployment was modelled in Navius Research gTech energy systems model under three innovation scenarios as shown for British Columbia below in **Figure 3**.

Figure 3: EGS innovation scenarios. Similar curves were applied for the other provinces modelled in this study.



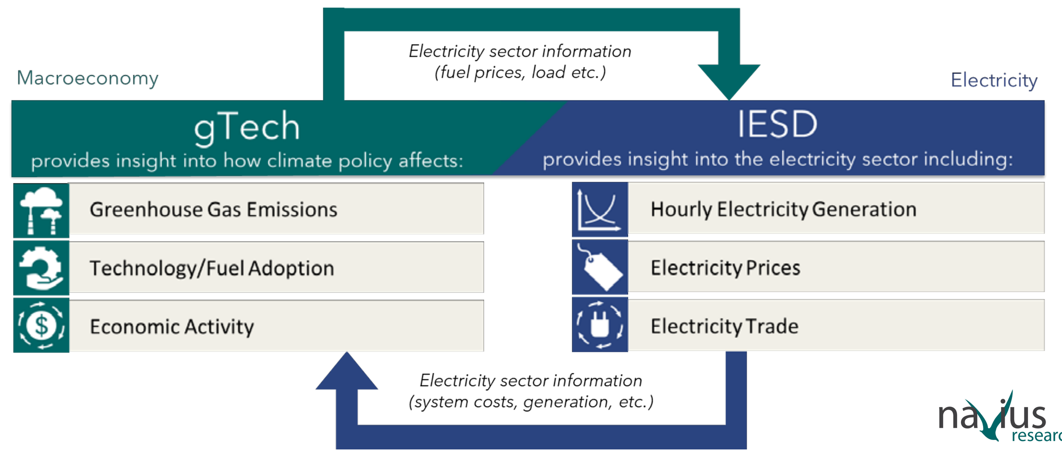
ENERGY SYSTEM MODEL

The above assumptions were used to incorporate EGS into Navius Research's two proprietary models:

- **gTech:** A computable general equilibrium (CGE) model of Canada and the United States. gTech enforces equilibrium in major markets to determine GDP, employment, trade, energy prices, and emissions.
- **Integrated Electricity Supply and Demand (IESD):** Simulates electricity systems to meet hourly electricity demand in each province. IESD simulates how EGS competes with other renewables, hydro, gas, and storage to minimize system costs.

These two models are integrated. In the integrated framework, IESD passes back electricity prices, system costs, and capacity outcomes to gTech. By iterating between the two models, we capture how improvements in EGS performance and costs reshape grid operations and, in turn, affect the broader Canadian energy system and economy.

Figure 4: Navius Research's two proprietary energy system models: gTech and ISED electricity supply module.



RESULTS

EGS installed capacity, impact on electricity prices, annual GDP, and energy mix from our analysis are shown below in **Figures 5-9**.

Figure 5: EGS installed capacity across AB, BC, NWT, and SK for high-cost, reference cost, and low-cost conditions.

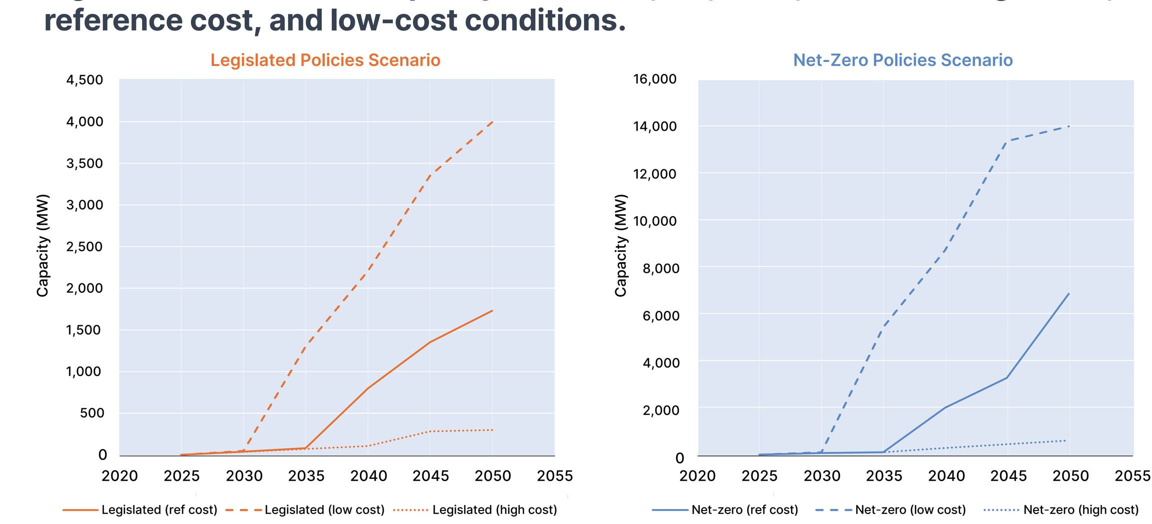


Figure 6: EGS deployment's impact on electricity prices in AB, BC, NWT, and SK.

