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GROUND WORK

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Regulatory guidelines for making Canada a geothermal **powerhouse**

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Foreword

Canada stands at a pivotal moment in its geothermal energy journey. A fragmented regulatory landscape, with only a few jurisdictions having geothermal-specific regulations, has been a significant barrier to the sector's growth. However, the potential for geothermal energy in Canada, particularly in the West, is vast and untapped. High upfront risks and the lack of a shared national template have discouraged investment—but the time is ripe for change.

The Cascade Institute's report *Groundwork: Regulatory Guidelines for Making Canada a Geothermal Powerhouse* is a timely and effective intervention that addresses these challenges head-on. It presents clear, transferable, and future-proof principles that jurisdictions across the country can adopt or adapt immediately.

The report's core recommendations are essential for fostering geothermal project success:

1. **Precisely define geothermal resources:** Geothermal resources should be defined to encompass heat and pressure, not just fluids. This broader definition ensures that the regulatory framework is comprehensive and inclusive of all potential geothermal applications.
2. **Remain technology agnostic:** The regulations should be flexible enough to accommodate various geothermal systems, including Enhanced Geothermal Systems, closed-loop systems, and heat storage. This approach will support innovation and the integration of new technologies as the sector matures.
3. **Streamline permitting processes:** Predictable and time-bound permitting processes are crucial to reducing investor risk and accelerating project development. Streamlining these processes will make Canada more attractive for geothermal investments.
4. **Cap lease sizes:** Capping lease sizes will ensure fair access to geothermal resources and prevent monopolization, promoting a competitive and equitable market.
5. **Set tenure timelines:** Balancing project flexibility with safeguards against speculation is essential. Setting clear tenure timelines will help achieve this balance.
6. **Mandate early-stage public outreach:** Early and transparent public engagement is vital for building trust and reducing opposition. This will help create a supportive environment for geothermal projects.

These smart, actionable recommendations are based on international best practices, including the United States' use of regulatory templates, Indonesia's automation of permit processes, the Philippines' energy-based definitions, Türkiye's public communication strategies, and New Zealand's commitment to Indigenous co-management. By integrating these and other international lessons, Groundwork offers a robust framework for Canada to step to the fore.

To expand the impact of the guidelines, I would highlight a few additional areas for priority action at the both the national and provincial levels:

- Incentives for first movers, such as exploration risk guarantees, feed-in tariffs, and power purchase agreements.
- Market-creation tools, such as integrating geothermal into energy mandates or setting geothermal capacity targets, to create demand signals for investment.
- Regulatory co-design with Indigenous partners to emphasize true co-ownership and shared governance, inspired, for example, by the Tu Deh-Kah project.
- A national convening mechanism or roadmap, to amplify the effectiveness of regulatory reforms and chart a path for geothermal in Canada.

The World Geothermal Congress 2026 in Calgary presents a strategic opportunity to advance geothermal regulation in Canada. In the lead-up, the International Geothermal Association is proud to partner with the Cascade Institute to convene provincial and territorial regulators, relevant federal agencies and departments, Indigenous energy leaders, municipal leaders, and utility representatives. The purpose of these engagements will be to promote the uptake of Groundwork's guidelines, align on a national regulatory template, share global best practices, and elevate Canada's leadership role in the geothermal sector.

With strategic coordination and a shared vision, Canada can set the regulatory gold standard for geothermal energy. This report points the way.

Dr. Marit Brommer

CEO, International Geothermal Association

DEEP Earth Energy Production project site in Saskatchewan (image credit: DEEP).

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EXECUTIVE SUMMARY

As the global energy transition gathers speed, Canada has the time-bound opportunity to become a global leader in clean geothermal power, if provinces act quickly to harmonize and extend geothermal regulations across the country. This report supports this opportunity by identifying international best practices from the 10 largest geothermal power producers globally to provide provinces and territories with essential insights and guidelines they can use to establish effective regulations.

Currently, geothermal power production in Canada is minimal. However, three provinces—British Columbia, Alberta, and Nova Scotia—have already implemented geothermal regulations, setting a promising precedent. By harmonizing and extending effective regulations across the country, Canada can leverage its substantial drilling expertise and capacity to develop its geothermal resources efficiently. Establishing a consistent regulatory framework will reduce delays and financial risks for developers, paving the way for a robust geothermal energy sector. This report provides a valuable foundation for Canadian jurisdictions to create and adopt comprehensive geothermal regulations.

> *By harmonizing and extending effective regulations across the country, Canada can leverage its substantial drilling expertise and capacity to develop its geothermal resources efficiently.*

Regulations for subsurface resources typically have three key components: resource definition, resource ownership, and resource tenure. These components are found in mining, oil and gas, and water regulations. Geothermal regulations must also rest on these three pillars, clarifying what the resource is, who owns it, and how it can be developed.

We surveyed the subsurface regulations from the world's 10 largest geothermal producers to identify regulatory best practices that Canadian jurisdictions should adopt. The insights for Canada from each country are summarized below:

International insights for geothermal regulations	
Country	**Key insights**
United States	Template regulations can bring consistency across jurisdictions.
Indonesia	Automation and comprehensive post-operation regulations bring speed and certainty.
Philippines	Clear, technology agnostic regulation speeds development.
Türkiye	Effective public communication reduces project opposition.
New Zealand	A thriving geothermal sector can honour treaties and Indigenous resource claims.
Kenya	Public funding can unlock private investment and create an industry.
Mexico	Mandated decision timelines drive project predictability.
Italy	Regulatory consistency across jurisdictions decreases scale-up risk.
Iceland	A dedicated regulatory body provides clarity and predictability.
Japan	Unclear regulations slow development and sow conflict between landowners.

We also identified six recommendations for effective geothermal regulations that were common across multiple counties and should be applied in Canada. Regulations should:

1. Precisely define the resource.
2. Be technology agnostic.
3. Establish efficient, clear, and consistent processes and permit requirements.
4. Define a maximum acreage of awarded rights to avoid resource monopolies.
5. Set realistic timeframes for tenure to allow flexibility for proponents while avoiding speculative resource grabs.
6. Enshrine early public outreach to build trust and support.

Based on our international case studies and Canada's unique jurisdictional landscape, we also propose some model language for potential inclusion in new geothermal regulations across the country:

Model geothermal **resource** definition:

A geothermal resource is energy in the form of heat and/or pressure, below the base of groundwater protection, and includes all dissolved or entrained minerals that may be extracted from the medium used to transfer that energy. This energy can be used to generate heat and/or electricity.

Model geothermal **ownership** definition:

Lease of rights to geothermal resources is granted by the Crown to the developer and includes the subsurface pore space (naturally occurring and human-made) over a given depth. Developers will apply to the Crown for the lease of subsurface pore space, and the lease of space will be awarded based on the merit of the application, following public notice and a period for additional applications.

