EXECUTIVE SUMMARY

Canada faces a decisive moment. For decades, the country has struggled with a chronic productivity gap and flagging innovation performance. Meanwhile, global competitors are moving aggressively to new markets through coordinated policies, bold investments, and strong public-private collaboration. If Canada is to thrive in this new era of competition, it must re-invent its approach to industrial policy and adopt one that aligns national strengths with global opportunities. Geothermal power provides the perfect place to start.

Canada has all the right ingredients for a successful geothermal industrial policy: an immense geothermal resource that far exceeds domestic demand, the significant drilling capacity honed by a world-class oil and gas sector, and a nascent but growing geothermal sector already demonstrating global leadership. With smart policies and investments, Canada can galvanize these assets to build a globally competitive geothermal energy sector while enhancing energy security and reducing emissions at home.

The linchpin is innovation. Next-generation geothermal technologies can unlock vast new energy potential, but cost and performance improvements are essential.

Canada has a proven model for tackling this kind of challenge: test centres. Pioneered by the Alberta Oil Sands Technology and Research Authority (AOSTRA)[1], test centres provide a platform to drive collaborative R&D that reduces costs and improves performance. A Geothermal Science and Technology Research Authority (GEOSTRA)[2] would deliver this capability with a series of test sites.

Yet test centres alone are not enough. A comprehensive policy suite is needed to translate innovation into scale. A Canadian Geothermal Roadmap can chart the path towards a policy framework that catalyzes the productivity gains Canada desperately needs while showcasing a new paradigm for industrial policy.

The stakes are high. Canada's competitors are racing ahead. But by seizing the geothermal opportunity today, Canada can reinvigorate its industrial strategy,

[1] Smejkal, E.; Massie, P.; Gall, L. (2025). *AOSTRA: A model for funding geothermal innovation*. Cascade Institute. https://cascadeinstitute.org/technical-paper/aostra/

[2] *GEOSTRA: Proposal for the establishment of a geothermal science and technology research authority (GEOSTRA)*. Cascade Institute. https://cascadeinstitute.org/geostra/

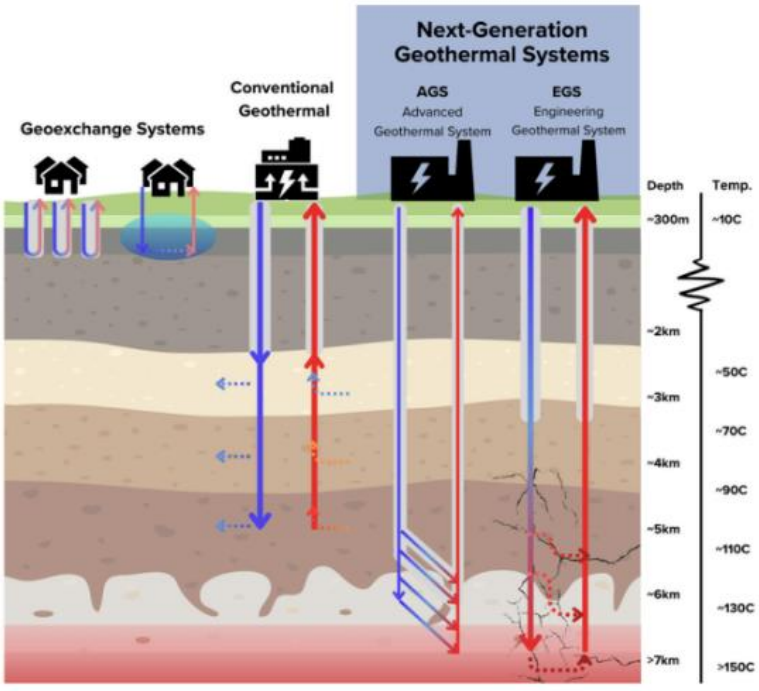
rebuild its innovation advantage, and position itself as a global leader in energy security and emissions reductions.

WHAT IS GEOTHERMAL ENERGY?

