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# The potential for test centres to accelerate Canadian geothermal innovation

Peter Massie*, Guy Brodsky and Emily Smejkal
Cascade Institute
massie@cascadeinstitute.org

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## INTRODUCTION

Canada faces the challenge of simultaneously achieving a step-change in productivity while accelerating decarbonization. This is particularly challenging for a net energy exporter, but Canada's subsurface engineering expertise can play a key role, as that expertise is directly transferable to geothermal power development. Simultaneously boosting productivity while reducing carbon emissions will require a robust industrial strategy, with a focus on innovation. Test centres are a proven, effective policy tool to overcome scale-up failures in capital-intensive, high-uncertainty resource industries.

A prominent example is the Alberta Oil Sands Technology and Research Authority (AOSTRA), which enabled the demonstration and early commercialization of steam-assisted gravity drainage (SAGD) in the oil and gas sector (Alberta Oil Sands Technology and Research Authority, 1990). Similarly, publicly supported basin-based test sites under the U.S. Department of Energy—including the Eastern Gas Shales Project (EGSP) and Western Gas Sands Project (WGSP)—produced an integrated toolkit of horizontal drilling, multi-stage fracturing, microseismic imaging, and resource-characterization methods that decades later underpinned the unconventional gas boom (Datta & Amarnath, 2023; Golden & Wiseman, 2015; Ong, 2019).

Test centres have already proved effective in driving geothermal innovation. The Frontier Observatory for Research in Geothermal Energy (FORGE) has drilled paired wells, executed a multi-stage stimulation in crystalline rock, confirmed inter-well connectivity, and conducted circulation testing supported by microseismic, fiber-optic, and tracer datasets—all publicly released (*Geothermal Data Repository (GDR)*, n.d.; Geothermal Technolgies Office - Department of Energy, 2023). A modern, local analogue further strengthens this case: Alberta's Natural Gas Innovation Fund (NGIF) Emissions Testing Centre. The Emissions Test Centre offers free-to-user laboratory testing, controlled-environment evaluation, and in-field validation of methane-measurement and mitigation technologies.

Taken together, these precedents illustrate that a national Geothermal Energy Observatory and Science and Technology Research Authority (GEOSTRA) could serve as Canada's test centre backbone. The remainder of this paper presents methods and results separately, highlighting cross-case insights and implications for the development and implementation of GEOSTRA.

## 1 METHODS

This study applies a comparative case-study methodology to four test centre archetypes relevant to subsurface and clean-energy innovation:

1. AOSTRA;
2. United States Department of Energy (DOE)'s EGSP/WGSP unconventional gas test sites;
3. Utah FORGE; and
4. Alberta's NGIF Emissions Testing Centre.

Data sources include publicly available program documentation, evaluation reports, regulatory datasets, technical proceedings, and openly published field-monitoring datasets.

Information extracted across cases includes governance structures, cost-share models, data-generation protocols, field-test architectures, instrumentation practices, and quantitative outcome metrics (e.g., production rates, reservoir performance, technology uptake). Analytical comparison focuses on three questions:

- how each test centre shifted technical feasibility,
- the degree to which testing infrastructure crowded in private investment, and
- how knowledge-diffusion mechanisms accelerated sectoral learning.

## 2 RESULTS

### 2.1 AOSTRA: A sustained, mission-driven test-centre model enabling large-scale resource unlocking

The Alberta Oil Sands Technology and Research Authority (AOSTRA) demonstrated how a test-centre model can unlock a capital-intensive, high-uncertainty subsurface resource. Over its lifetime, AOSTRA invested more than $620 million in nominal dollars and coordinated roughly equivalent industry cost-sharing, making it one of the largest technology-development programs in Canadian history (Wiggins, 2009).

In particular, AOSTRA's Underground Test Facility provided a platform for testing horizontal well pairs and the steam-assisted gravity drainage (SAGD) recovery method that de-risked in situ oil sands operations. SAGD existed prior to AOSTRA, but industry failed to develop and deploy the technology due to the perceived risk. Because the Underground Test Facility was constructed and operated as a research site rather than a commercial project, researchers and operators could experiment with drilling geometries, completion configurations, steam distribution strategies, and instrumentation protocols that would have been prohibitively risky or costly for the private sector to pursue alone (Smejkal et al., 2025).

AOSTRA's systematic, staged testing approach directly unlocked the resource base. In situ production grew from nearly zero in the late 1980s to more than 1.8 million barrels per day today, generating billions in royalty revenues and catalyzing a globally significant extraction industry (Alberta Energy Regulator, 2024).

Importantly, AOSTRA provided an organizational structure for companies to collaborate on emerging technologies, while protecting existing intellectual property. Its governance framework—which combined public mission clarity, industry co-investment, embedded technical expertise, and an IP model that enabled sector-wide diffusion—provides a clear institutional precedent for geothermal. Member firms shared the costs and risks of developing new innovations, and the resulting IP was licensed to member firms for a nominal fee (Alberta Oil Sands Technology and Research Authority, 1990). Like geothermal, oil sands extraction required innovation across drilling, completions, reservoir management, and surface-facility integration under conditions of high uncertainty. AOSTRA shows how a long-term test-centre mandate can shorten technology learning curves, reduce investment risk, and create the enabling environment for large-scale private deployment (Smejkal et al., 2025).