Model geothermal **tenure** stages:

Development:
Five years
Five-years renewals

Operations:
30 years
Ten-year renewals

Decommissioning:
Two years
Single site-specific renewal

Based on its transferable subsurface expertise and abundant geothermal resource, Canada can be a leader in geothermal energy, meeting growing demand for electricity with clean, secure, and affordable baseload power while bolstering Canada's energy security. To achieve this potential, the country will need clear and consistent subsurface regulations. Putting such regulations in place is a necessary condition for project financing and development, as geothermal resources cannot be developed in Canada without a regulatory pathway.

Following this report, we will use the guidelines proposed here to develop model regulations that can be adapted and rapidly implemented by the 10 Canadian jurisdictions currently lacking subsurface geothermal regulations. These model regulations can also inform improvements to, and consistency among, the regulations in the three jurisdictions that currently have them.

DEEP Earth Energy Production project site in Saskatchewan (image credit: DEEP).

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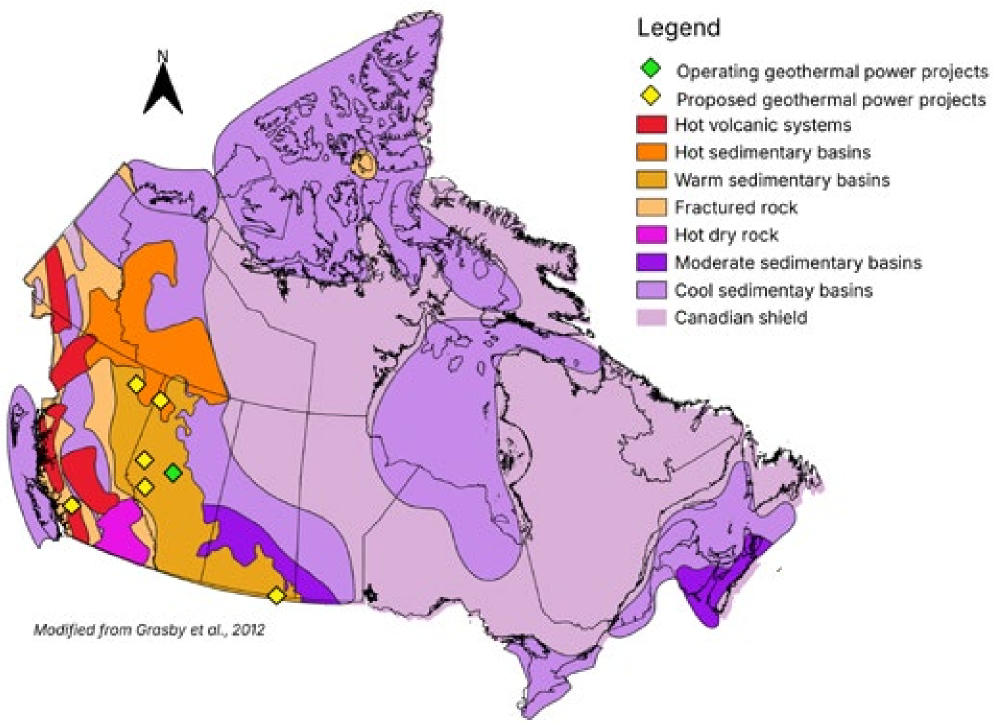
1.Introduction

Canada has an immense geothermal resource, particularly in the West. British Columbia and the Yukon have high heat gradients thanks to volcanic activity. Alberta, Saskatchewan, and the Northwest Territories have sedimentary basins that host natural reservoirs of hot fluids (Grasby et al., 2012). These provinces and territories can access geothermal resources using readily available conventional technologies. The remainder of the country will require deeper drilling and next-generation geothermal technologies to access geothermal resources (Figure 1). Canada has a time-bound opportunity to be a leader in clean, geothermal power, but to get there, the country needs clear and consistent regulations from coast to coast.

FIGURE 1:

Canada's geothermal potential and power projects



Geothermal energy can be accessed in the West using existing technology. Next-generation technology will expand geothermal energy use across the country. Modified from Grasby et al., 2012.

Recognizing the factors that can accelerate geothermal power production is the first step toward establishing Canada as a geothermal superpower. Three factors determine the number of geothermal projects in a particular jurisdiction: geology, project financing, and regulations (Table 1). Most of the world's electrical geothermal development occurs in regions with advantageous geological conditions, where effective regulations are already in place. Subsurface regulations, which are the focus of this report, are particularly important, as existing surface and environmental regulations will often suffice for guiding above ground geothermal project development.

TABLE 1:
Subsurface regulations, the focus of this report, are a key factor for geothermal project success

Geology	Project financing	Regulations
✔ Heat gradient	✔ Public funding	✔ Surface
✔ Natural reservoirs or formations	✔ Private investment	✔ Subsurface
✔ Proximity to users	✔ Financial incentives	✔ Environmental

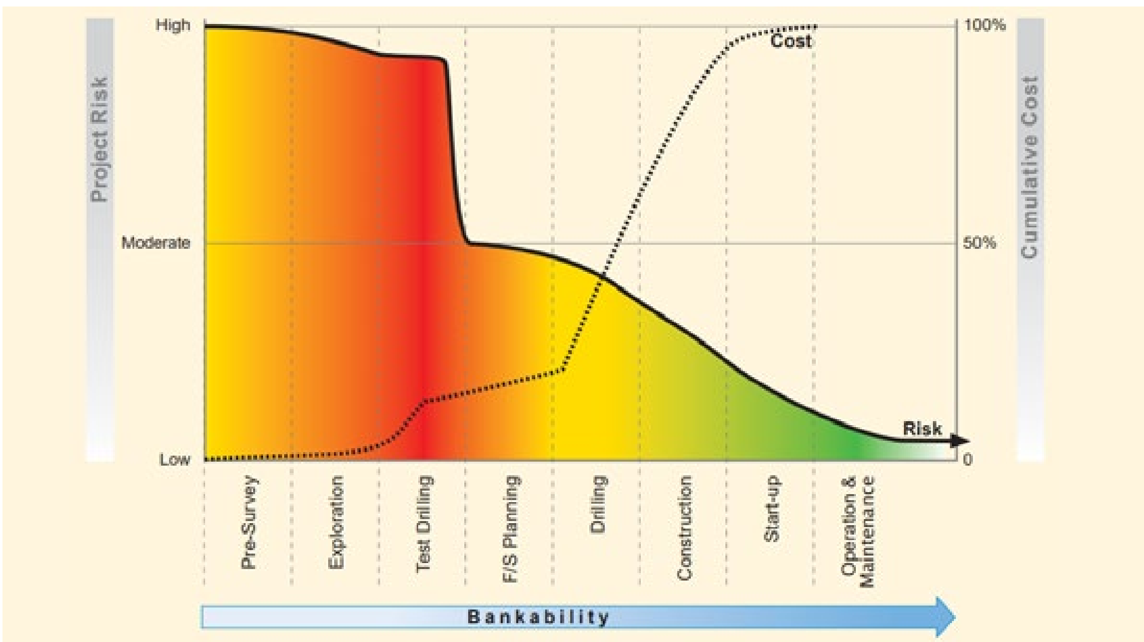
Along with a viable resource, geothermal projects require significant front-end capital for development. This financing is needed at the highest-risk phase of development and is challenging to secure (Figure 2). Both private and public funds have been used for geothermal power development globally. Some jurisdictions have also used financial incentives to encourage geothermal development, such as:

- Drilling insurance on geothermal exploration wells (International Energy Agency, 2020).
- Long-term power plans that include geothermal capacity targets (California Public Utilities Commission, 2024).
- Cost matching to non-renewable energy resources (Ministerie van Economische Zaken en Klimaat, 2023).
- Power purchase agreements between power providers/users and geothermal developers (Gehringer & Loksha, 2012).
- Public funding for geothermal test centres and technology development (Geothermal Technologies Office—Department of Energy, 2023).
- Government-led exploration to derisk geothermal resources (Shimbun, 2024).

These policy tools are explored and evaluated elsewhere (Compernolle et al., 2019; Crewson & Thompson, 2015; Dumas, 2019; Speer et al., 2014), but additional work is needed to understand the role they played in geothermal development for the leading geothermal power-producing countries, and what lessons they provide for Canada.

FIGURE 2:

Geothermal project risk decreases with capital spent



Gehringer & Loksha, 2012.

While the financing of geothermal projects is not the focus of this report, the presence of geothermal regulations can help to reduce the development risk for projects and therefore enable private investment.

Regulations, particularly subsurface regulations, are key to geothermal project success. Effective regulatory frameworks can help alleviate environmental costs and balance environmental and economic trade-offs. Regulations can provide certainty for investors while promoting responsible development, public safety, and environmental stewardship. While geothermal energy, located deep underground, avoids many environmental risks typically associated with energy projects, such as flooding, waste management, emissions, and habitat destruction, it does present subsurface challenges, including water use, water contamination, ground temperature changes, and seismic activity (Table 2; McClean & Pedersen, 2023).

TABLE 2:
Regulations protect the surface and subsurface from environmental impacts

Surface impacts	Subsurface impacts
Soil	Groundwater
Surface water	Drilling
Habitat	Seismic activity
Permafrost	Formation isolation
Ground subsidence	Responsible production
Noise	Co-production with additional resources
Air pollution	
Visual impact	

The surface infrastructure, environmental considerations, and use of geothermal energy at the surface are already regulated under existing environmental, building, and infrastructure frameworks, and thus fall outside the scope of this report. Similarly, shallow geoexchange systems (also known as ground-source or geothermal heat pumps) and subsurface thermal storage installations are governed by provincial and territorial regulations related to building codes, environmental protection, and surface water management in Canada (Gall et al., 2024). While geoexchange and thermal storage have significant potential, these technologies are distinct from deep geothermal developments from both a policy and technical perspective (Abesser et al., 2020). This report focuses on deep-subsurface geothermal regulations in recognition that clear guidelines and standards can give Canada a competitive advantage over other jurisdictions.

Proposed geothermal projects have highlighted the lack of geothermal regulations in Canada, with only three provinces (British Columbia, Alberta, and Nova Scotia) with regulations in place. Of these three, there is little regulatory consistency between them. This lack of regulation has led to delays for Canadian geothermal projects and added financial risk for developers (Hickson et al., 2023). There is currently no template for geothermal regulations that Canadian jurisdictions could easily adopt.

To bridge this gap, we analyze the countries that excel in geothermal energy production worldwide—specifically, the top 10 global geothermal power producers. For each country, we evaluate the definition of geothermal resources, ownership structures, and tenure timelines. By examining the subsurface regulations in these experienced countries, we can identify best practices that Canada can adopt to create and enhance our own geothermal regulations.

Based on our insights from the global scan, this report presents regulatory guidelines tailored specifically for Canada, considering its unique national circumstances and goals. These guidelines can help Canadian provincial and territorial governments, along with their respective energy regulators, introduce new (or strengthen and align existing) geothermal regulations.

As a follow-up to this report, the Cascade Institute, in collaboration with government, academia, and the geothermal industry, will use these guidelines to develop a regulatory template that can be adapted and rapidly implemented by the 10 Canadian jurisdictions currently lacking subsurface geothermal regulations. By aligning with international standards and adapting successful strategies, Canada can ensure a robust and efficient regulatory framework that supports the growth of its geothermal energy sector, ultimately contributing to a more sustainable and resilient energy future for all Canadians.

> *With the right regulatory frameworks and financial supports, Canada can unlock its geothermal potential and become a global leader in clean energy.*

Section 2 of this report will outline the key components of geothermal regulations—the resource definition, ownership model, and tenure timeline—highlighting why clarity in each component is essential. ***Section 3*** will outline the status of geothermal regulations in Canada and identify the gaps that exist currently. ***Section 4*** will review the geothermal regulations for the top 10 geothermal power producers and provide insights for Canada from each. Finally, ***Section 5*** will present recommendations and guidelines for Canada to build geothermal regulations based on global best practices.

Canada's vast geothermal resources, particularly in the West, provide a strong foundation for expanding geothermal power production. By implementing effective regulations and leveraging existing expertise in drilling and subsurface resource extraction, Canada can rapidly scale up its geothermal energy sector. With the right regulatory frameworks and financial supports, Canada can unlock its geothermal potential and become a global leader in clean energy.

2. Compnents of geothermal regulations

Most Canadian regions have implemented some form of subsurface regulations, which are based on oil and gas extraction, water extraction, or mineral extraction (Gall et al., 2024). While there are notable similarities between geothermal and oil and gas developments, key differences require regulations specifically tailored to geothermal. Existing oil and gas regulations can serve as a foundation for geothermal guidelines, but geothermal systems possess unique characteristics that existing regulatory frameworks do not adequately address.

Geothermal wells differ from water, oil, and gas wells in four significant ways:

1. Geothermal wells are drilled much deeper than water wells, requiring larger and more complex equipment.
2. Geothermal wells have a larger diameter compared to oil and gas wells, requiring bigger drill rigs and specialized drilling and completion equipment.
3. Geothermal wells handle much larger volumes of fluid than oil and gas wells requiring large pumps and high operating pressures.
4. Geothermal wells extract both heat and fluids from the subsurface, with energy representing the primary resource, requiring specific regulations.

Regulating the activities involved in drilling and operating geothermal wells is essential to ensure public safety, minimize environmental impacts, and promote responsible resource development.