Geothermal energy is heat generated from deep within the Earth. This energy can be used at the surface directly for heating, or converted into electricity, known as geothermal *power.* Greater depths offer access to more heat in the form of higher temperatures. Regardless of the temperature and depth, geothermal energy is harnessed by drilling into the Earth to capture heat by circulating fluid. However, there are a variety of ways this can be done:

Geoexchange systems use shallow wells to provide heat and cooling to homes, businesses, and communities. Also known as ground source heat pumps, these systems can be installed almost anywhere in Canada south of the permafrost line. Geoexchange technologies are mature and have even been installed in Parliament Hill's Centre Block.

Conventional geothermal (hydrothermal) drills much deeper to circulate fluid through a naturally occurring body of porous rock (aquifer). Depending on the temperature, conventional geothermal can produce heat, power, or both. Hydrothermal is mature, and examples include the Geysers (United States), Hellisheidi (Iceland), and Larderello (Italy).



Next-generation geothermal uses engineered pathways to circulate a fluid. Advanced Geothermal Systems (AGS) circulate water through wells that form a closed loop, like a radiator. Enhanced (or Engineered) Geothermal Systems (EGS) use open networks of fractures between wells. With innovation, these systems can eventually be installed anywhere. Both AGS and

EGS have been demonstrated, but additional innovation is required. Examples include Eavor, the world-leading Canadian AGS company, and Fervo (EGS).

Superhot rock geothermal proposes to access temperatures greater than 375 °C. At these super-critical temperatures, geothermal wells produce 5-10 times more energy. These systems require significant innovation. No commercial facilities exist, but the proposed Krafla Magma Testbed in Iceland seeks to act as a test bed for this emerging technology.

WHY GEOTHERMAL POWER?

Geothermal power lies at the nexus of conventional and clean energy, and supports both energy security and continued progress on emissions reductions. Furthermore, it has the potential to unite Canadians and leverage regional strengths.

Geothermal power is:

Abundant: Geothermal energy is nearly unlimited. The International Energy Agency estimates there are 600 TW of technical potential,[3] or more than sixty times the global installed generating capacity. Conservatively, 800 GW could be cost-effective with continued innovation by 2050, meeting 15 percent of total growth in world electricity demand.

Reliable: Geothermal provides 24/7 baseload power—independent of the weather—so it can play a role in grids similar to hydroelectric, gas-fired, or nuclear power, all while supporting installed wind and solar.

Economic: At US$60-100 per Megawatt-hour (MWh), geothermal is already competitive in select locations. In the recently delisted Liftoff Report, the U.S. Department of Energy forecasts next-generation geothermal technologies could drop that price to US$45/MWh by 2035—on par with natural gas.

Energy-dense: Because geothermal energy is extracted from the subsurface, projects generate far more power per unit of surface area than other renewables, minimizing landscape disturbance and visual impacts. A 10 MW geothermal power plant—enough to power about 10,000 homes—is about the size of a football stadium.

[3] IEA. (2024). *The Future of Geothermal Energy*, IEA. Paris https://www.iea.org/reports/the-future-of-geothermal-energy, Licence: CC BY 4.0

Minimal transmission: Reservoir engineering makes it possible to site next-generation geothermal projects close to energy users, including cities, industrial sites, and data centres. This minimizes the need for new transmission.

Lucrative: The global opportunity is immense, with investment estimated at US$2 trillion or higher by 2050.[4] Between 2020 and 2024 alone, investment grew eight-fold, from under US$100M to US$790M. Meta,[5] Google,[6] and Microsoft[7] have all secured both conventional and next-generation geothermal projects to power their data centres.

WHY NOW?

Geothermal power is experiencing a technological revolution. Historically, conventional geothermal power projects were confined to locations with high temperatures and naturally occurring aquifers. However, these locations are challenging to identify from the surface and are geographically limited. Today, the next generation of geothermal technologies makes it possible to create these conditions using technologies adapted from the oil and gas sector. This innovation dramatically increases the potential range of geothermal power, and creates the prospect of abundant, reliable, and renewable geothermal power almost anywhere.