### 2.2 EGSP/WGSP: Basin-specific subsurface experimentation enabling unconventional gas technologies

The U.S. Department of Energy's Eastern Gas Shales Project (EGSP) and Western Gas Sands Project (WGSP) illustrate the power of basin-specific test centres to de-risk subsurface technologies. Launched in 1976 and 1978 respectively, both programs were structured around a shared recognition that unconventional gas resources—though potentially vast—could not be unlocked without deliberate, place-based research.

The EGSP and WGSP addressed a fundamental market failure: unconventional gas formations existed in tight, low-permeability rock where extraction technology could not produce at sufficient scale to justify private investment. Hydraulic fracturing had been technically possible since the 1920s, but what the industry lacked was not the ability to fracture rock—it was the geological understanding needed to fracture it effectively. Both programs attacked this gap through multi-well experimental pads, coordinated coring and logging, and new diagnostic tools—including 3D microseismic imaging developed by Sandia at the MWX Site near Rifle, Colorado, and electromagnetic measurement-while-drilling proved out in the EGSP—that have since become industry standards. Analysis of closely spaced offset wells revealed that horizontal drilling would expose significantly more producible fractures than vertical wells, the critical geological insight underpinning what followed. A pivotal 1986 horizontal well test in West Virginia demonstrated a three-fold production improvement and established multi-stage fracturing along a horizontal section as the template for all subsequent unconventional development (Ong, 2019).

The programs co-invested alongside industry rather than displacing it. Cost-shared stimulation trials engaged Mitchell Energy, Columbia Gas Systems, Halliburton, and Schlumberger in experiments they would not have financed independently. The Gas Research Institute—funded by a levy on interstate gas transactions—served as the primary co-investment vehicle, coordinating with the DOE through semi-annual meetings to align research with commercialization. As DOE early-stage funding declined, the Gas Research Institute assumed the lead in demonstration funding, ensuring continuity across the technology readiness spectrum. Production tax credits further de-risked deployment until unsubsidized production became economical (Leveille, 2026).

Technical meetings and proceedings disseminated results to operators, academics, and service companies, accelerating industry-wide learning (Datta & Amarnath, 2023; Golden & Wiseman, 2015). The long-run impact of

the EGSP/WGSP test-centre model becomes evident when evaluating how these publicly coordinated datasets, drilling experiments, and completions trials established the template for later private-sector breakthroughs. The unconventional gas boom succeeded because operators were able to build directly on openly disseminated technical knowledge—much of which originated in DOE-run test centres—allowing firms to shorten drilling and completion learning cycles and scale production much faster than would otherwise have been possible. This suggests that similarly early-stage, basin-specific testing and open data sharing will be essential for accelerating enhanced geothermal development (Leveille, 2026).

Decades after the DOE's basin-based programs generated standardized field data, characterized stress regimes, and validated directional drilling and staged stimulation, the United States experienced an unprecedented expansion of unconventional production—from roughly 200 Tcf of proved gas reserves in 1980 to more than 691 Tcf by 2022, with unconventional output exceeding 80 Bcf/d by 2024 (Datta & Amarnath, 2023). These outcomes reflect a learning-curve dynamic in which early public demonstration dramatically reduces the cost, risk, and uncertainty borne by later commercial developers.

### 2.3 Frontier Observatory for Research in Geothermal Energy (FORGE)

Utah FORGE has not only demonstrated stimulation-driven reservoir creation and inter-well connectivity; it has also played a foundational role in improving modern high-temperature drilling performance in hard crystalline rock. Drilling at FORGE proved step-change improvements in drilling efficiency, including increased rates of penetration, deployment of advanced drilling technologies, and real-time fiber-optic diagnostics that materially accelerated drilling learning rates. These improvements occurred while drilling the highly deviated 16B well, and they reflect FORGE's ability to serve as a controlled environment for testing and validating drilling innovations in deep, hot granite (McClennan, J., England, K., and Swearingen, L., 2024; McLennan et al., 2025).

Fervo Energy's results at Cape Station illustrate the spillover effect of FORGE's de-risking. In 2024, Fervo reported that drilling rates along horizontal laterals improved from 39.4 ft/hr in early wells to 64.2 ft/hr in later wells, with the fastest well drilled from spud to total depth in only 20–21 days (International Energy Agency, 2026b). These improvements occurred in deeper, hotter granite than FORGE's wells and reflect how FORGE's drilling and geomechanical datasets supported private developers in refining bit design, BHA selection, mud programs, and steering strategies (**Fehler! Verweisquelle konnte nicht gefunden werden.**) (Fervo Energy, 2024a; International Energy Agency, 2026a). Fervo also demonstrated record-setting enhanced geothermal performance—flow rates exceeding 95–107 kg/s—supported by multi-stage plug-and-perf completions and reservoir-monitoring techniques first validated at FORGE (Fervo Energy, 2024b). The pairing of public-sector de-risking (FORGE) and private-sector scaling (Fervo) offers a direct analog for how GEOSTRA could accelerate geothermal deployment in Canada.