Regulations for subsurface resources typically have three key components: resource definition, resource ownership, and resource tenure (McClean & Pedersen, 2023). These components are also used for mining, oil and gas, and water regulations. Geothermal regulations can use these same pillars to clarify what the resource is, who owns it, and how it can be developed.

> *Regulations for subsurface resources typically have three key components: resource definition, resource ownership, and resource tenure*

2.1. Resource definition

Resources need to be clearly defined if they are to be regulated, but there is currently no standardized definition for what constitutes a *geothermal resource* across Canadian jurisdictions. This definition should answer the following questions:

- Is the resource defined as pore space, heat, fluid, energy, or all of the above?
- Is the energy naturally occurring, human-made, or both?
- Does the energy occur at the surface, in the subsurface (and if so, at what depths?) or both?
- What can the geothermal energy be used for?

Section 5 provides principles of how Canada could address these questions.

2.2. Resource ownership

As outlined in the Constitution Act of 1982, each of Canada's provinces own and govern the sub-surface resources within their boundaries. Exceptions are resources within federal lands, such as military bases and national parks, which are governed federally (Constitution Act, 1982). The Northwest, Yukon, and Nunavut Territories have jurisdiction over their subsurface resources, but ownership remains with the federal government (Minister of Public Works and Government Services Canada, 2001; CIRNAC, 2013; CIRNAC, 2024). Subsurface resources beneath Indigenous lands are governed under relevant provincial laws (Government of Canada, 2019). Current practices for the development of resources within Indigenous lands are outlined in Box 1.

Indigenous subsurface rights in Canada are a complicated patchwork of overlapping Indigenous, provincial, and federal jurisdictions. A nation's specific location and legal context will determine if a particular nation owns its subsurface rights, if those rights are held by the Crown, or if—as is often the case—those rights exist somewhere in between.

This complexity results from a lack of guidance in the Constitution Act of 1867, and the interpretation and legislation of Indigenous land rights varies by province (Catlyn, Ayanna Ferdinand, 2021; Centre for First Nations Governance, 2024; Indigenous and Northern Affairs Canada, 2016). However, federal law does influence how provinces regulate land and engage with Indigenous Peoples. Section 35 of the Charter of Rights and Freedoms of 1982 affirms the existing treaty rights of the Indigenous Peoples of Canada (First Nations, Métis, and Inuit Peoples) (CIRNAC, 2023a). The Supreme Court of Canada has defined legal tests for identifying rights based on Aboriginal Title, which is a common law doctrine that affirms the customary tenure of Indigenous Peoples who have long occupied the land (Irwin, 2018). The federal government also provides guidance on land management through the 2023 Framework Agreement on First Nations Land Management Act—which was designed to align with the United Nations Declaration on the Rights of Indigenous Peoples—and the departments of Indigenous Services Canada and CIRNAC (CIRNAC, 2023a).

Provincial governments lead the work of defining who owns subsurface resources and the conditions under which they can claim subsurface rights. The subsurface rights for Indigenous communities are poorly defined. All reserves are considered Crown land set aside for First Nations communities, but reserves are relatively small in size, and Indigenous nations have claims to treaty lands beyond reserve lands based on federal and provincial law.

Though Indigenous Peoples can submit claims or challenge the constitutionality of regulatory procedures, provinces and territories each have their own ways of managing land tenure, leasing, permitting processes, and definitions of subsurface rights. This has created a fragmented regulatory landscape characterized by varying levels of uncertainty and adherence to federal guidelines. For example, Alberta has the most developed legal system for managing subsurface rights owing to their oil and gas sector activity, but the legislation does not specifically address Indigenous rights. Providing further regulatory clarity, the Crown of Alberta also declared that it owned all pore space under the Carbon Capture and Storage (CCS) Statutes Amendment Act and has held that the duty to consult does not emerge until it has already allowed an actor to use the land for a particular activity (Kaplinsky, Eran & Percy, David, n.d.).

Most provinces treat surface and subsurface land rights separately (also known as a split estate)—despite how interconnected they are (McIntosh, 2023). This division can place limits on the natural resource rights of Indigenous Peoples because it is not clear whether their rights extend to subsurface resources; there is little evidence for the traditional use of subsurface resources by First Nations that could inform an Aboriginal Title claim (Irwin, 2018; Stefaniuk, 2023). In theory, federal law should protect the duty to consult and respect the sovereignty of Indigenous nations. In practice, control over Crown lands and natural resources is highly contested and primarily rests with provincial governments (Neimanis, 2011; Stefaniuk, 2023).

BOX 1:

The state of Indigenous geothermal development

Since 2017, the federal government has introduced several initiatives to develop the renewable energy capacity of remote and off-grid Indigenous and Northern communities to address widespread dependence on expensive fossil fuel imports (Canada Energy Regulator, 2023; CIRNAC, 2023b; NRCan, 2023, 2024a). In November 2024, the government committed $2 million in funding through one of these programs to support geothermal resource development (NRCan, 2024b). By partnering with the Acho Dene First Nation's economic development corporation, the Government of Canada is promoting community-led resource development in the Northwest Territories. Cooperative Indigenous ownership and joint decision-making are foundational principles for building clean energy solutions, as established in the recent Indigenous Geothermal People's Declaration (Eagle-Bluestone, 2024).

Fort Liard (Echaot'l Koe), where this project is set to take place, is on Crown land. Compared to ongoing provincial land rights disputes in the territory, federal land ownership and Indigenous project ownership and co-development will likely lead to a less complicated land management process (McIntosh, 2024). The project will still be required to abide by territorial resource development regulations, but the decision on ownership of the geothermal resource resides with the federal government. While there are examples of projects successfully incorporating Indigenous-owned lands into subsurface geothermal developments (e.g. the Tu Deh-Kah Geothermal project in Fort Nelson, B.C.), it is not clear whether this model has a clear path forward in parts of the country with more complicated regulatory landscapes (Bercovici, 2022).

While provinces enjoy legislative powers delegated by the Constitution, the territories exercise delegated powers under the authority of the Parliament of Canada. Historically, this authority has meant that the Yukon, the Northwest Territories, and Nunavut were primarily governed by federal officers. Over the past several years, Yukon and Northwest Territories have achieved devolved authority, meaning that they now have jurisdiction over land, water, and mineral tenure and environmental protections (Minister of Public Works and Government Services Canada, 2001; CIRNAC, 2013). Nunavut signed the Nunavut Lands and Resources Devolution Agreement in 2024 and can now make decisions about lands administration, development, and resource management (CIRNAC, 2024). The Government of Canada still has jurisdiction over subsurface resources offshore and within federally owned lands (e.g. national parks and military installations).