At the same time, energy demand will only continue to grow from the electrification of existing activities, and new industries like AI. Under business as usual, Canada will need to increase electricity capacity by 50 percent by 2050.[8] Under net zero, this would need to more than double. Finding new sources of electricity generation has never been more important.

New sources of baseload power are particularly valuable. Variable renewables like wind and solar are the lowest-cost source of new generation but will require large quantities of storage to achieve flexibility. Expanding baseload power with sources

[4] IEA. (2024). *The Future of Geothermal Energy*, IEA. Paris https://www.iea.org/reports/the-future-of-geothermal-energy, Licence: CC BY 4.0
[5] Kearney, L. (2025). Meta signs deal for advanced geothermal power in New Mexico. *Reuters*. https://www.reuters.com/sustainability/boards-policy-regulation/meta-signs-deal-advanced-geothermal-power-new-mexico-2025-06-12/
[6] Hanley, S. (2024). Google agrees to buy 115 MW of geothermal power from Fervo & NV Energy. *CleanTechnica*. https://cleantechnica.com/2024/06/17/google-agrees-to-buy-115-mw-of-geothermal-power-from-fervo-nv-energy/
[7] Swinhoe, D. (2023). *Microsoft signs 51MW geothermal PPA in New Zealand*. Data Centre Dynamics. https://www.datacenterdynamics.com/en/news/microsoft-signs-51mw-geothermal-ppa-in-new-zealand/
[8] Navius Research. (2025). Canada Energy Dashboard. Available at: canadaenergydashboard.com

like geothermal could reduce total electricity costs by 60 percent relative to variable renewables and storage alone.[9]

WHY CANADA?

As growing tensions with the U.S. force Canada to re-examine its chronic productivity crisis, a New Canadian Industrial Strategy is more important than ever.[10] This requires Canada to make big, bold, and strategic bets on existing strengths. But passive funding in strategic sectors alone is not enough. Successful industrial policy must also build durable public-private collaboration and develop a comprehensive policy suite.

High-potential sectors might be selected based on existing industrial strengths, innovative capacity, natural resources, expertise, and/or alignment with emerging global opportunities. Geothermal power is a natural fit for such an approach. Canada holds three decisive advantages that position it to lead: a robust geothermal energy resource, world class existing industries, and a burgeoning geothermal power sector.

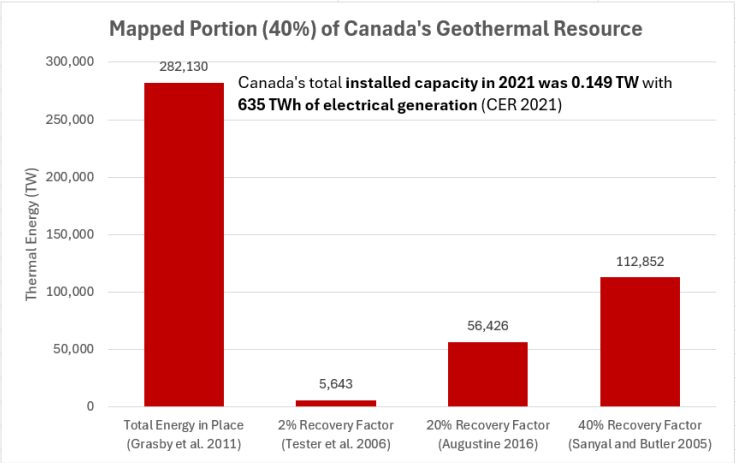
Together, these factors make geothermal an ideal candidate for a renewed approach to Canadian industrial strategy. Geothermal power is an area where national strengths align with global opportunities, and where smart policies can turn domestic advantages into long-term prosperity.

[9] Sepulveda, N. A., Jenkins, J., de Sisternes, F. J., Lester, R. K. (2018). The role of firm low-carbon electricity resources in deep decarbonization of power generation. *Joule, 2(11).* https://doi.org/10.1016/j.joule.2018.08.006

[10] Southin, T., Allan, B., Bataille, C., Beck, M., et al. (2025). *The right move at the right time: a new Canadian industrial strategy.* Commission on Carbon Competitiveness (C3) and Transition Accelerator.