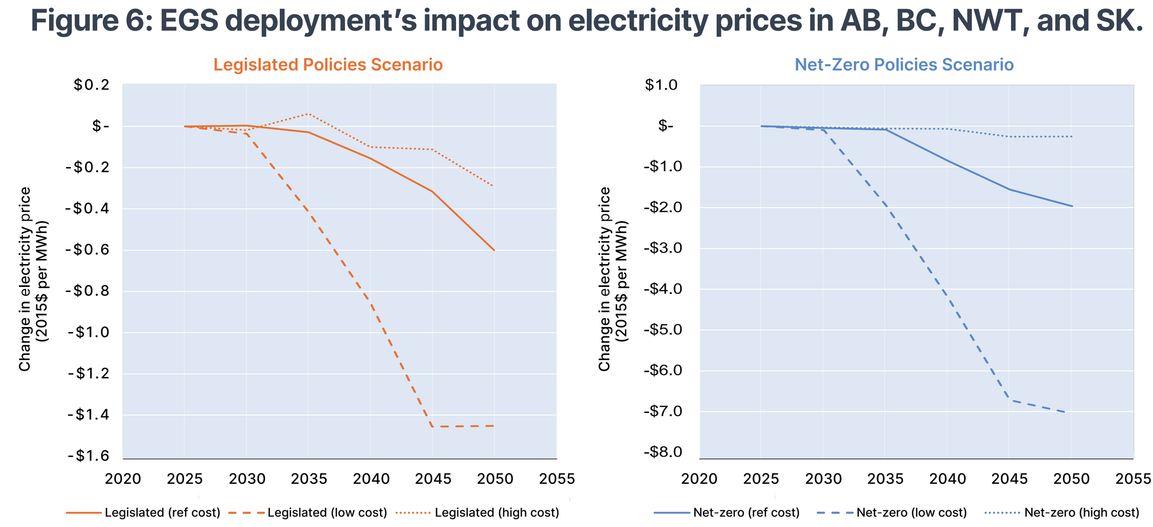


Figure 7: EGS deployment's impact on annual GDP across AB, BC, NWT, and SK.

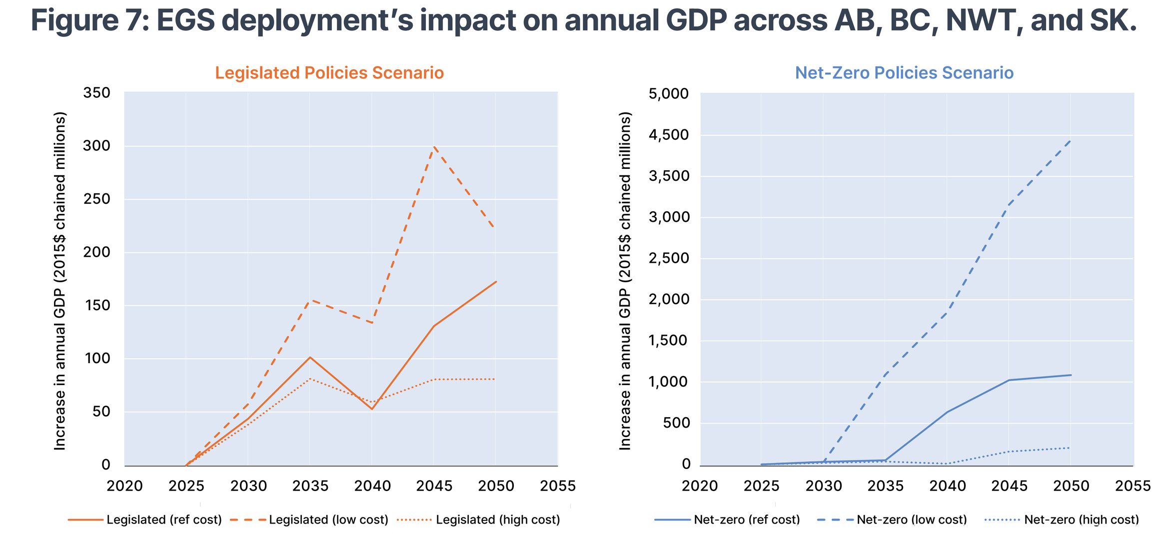


Figure 8: EGS deployment's impact on energy generation mix in 2050 across AB, BC, NWT, and SK.