While this report focuses on the subsurface aspect of resource development, developing geothermal resources also requires surface land access. Eighty-nine percent of Canada's surface land is owned by the federal and provincial governments, while the remaining 11 percent is privately held (Neimanis, 2011). Surface land rights in Canada do not extend to mineral or subsurface rights (Constitution Act, 1982). To develop the subsurface for geothermal energy extraction, the subsurface rights holders will require the permission of the surface landowner. Individual jurisdictions will have regulations and protocols for how to accomplish this. Recommendations around surface access regulations will not be addressed in this report.

Geothermal resource ownership regulations should answer:

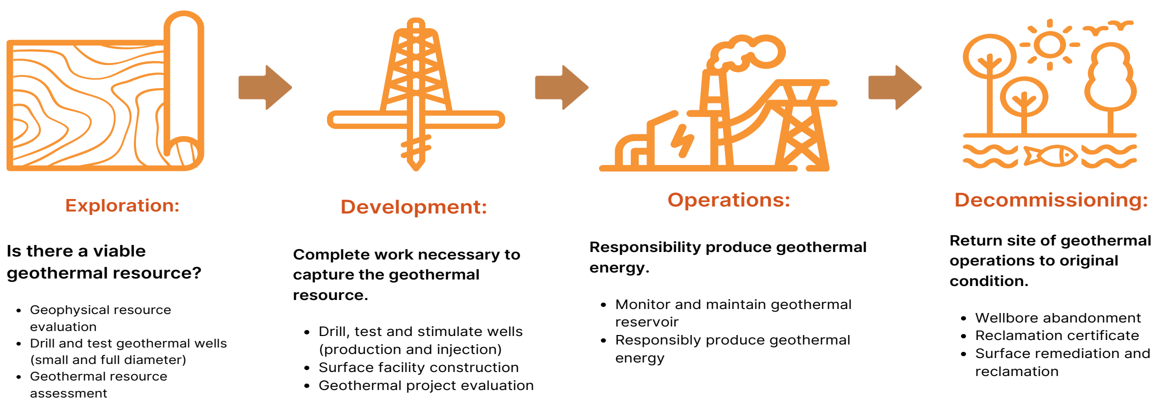
- Who owns the subsurface geothermal resource?
- How are geothermal rights granted?
- What size lease area is granted and at what depth within the subsurface?
- Are multi-commodity rights and extraction permitted?

Section 5 of this report provides guidelines for how Canadian jurisdictions should answer these four questions.

2.3 Resource tenure

The tenure for geothermal resources outlines how long rights are granted to a developer and what activities are permitted during that time. Geothermal project development can be broken into four phases: exploration, development, operations, and decommissioning (Gehringer & Loksha, 2012). Each of these phases will have a different length of tenure based on the activities allowed. A separate permit is normally required for each phase (or specific activities within a phase) to ensure responsible development of the resource. Applications by the developer are also used to move between the tenure phases. For example, an application would be required for the lease of the subsurface rights, which would enable geothermal development. A drilling permit would be required from the regulator to drill a deep geothermal well during any phase of development.

FIGURE 3:
Geothermal resource development occurs in four stages



Each stage will have different timelines, requirements, applications, and permitted activities. Based on Gehringer & Loksha (2012).

2.4. Additional components

Permitting and timelines

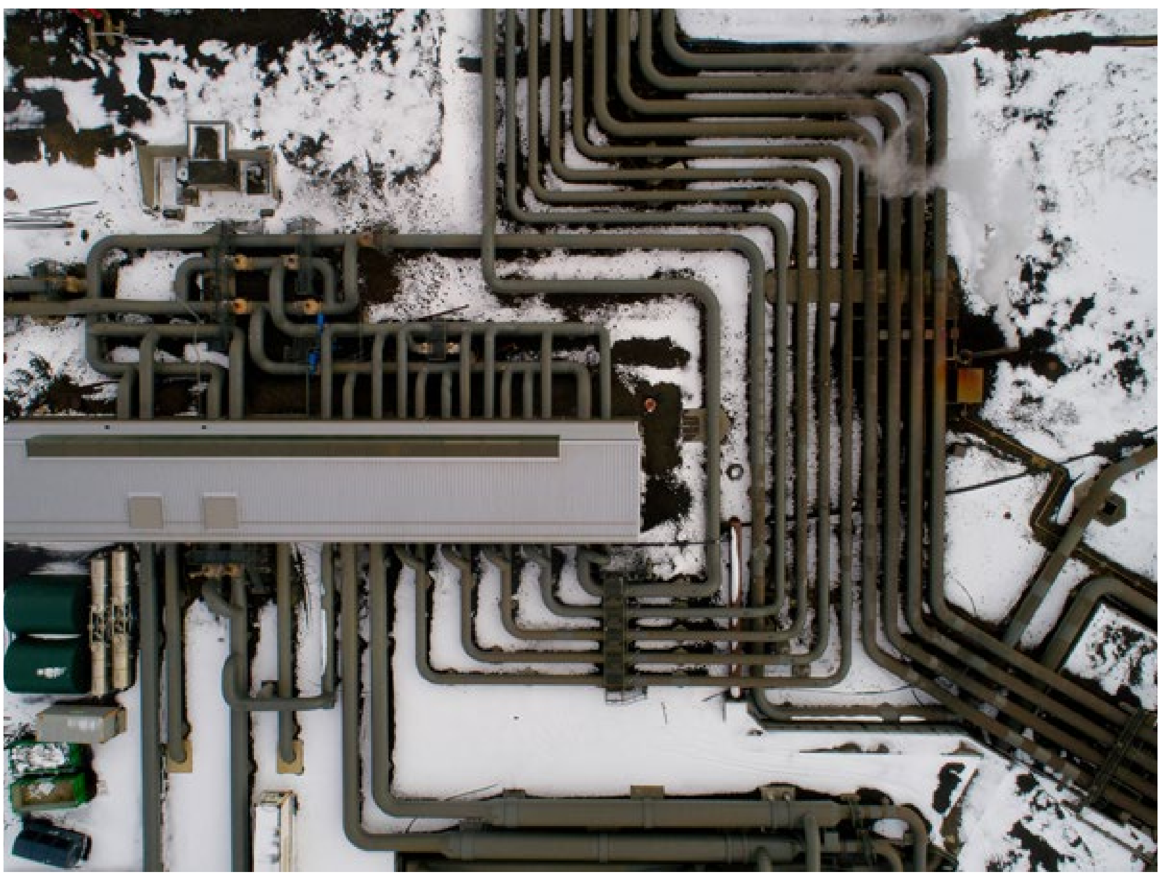
To reduce project risk and encourage geothermal resource development, it is crucial to streamline the regulatory process, ensuring it is clear, timely, and efficient. Beyond the permits required to progress through each stage of tenure, additional approvals will be needed for activities such as drilling, water use, well completions, surface construction, and other related operations. Regulators should establish limits on permitting response times to provide predictable timelines for developers. The permitting requirements should consider factors such as the size of the development, the intended use of geothermal energy, the technology employed, and the location's environmental sensitivity and proximity to population centres. Clear timelines for permitting decisions, balancing thorough review with developers' project timelines, reduce project risk.