A STRONG GEOTHERMAL RESOURCE

Canada's geothermal energy resource far exceeds domestic demand. According to the Geological Survey of Canada, "Canada's in-place geothermal power exceeds one million times Canada's current electrical consumption."[11]



Canada's greatest geothermal resources are in Western Canada, co-located with grids that are fossil-dependent—such as Alberta and Saskatchewan—or in need of new sources of capacity and energy—such as British Columbia. Both British Columbia and Alberta have taken steps to identify their geothermal resources.

British Columbia: The province has identified three volcanic belts with high-temperature geothermal potential.[12] The Garibaldi Volcanic Belt includes Mt. Garibaldi, Mt. Meager, and Mt. Cayley and has the largest data set and largest amount of geothermal energy. Mt. Meager alone is estimated to contain 100 MW of recoverable geothermal power.[13]

Alberta: The Alberta Geologic Survey identified three promising geothermal aquifers with an estimated 112 GW of gross thermal energy and 17 GW of gross electrical capacity.[14] These resources could provide over 150 percent of the Alberta's current electricity needs.

Despite this massive potential, less than half of Canada's geothermal resource has been assessed. To address the gap, the Cascade Institute is developing a Canadian Geothermal Heat Map using advanced machine learning tools

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[11] Grasby, S.E., Allen, D.M., Bell, S., Chen, Z., et al. (2012). *Geothermal Energy Resource Potential of Canada*. Geological Survey of Canada. Open File 6914 (revised), 322p. doi:10.4095/291488.

[12] Government of British Columbia. 2017. *Geothermal Resources in B.C.* Retrieved from: https://www2.gov.bc.ca/gov/content/industry/electricity-alternative-energy/renewable-energy/geothermal-energy/exploration-and-sales/geothermal-resources-in-bc

[13] Witter, J. (2019). *South Meager Geothermal Project: New Perspectives from Recently Unearthed Data*. Innovate Geothermal Ltd. for Geoscience BC. https://cdn.geosciencebc.com/pdf/Report-2019-07-Innovate-Geothermal.pdf

[14] Alberta Energy Regulator. (2025). *Alberta Energy Outlook 2025*. https://static.aer.ca/prd/documents/sts/ST98/2025/Alberta-Energy-Outlook_report.pdf

developed at Stanford University.[15] This project will fill gaps in the existing maps, highlight data needs, identify high-priority targets for geothermal exploration and development, and facilitate investment.

A COMPETITIVE AND INNOVATIVE ENERGY SECTOR

Canada's world-class oil and gas sector is one of the nation's greatest industrial and regional strengths. As the fourth-largest producer and third-largest exporter of crude oil, and the fifth-largest producer and sixth-largest exporter of natural gas, the sector is a global player. In 2023, it contributed 7.7 percent of GDP, supported 446,000 jobs (including 181,000 direct), and drove $64 billion in capital investment.[16]

Canada's Energy Innovation Advantage

Canada is "hyper-dominant" in ~0.2% of patent areas, many of which are in oil and gas technologies directly applicable to geothermal:

- Positioning, fracturing, and completing wellbores
- Single-trip milling and whipstock systems
- Advanced flow control for wellbores and hydrocarbon reservoirs
- Agitation tools for enhancing well pump efficiency
- Automated systems for well monitoring, gas analysis
- Tools and methods for well servicing, borehole production
- Wireline tools and continuous circulation systems
- In situ heavy oil recovery
- Enhanced recovery techniques and steam injection

Much of the supply chain required for geothermal energy projects could be met by companies and suppliers currently supporting Canada's oil and gas industry. The IEA estimated up to 80 percent of the skills and technologies required for geothermal development are directly transferable from oil and gas.[17]

In Canada, that overlap may be even greater. Alberta's in-situ oil sands operations, for example, involve creating and managing high-temperature subsurface environments, giving Canadian firms deep expertise that is directly applicable to geothermal. In fact, Canadian oil sands

[15] Cascade Institute. *Canada Heat Map*. https://cascadeinstitute.org/canada-heat-map/
[16] Natural Resources Canada. (2025). *Energy Fact Book 2024-2025*. Section 6: Oil, natural gas and coal.
[17] IEA (2024). *The Future of Geothermal Energy*, IEA. Paris https://www.iea.org/reports/the-future-of-geothermal-energy, Licence: CC BY 4.0

technologies have already been deployed at the Geysers geothermal field in California.