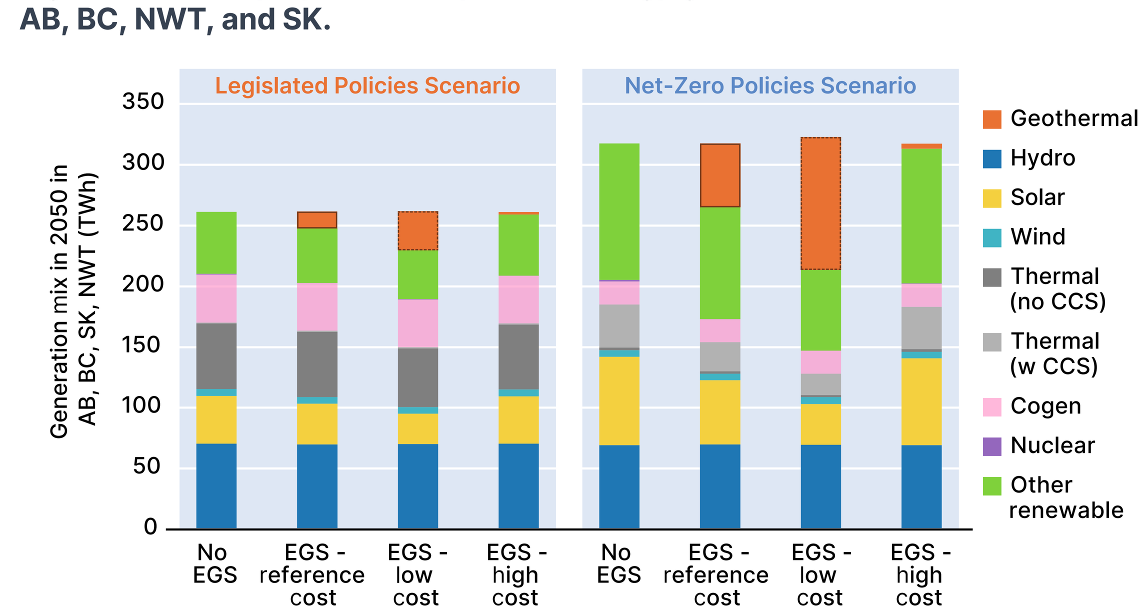
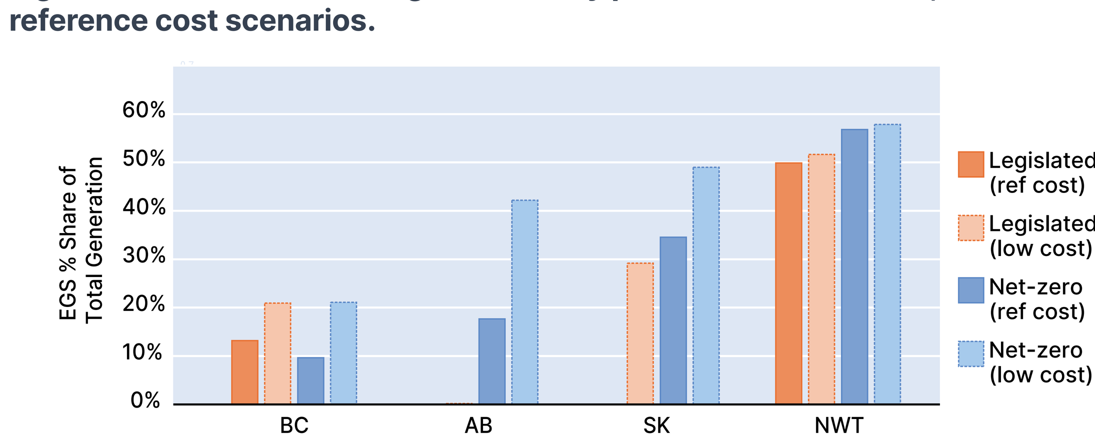


Figure 9: EGS share of total generation by province and scenario, low-cost and reference cost scenarios.



CONCLUSIONS

This study provides the first detailed assessment of the potential role of EGS in Canada. By pairing granular techno-economic modelling with Navius Research's gTech and IESD energy-economy models, we evaluate how EGS deploys under different policy and technology scenarios.

The results are compelling. Under existing conditions (current legislated policies scenario and reference cost conditions), modest deployment of EGS in western Canada produces meaningful economic value.

Under net-zero policies, the value of EGS grows considerably. With EGS acting as a source of clean baseload power, it plays a significant role in western Canada's generation mix, particularly in Alberta and Saskatchewan. This indicates EGS could provide similar value to Canada as other baseload technologies do today, such as nuclear energy in Ontario and gas in western Canada.

Collectively, these results underscore the importance of near-term investment in innovation in drilling, EGS reservoir engineering capabilities, and characterizing Canada's deep geothermal resource. Accelerating innovation to drive down costs is of particular significance. Facilities such as the U.S. Department of Energy's Frontier Observatory for Research in Geothermal Energy (FORGE) provide a template for how this can be rapidly achieved.

NEXT STEPS

1. **DEFINE RESOURCE AVAILABILITY.** Assumptions on resource potential were made using regional assessments, and do not reflect Canada's full EGS potential.
2. **IDENTIFY KEY SENSITIVITIES** such as drilling costs, plant capital, flow rates, and other key metrics to inform R&D priorities.
3. **ASSESS ADDITIONAL POLICIES** such as the Investment Tax Credit, carbon pricing, and other incentives to accelerate deployment.

Scan this code to explore the results and underlying assumptions.

References

1. Brasnett, G., Eyre, M., and Massie, P. (2025). *The Deep Heat Advantage: A techno-economic analysis of enhanced geothermal systems in western and northwestern Canada*. Cascade Institute.
2. Navius Research – Model Documentation.

The Cascade Institute sincerely appreciates the support of Navius Research in making this study possible.