Fees and royalties

Geothermal regulations should clearly outline the fees required for each phase of development and the cost of losing resource rights. These fees should be enough to cover the cost of regulator staff reviewing applications but should not be a financial deterrent for developers. Having these costs clearly stated as part of the regulation will allow for transparent and predictable development costs. If a government intends to raise revenues from geothermal development, it could do so through revenue-based royalties rather than fees on development.

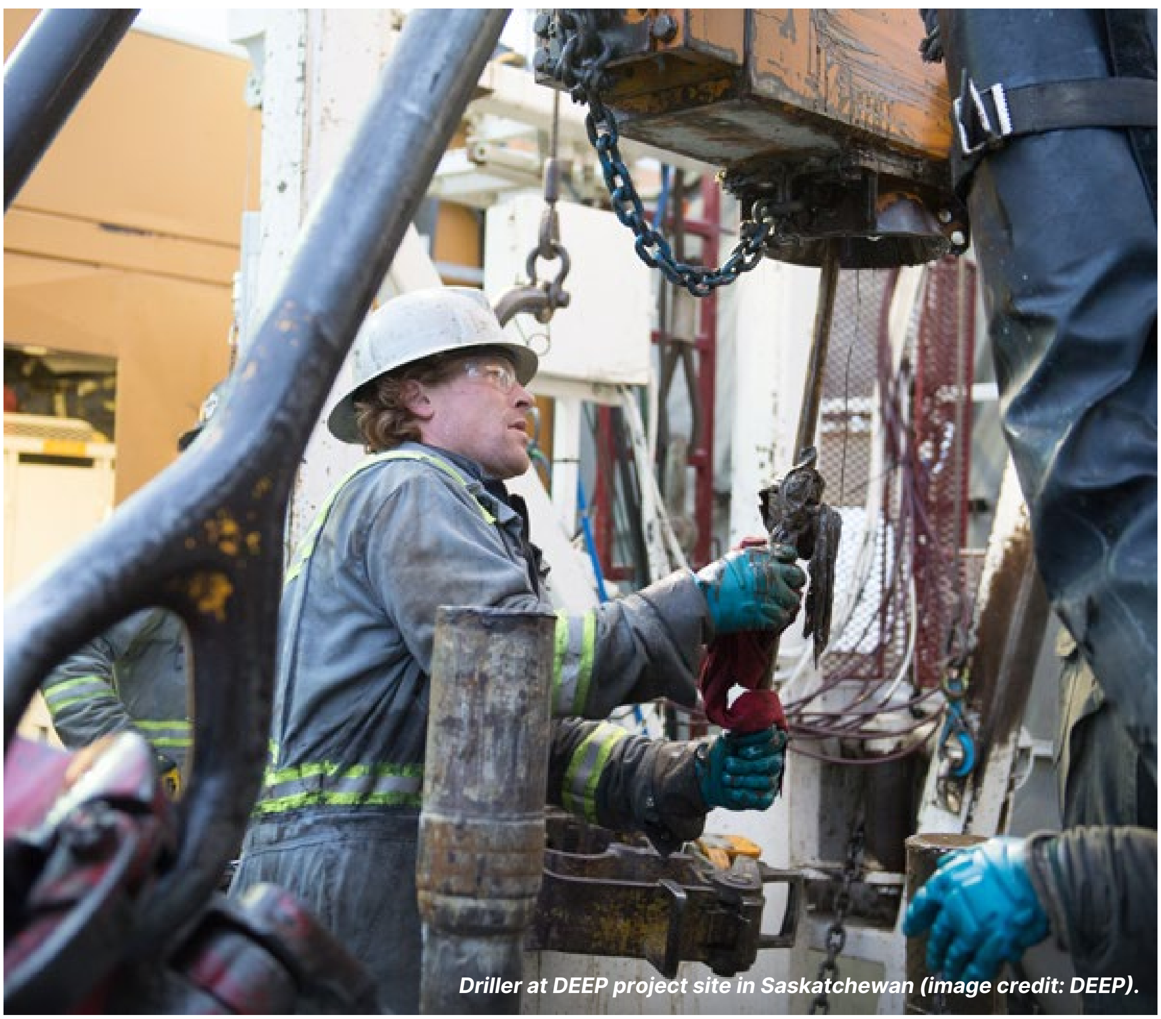
Liability management

Liability regulations are essential to ensure responsible management of subsurface developments, such as geothermal projects. These regulations hold developers accountable for the abandonment and reclamation of installations, ensuring environmental and financial responsibilities are met. Without such regulations, there is a risk of orphaned projects, where the financial incapacity of developers leaves substantial environmental liabilities for the state to manage. By requiring measures like security deposits or bonds, jurisdictions can mitigate potential financial risks and encourage responsible development practices. These regulations not only protect the environment but also ensure that public funds are not unduly burdened with reclamation costs, promoting sustainable and responsible resource management.



3. The regulatory state of play in Canada

Because of the similarities between oil and gas development and geothermal development, some Canadian jurisdictions have existing regulations for leasing resource rights, drilling, and production of subsurface fluids that can be modified and augmented to include geothermal resources. Of Canada's thirteen jurisdictions, three (British Columbia, Alberta, and Nova Scotia) currently have regulations for deep geothermal resources (Directive 089, 2022; Geothermal Resources Act, 2010; Government of Nova Scotia, 2018). Saskatchewan has permitted a geothermal project and has temporary measures in place to allow for geothermal development while they develop regulations (Government of Saskatchewan, 2019). A summary of these regulations can be found in Table 3.



Driller at DEEP project site in Saskatchewan (image credit: DEEP).

TABLE 3:

Only four provinces have or are developing geothermal regulations

Jurisdiction	Definition	Resource ownership	Tenure
Alberta	Natural heat in rock formations and fluids in the earth below the base of groundwater protection (Alberta Regulation 116/2022).	The Crown of Alberta owns mineral resources in the province and leases these titles to developers. Mineral title holders have the right to explore for, develop, recover, and manage geothermal resources (Alberta Regulation 251/2021).	Leases are initially issued for a five-year term and allow for exploration, recovery, and development. Leases can be extended for an additional five years if a geothermal assessment report proves the lease is potentially productive (Alberta Regulation 251/2021).
British Columbia	Natural heat of the earth that reaches temperatures of 80°C or above, and substances including steam, water, and water vapour, as well as substances dissolved therein (except for oil and gas) (Geothermal Resources Act, 2010).	The government of British Columbia owns all geothermal resources, and the Ministry of Energy, Mines, and Low Carbon Innovation administers them (Geothermal Resources Act, 2010).	Exploration permits last one year and can be renewed seven times (Geothermal Resources Act, 2010). Leases for production expire after 20 years and can be renewed for five years, or 20 years under an approved production plan (British Columbia Energy Regulator, 2023).
Nova Scotia	Natural heat created by the earth or from substances including water, steam, and water vapour below the surface of the earth (Government of Nova Scotia, 2018).	The Crown owns mineral resources and, based on the specifications of the Mineral Resources Act, the same regulations apply as if the geothermal resources were minerals (Government of Nova Scotia, 2018).	Exploration licences last two years, and renewals add two more years. A mineral lease lasts 20 years (Government of Nova Scotia, 2018).
Saskatchewan	The province provides some guidance, but no definition or specific geothermal regulations.	The Crown of Saskatchewan owns most, but not all, mineral resources (Crown Minerals Act, 1985). The Crown can lease pore space that contains or previously contained Crown minerals.	Saskatchewan's Subsurface Mineral Tenure Regulations set the term of a permit at eight years. A permit may be converted to a lease with a term of 21 years and can be renewed for additional terms (Government of Saskatchewan, 2015).