Canada's oil and gas sector is also among the most innovative globally. A study of patenting activity found that Canada is "hyper-dominant" in 0.2 percent of all patent areas—most of which are in transferable oil and gas technologies—further underscoring the country's potential to lead in geothermal development.[18]

A DIVERSE AND GROWING GEOTHERMAL INDUSTRY

Canada already hosts innovative firms and projects that are part of a robust industrial ecosystem. These include:

FutEra Power: This innovative facility harnesses geothermal heat from an active oil field near Swan Hills, Alberta, to generate electricity. It currently delivers the only geothermal electrons to Canada's power grid, showcasing a successful integration of oilfield infrastructure with renewable energy production.

Eavor: Eavor's next-generation system extracts heat using a closed-loop design. Successfully demonstrated in Alberta, the technology is now being deployed in Germany, marking a significant step in scalable, clean geothermal energy.

DEEP Earth Energy: Located near Estevan, Saskatchewan, this project combines conventional and next-generation enhanced geothermal systems. Developed in partnership with SLB, it represents a major step forward in deep geothermal resources for sustainable power generation in Canada.

Tu Deh-Kah: Located in Fort Nelson, British Columbia, this Indigenous-owned project aims to generate power by repurposing a natural gas field. It exemplifies community-driven clean energy development and the innovative reuse of legacy infrastructure.

Meager Creek: Located near Pemberton, British Columbia, this project taps into Canada's hottest geothermal resource. With temperatures reaching up to 275°C and an estimated potential capacity of over 100 MW, Meager Creek is positioned to deliver reliable, baseload, renewable electricity.

[18] Torrance, A.W., Friedman, L.C. (2024). *Own the technology podium: Patent importance reveals Canada's place in the worldwide innovation ecosystem*. IP: A Driver for Economic Growth Conference.

Alberta Drilling Accelerator: This public-private partnership provides targeted funding to leverage Alberta's world-class drilling expertise. The initiative supports innovations with cross-sector applications in oil, gas, critical minerals, geothermal energy, and other subsurface resources.

World Geothermal Congress: Calgary will host this prestigious triennial event in June 2026, recognizing Canada's leadership in the global energy sector. The selection highlights the country's unique advantage in leveraging oil and gas expertise and technologies to advance geothermal innovation.

In addition to the projects listed above, Canada's geothermal sector benefits from a deep bench of technical expertise, particularly in high-temperature development and operations rooted in the oil sands industry. Numerous other innovators, researchers, and Indigenous-led initiatives across the country are contributing to this emerging energy landscape. As geothermal gains momentum, the oil and gas service industry—already adapting its technologies and skill sets—will play an increasingly vital role in supporting and scaling geothermal development nationwide.

THE PATH TO SCALE: INNOVATION AND NEXT-GENERATION GEOTHERMAL

Canada can leverage conventional geothermal power technology, particularly at high-temperature sites—such as Mt. Meager in British Columbia. These projects provide a vital launch pad for Canada's nascent geothermal industry. However, the true opportunity for Canada is in next-generation geothermal technologies. By creating artificial reservoirs, advanced and enhanced geothermal systems reduce risk and massively expand geographic deployment beyond what is possible with conventional technology.