Fervo's commercial success has attracted substantial private capital, demonstrating the crowding-in effect of FORGE's public de-risking. Since bringing its first commercial enhanced geothermal project online in Nevada in 2023, Fervo has raised approximately $1.5 billion in total capital (Sika), including a $244 million Series D funding round led by Devon Energy (Fervo Energy) and an oversubscribed $462 million Series E funding round that attracted investors including Google, Breakthrough Energy Ventures, and CPP Investments (Fervo Energy). This trajectory illustrates how publicly funded test centre infrastructure can catalyze large-scale private capital formation in nascent energy sectors.

### 2.4 NGIF Emissions Testing Centre: A contemporary Alberta example of rapid technology validation

The NGIF Emissions Testing Centre provides a modern Alberta example of how test-center infrastructure accelerates commercialization. The Emissions Testing Centre combines controlled-environment laboratory testing at the University of Calgary with real-world validation at fully instrumented operating facilities such as the West Wolf Lake Gas Plant and CREEW methane-monitoring sites. The test centre supports startups and established technology developers by offering free-to-user access, rapid apparatus fabrication, environmental simulation (–40 °C to +80 °C), and hands-on engineering support, enabling innovators to iterate quickly on methane measurement, detection, and mitigation technologies. (*Natural Gas Innovation Fund*, n.d.).

Since its 2021 launch, the Emissions Testing Centre has received more than $11 million in initial federal/provincial support and an additional $15 million commitment for ongoing operations. More than 70 companies have participated, contributing to Alberta exceeding its methane reduction target (45% below 2014 levels) three years early, achieving a 52% reduction by 2023 (C. E. C. Staff, 2025). The Emissions Testing Centre's combination of controlled laboratory evaluation, field-testing at live industrial sites, and commercialization support demonstrates exactly the kind of integrated, measurement-rich testing ecosystem needed for

geothermal: it lowers adoption barriers, standardizes performance data, and helps regulators, investors, and operators build confidence in emerging technologies.

## 3 DISCUSSION: IMPLICATION FOR A CANADIAN GEOTHERMAL TEST CENTRE

Several cross-case themes emerge.

First, enduring mission clarity and continuous funding—exemplified by AOSTRA and FORGE—are essential for enabling long-horizon subsurface technology development (Ough, 2025; Smejkal et al., 2025). A clear mandate is essential to focus scarce resources and demonstrate progress against a limited number of priority barriers. For example, AOSTRA was mandated to focus on the economic viability of oil sands resources too deep to mine conventionally.

Second, place-specific, in situ testing is indispensable for characterizing geological variability and reducing commercial uncertainty, as demonstrated in both the DOE's basin-based unconventional gas programs and FORGE (Datta & Amarnath, 2023; Ough, 2025). This is essential in the subsurface for two key reasons. First, subsurface technology performance is highly dependent on geologic formations, which can vary significantly across regions. Second, there is a fixed cost associated with the infrastructure needed. A single well can cost upwards of $10M, which is prohibitive for pre-revenue firms. Public infrastructure addresses this barrier to entry and crowds-in investment.

Third, open data and coordinated knowledge-sharing substantially accelerate sectoral learning, as shown by DOE's regular technical meetings and FORGE's public repository (Datta & Amarnath, 2023; *Geothermal Data Repository (GDR)*, n.d.; Leveille, 2026; Ough, 2025). This accelerates the uptake of innovative spillovers, and facilitates replications in similar geologic formations, as per Mitchell Energy.

Fourth, cost-sharing and balanced IP frameworks can attract private participation while ensuring broad societal benefit (Smejkal et al., 2025). These frameworks must incentivize participation by balancing protection of a firm's existing IP and sharing in new IP being developed. Test centre organizers must ensure IP frameworks are tailored, and reflect the context of the nation, industry structure, and technology. There is no one-size-fits-all approach.

Finally, the NGIF Emissions Testing Centre example underscores that Canada already possesses the institutional capacity and cultural familiarity required to operate modern, measurement-rich test centres that accelerate commercialization and address policy priorities. The Emissions Testing Centre's demonstrated contribution to methane-reduction outcomes shows how measurement-driven innovation programs can achieve quantifiable environmental impact—an important signal for the design of GEOSTRA (C. E. C. Staff, 2025).

## 4 CONCLUSIONS

Across AOSTRA, DOE's unconventional gas test programs, Utah FORGE, and the NGIF Emissions Testing Centre, test centres have repeatedly proven capable of:

- advancing technical frontiers,
- catalyzing private-sector investment, and
- accelerating learning through open data and coordinated demonstration.

A GEOSTRA modeled on these precedents—particularly FORGE's open-data discipline and the Emissions Testing Centre's integrated lab–field validation architecture—would embody the most effective pathway to accelerating geothermal deployment in Canada.

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