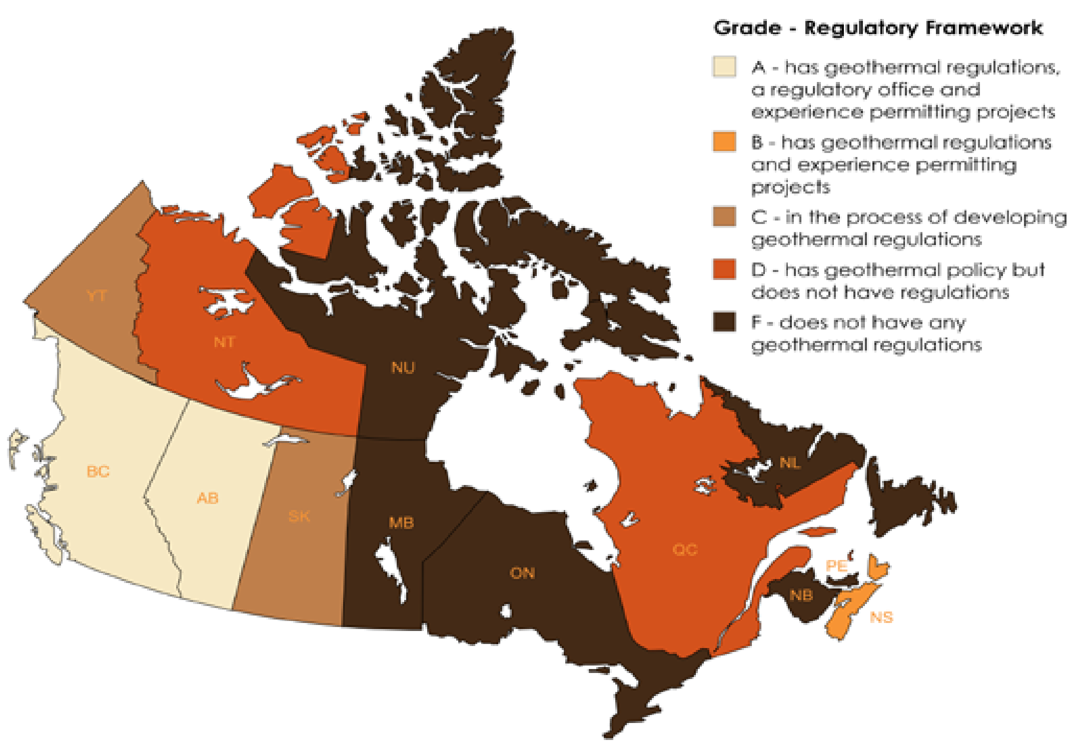
Other jurisdictions are developing geothermal regulations:

- The Yukon Territory is developing regulations for geothermal resources (Government of the Yukon, 2023).
- The Northwest Territories and Quebec both have policy statements regarding geothermal development, but do not have regulations in place (Government of the Northwest Territories, 2018; Government of Quebec, 2022).

The remaining Canadian jurisdictions do not have any geothermal regulations. Figure 4 presents a summary of the status of Canadian geothermal regulations, based on the classifications created by Young et al. (2019). A detailed description of each province's regulatory status is available in Appendix B of the Ultradeep Geothermal Research and Action Roadmap (Gall et al., 2024). By developing and harmonizing geothermal regulations across all jurisdictions, Canada can create a conducive environment for geothermal project development. This will minimize project development risks and attract private investment.

FIGURE 4:

Geothermal regulation in Canada is inconsistent and incomplete



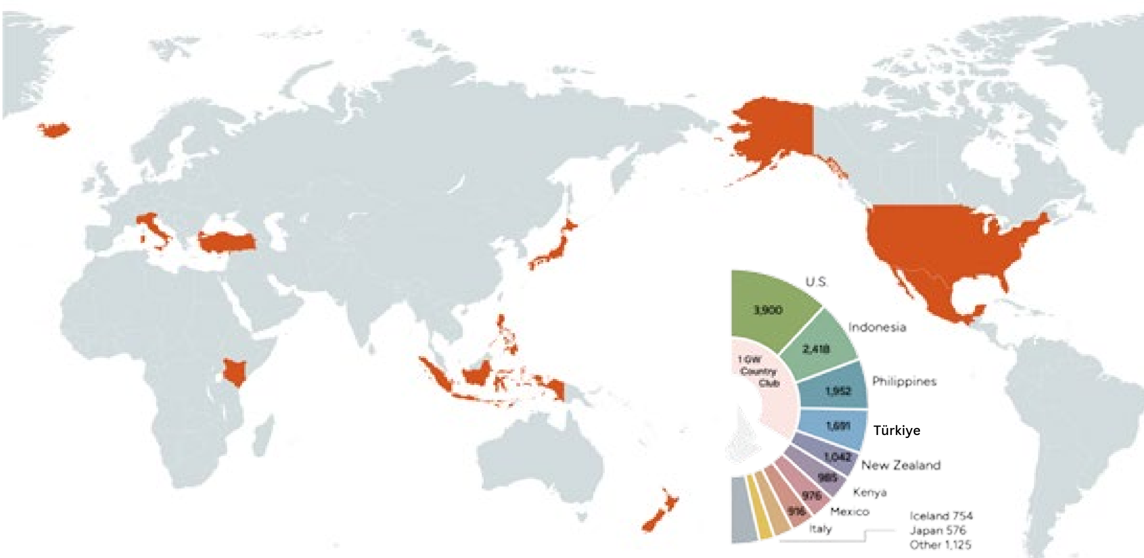
Classifications based on Young et al., 2019.