However, next-generation systems require improvements in cost and performance before they can be considered commercially competitive. The Cascade Institute has identified four innovation priorities to reduce costs and improve performance:[19]

Drilling: Makes up 40-60 percent of project costs and must fall significantly. Reducing drilling costs is vital, as broad deployment of these systems will require

[19] Gall, L., Lovekin, D., Pearce, R., Smejkal, E. (2024). *Ultradeep Geothermal Research and Action Roadmap*. Cascade Institute. https://cascadeinstitute.org/technical-paper/geothermalroadmap/

drilling to depths of 10 kilometres or more to reach temperatures of 400°C. Key opportunities include drill bit longevity, rate of penetration, high-temperature drilling, and novel drilling technologies (e.g., plasma, millimetre wave).

High-temperature tools: Downhole tools must withstand extreme pressure and temperatures, especially for superhot rock projects that target temperatures of 375°C or above. At these temperatures, energy output increases five- to ten-fold.[20] If such wells could be drilled cost-effectively, geothermal could be produced virtually anywhere, unlocking a clean energy resource many times greater than global demand. Key opportunities include insulated drill pipe, mud chemistry, advanced materials, and coatings.

Well completion: Wells are complex structures made of layers of cement and steel that must also withstand extreme pressure and temperatures. Key opportunities include advanced anti-corrosion materials and self-healing ductile cement.

Heat extraction: Can be advanced through reservoir engineering, with a focus on maximizing flow rates to increase power output. Key opportunities include closed-loop design and hydro-shearing, fracture mapping and modelling, and demonstrating reservoir creation in diverse geologies.

The innovation required represents a significant challenge. However, this challenge also creates an opportunity. Other countries have seized on the intellectual property and economies of scale needed to compete in commercial technologies for other renewable power sources, but the need for geothermal innovation creates an opportunity for made-in-Canada solutions.

TEST CENTRES: CATALYZING INNOVATION

Test centres offer a strategic pathway for Canada to unlock its domestic geothermal potential while positioning itself as a global exporter of clean energy technologies. By bringing together top minds from industry, academia, and the public sector, these platforms enable collaborative problem-solving on well-defined, high-impact challenges—and they have a proven track record of success:

NASA: In the 1970s, when wind energy was uncompetitive and niche, NASA created a series of test centres across the U.S. that facilitated collaboration

[20] Clean Air Task Force. (2022). *Superhot Rock Energy: A Vision for Firm, Global Zero-Carbon Energy*. https://cdn.catf.us/wp-content/uploads/2022/10/21171446/superhot-rock-energy-report.pdf

among industrial champions such as Boeing and General Electric. NASA achieved a 20-fold increase in power output in a few years and made advances that unlocked decades of cost declines.

Riso National Laboratory for Sustainable Energy: This Danish research lab established test centres that helped transform companies like Vestas into global wind energy leaders, now valued in the billions of dollars. Publicly funded test platforms allowed leading companies to accessibly and easily test new wind turbine models, enabling rapid improvements and commercialization.

Western Gas Sands Project and Eastern Gas Shales Project: The U.S. Department of Energy along with an industry-funded Gas Technology Institute led a sustained and collaborative research program to unlock unconventional gas reserves. Large-scale coring and logging programs helped to characterize the resource, then public-private experiments in test centre wells established advanced drilling, modelling, and stimulation techniques to commercialize fracked gas. The U.S. is today the largest global gas exporter, largely due to technological innovations spurred by the unconventional gas program.

Frontier Observatory for Research in Geothermal Energy: Located in the U.S., FORGE offers a dedicated test site to lower barriers for innovative geothermal firms. In just five years, drilling costs have dropped by 50 percent, and performance has exceeded key benchmarks. Fervo Energy, backed by Bill Gates, leveraged FORGE's expertise to finance a 500-megawatt geothermal plant and secure a contract to power Google's data centres.

Alberta Oil Sands Technology and Research Authority (AOSTRA): Perhaps the most compelling Canadian example, AOSTRA revolutionized heavy oil production in the 1970s and 80s. With an initial $100-million public-private investment, it unlocked vast oil sands reserves and generated nearly $1 trillion in economic returns. Alberta has successfully used this model before—and Canada can do so again for geothermal.

A GEOTHERMAL SCIENCE AND TECHNOLOGY RESEARCH AUTHORITY

Building on the success of AOSTRA, the Cascade Institute proposes a strategic approach to accelerate geothermal innovation through a new national initiative, the Geothermal Science and Technology Research Authority (GEOSTRA). GEOSTRA would consist of:

Four connected experimental test sites in unique geologies across Canada to accelerate innovation and decrease risk. Each site would be allotted up to $125M to target innovation on discrete but complementary research. Funding will support two sets of activities:

- Infrastructure ($95M) including site characterization, experimental drilling, stimulation, and potentially small-scale power generation.
- An R&D program ($30M) to advance key technologies at each site.

Federal, provincial, and university labs that convene Canada's best researchers and scientists to conduct applied research and analysis, catalyzing advances in the field. $50M of funding would target advanced capabilities at laboratories to complement field work.

An innovative intellectual property framework to facilitate collaborative innovation, create and maintain made-in-Canada IP, and ensure that private and public investors benefit.

Stage-gated investments against key milestones to manage risk and ensure results.

As technologies move through the innovation cycle from early-stage R&D to commercialization, it will be critical to identify and attract the appropriate sources of capital. Both public and private funding will have important roles in financing the test centres and follow-on deployment. GEOSTRA would catalyze the breakthroughs needed to make geothermal a cornerstone of Canada's clean energy future—delivering domestic energy security and global technology leadership.

NEXT STEPS: A GEOTHERMAL ROADMAP FOR CANADA

While test centres like GEOSTRA are critical to unlocking Canada's geothermal potential, a broader strategy is needed to fully integrate geothermal into the national energy and industrial landscape.

A Canadian Geothermal Roadmap would convene stakeholders from government, industry, Indigenous communities, and academia to chart a comprehensive path forward. This roadmap would define the opportunity for Canada and identify a comprehensive suite of policies needed to realize Canada's geothermal potential. In addition to a detailed technology assessment, key elements include:

Resource characterization: Canada's geothermal potential is only partly mapped, leaving big gaps for developers. A Geothermal Heat Map project being undertaken by the Cascade Institute will use advanced data and AI to identify high-potential zones, improve cost models, and guide site selection. Updated mapping is critical to showcase Canada's opportunity and attract investment.

Regulatory frameworks: Geothermal regulation is fragmented—only B.C., Alberta, and Nova Scotia have specific rules, all inconsistent. Canada needs harmonized, technology-agnostic frameworks that clarify definitions, tenure, permitting, and Indigenous co-management. Streamlined regulation would cut risk, speed projects, and strengthen Canada's position. For more information, see Cascade's recent report *Groundwork: Regulatory guidelines for making Canada a geothermal powerhouse*.[21]

Financial measures: Early geothermal projects carry high risk and need public backing to draw private capital. Tools like funding streams, loan guarantees, tax incentives, and tailored financing for Indigenous and community projects can reduce upfront risk, spur deployment, and share benefits widely.

Promote international collaboration and export: Canada's expertise can translate into global leadership. Partnerships with international test centres and support for Canadian firms abroad will open markets. The 2026 World Geothermal Congress in Calgary offers a chance to showcase leadership and attract investment.

CONCLUSION

Geothermal energy is a viable technology with a bright future. With the right investments, partnerships, and policy frameworks, Canada can reinvent its approach to industrial policy and unlock an era of prosperity and energy security.

We invite you to join the conversation at the Geothermal Accelerator Conference on September 9, 2025, where industry representatives, researchers, policymakers, and Indigenous leaders will come together to shape the future of geothermal in Canada. Your insights and collaboration are essential to building a thriving geothermal sector that benefits all Canadians.

The Geothermal Accelerator is more than a conference—it's a call to action. Join us in shaping a prosperous, secure, and sustainable energy future for Canada.

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[21] Smejkal, E., Cosalan, P.S., Cortinovis, S.R. (2025). *Groundwork: Regulatory guidelines for making Canada a geothermal powerhouse.* Cascade Institute. https://cascadeinstitute.org/technical-paper/groundwork/