4. Regulations of top global geothermal electricity producers

We surveyed the subsurface regulations from the world's 10 largest geothermal producers to identify regulatory best practices from around the world that Canadian jurisdictions should adopt. While production capacity is not necessarily a product of effective subsurface regulation (for example, a country could have limited subsurface regulations but tremendous financing or an undeniable resource), it is hard to imagine significant geothermal production emerging in a country with little or poor subsurface regulation. Our analysis assumes that countries with successful geothermal industries have learned lessons that can be translated into effective regulation in Canada.

FIGURE 5:

Just 10 countries generate over 90 percent of the world's geothermal power



Canada currently generates only six megawatts (0.006 gigawatts) of geothermal power, at a natural gas co-producing facility in Swan Hills, Alberta (Huang et al., 2024). Modified from ThinkGeoEnergy, 2024.

Many of the countries evaluated did not have regulatory documents and laws available in English. Evaluations were completed using translated copies of these documents. In case of discrepancies, please refer to the regulations in their original language.

For each country, we evaluate the following components, which we outlined above in Section 2.

Resource **definition**:

- How is geothermal energy defined?
- Are geothermal resources governed by pore space, heat, pressure, or fluid?
- Where is the energy originating from and at what depths is it found?
- What can geothermal energy be used for?

Resource **ownership**:

- Who owns the subsurface geothermal resource?
- How are geothermal rights granted?
- What size lease area is granted and at what depth within the subsurface?
- Are multi-commodity resource rights and extraction permitted?

Resource **tenure**:

- How are the stages of geothermal development defined?
- What activities are permitted during each stage?
- How long is ownership granted during each stage?

Insights for Canada:

- What can Canada learn from this county’s experiences with subsurface geothermal regulation?

4.1. UNITED STATES:

Template regulations can bring consistency across jurisdictions

The United States is the global leader in installed geothermal electricity capacity at 3,900 megawatts as of 2023 (ThinkGeoEnergy, 2024). Most of the installed capacity exists in the western portion of the country, within the volcanic Pacific Ring of Fire (Mlawsky & Ayling, 2020).

FIGURE 6:

Geothermal power plants in the continental U.S. are concentrated in the west, where heat is close to the surface

(ThinkGeoEnergy, 2025)

The regulation of subsurface geothermal resources in the United States is complex. Geothermal definition, ownership, and tenure vary by state. For example, ownership of geothermal resources can be tied to the surface landowner, the mineral rights owner, or the water rights owner, depending on the state. The National Renewable Energy Laboratory identified this complexity as a non-technical barrier to geothermal development in 2019, and they have since published considerations for state geothermal regulations (Levine et al., 2023;

Young et al., 2019). These considerations include geothermal resource ownership, definition, leasing process, and the permitting process. They are primarily focused on the exploration, development, and operation phases of geothermal project development.

Levine et al. also outline the existing geothermal regulations for federally owned lands in the United States. The Bureau of Land Management manages the subsurface rights on federally owned lands. Over 60 percent of the country's geothermal electricity is generated from these lands (Bureau of Land Management, 2024a). The regulations governing federal subsurface geothermal development could be a useful model for Canada

RESOURCE DEFINITION

Resource: The resource is fluid, heat, and byproducts and includes both surface and subsurface resources.

Source, temperature, and depth: No depth or temperature range is prescribed, but the definition includes both naturally occurring and artificially introduced fluids and would include heat storage.

Use: The resource can be used for both heat and power.

On federally owned lands, geothermal steam and associated geothermal resources are defined as:

- All products of geothermal processes, including indigenous steam, hot water, and hot brines.
- Steam and other gases, hot water, and hot brines resulting from water, gas, or other fluids artificially introduced into geothermal formations.
- Heat or other associated energy found in geothermal formations.
- Any byproducts (43 CFR Part 3200—Geothermal Resource Leasing, 2025).

These resources can be used for electricity and/or heat (43 CFR 3270.10). This definition is inclusive of both surface and subsurface geothermal resources. It also includes both naturally occurring and artificially introduced fluids, ensuring that developers can use conventional, enhanced, or advanced geothermal technologies to capture the resource. The definition also includes the introduction of hot fluids into the subsurface and would therefore apply to heat storage as well.

RESOURCE OWNERSHIP

Ownership: The U.S. government owns geothermal resources on federal land.

Granting rights: The Bureau of Land Management grants rights to explore and develop geothermal energy through leases.

Lease size: Lease areas range from 640 to 2,560 acres, with a maximum of 51,200 acres per developer per state.

Multi-commodity extraction: Allowed, but additional permits are required.

On federally owned lands, subsurface geothermal resources are treated as a mineral resource. The federal government of the United States owns this resource, and the Bureau of Land Management grants leases to it. The Bureau is also responsible for regulating subsurface resource development on federal lands (Federal Land Policy and Management Act of 1976, as Amended, 2022).

Based on the federal definition of geothermal resources, developers who have leased rights would be entitled to use the heat and fluid, either naturally occurring or introduced. The developer would also own byproducts existing within the geothermal fluid (such as critical minerals). Oil, gas, and helium are excluded from the geothermal lease, and the developer would not have the right to extract these. The Bureau of Land Management has the right to lease these rights over the same area as the geothermal lease, if they do not interfere with geothermal operations (43 CFR 3210.13).

Subsurface geothermal leases may be issued either through a competitive or non-competitive process. For lands considered prospective for commercial electricity production, leases are granted by the competitive process. Developers nominate lands, up to 5,120 acres, for inclusion in a geothermal lease sale. The Bureau of Land Management may also add adjacent lands to those nominated by the developer for inclusion at a sale. The Bureau must hold a competitive bid for geothermal leases at least every two years. It can also offer lands for competitive bids, even if no nominations have been submitted. Competitive leases must be announced at least 45 days prior to sale, with details around the lands available, the time of the sale, and the bidding requirements. The lease is awarded to the highest qualified bidder (43 CFR Part 3200, Subpart 3203).

If no valid bids are received, the geothermal lease area will be available for noncompetitive purchase for two years after the competitive bid process closes. The noncompetitive leasing process is used for lands intended for only direct heat use, and lands subject to a mining claim. Developers can only apply for the noncompetitive purchase of geothermal rights on lands that have been previously offered through the competitive leasing process (43 CFR Part 3200, Subpart 3205).

The size of geothermal leases on federal lands cannot be smaller than 640 acres (one square mile), except for direct-use leases, which have no prescribed minimum. A single developer may not hold more than 51,200 acres in any one state (43 CFR Part 3200, Subpart 3206). There is no prescribed depth for federal geothermal leases and rights are awarded based on nomination and intended use.

RESOURCE TENURE

Tenure type	Permitted activities	Timeline
Primary	Geophysical and geochemical surveys, drilling, testing, and resource assessment.	10 years with up to two five-year extensions
Drilling Extension	Drilling of exploratory and confirmation wells.	Five years
Production	Drilling production and injection wells, electricity generation, and direct-use applications.	35 years with up to a 55-year extension

Subsurface geothermal leases on federal lands tenure consists of:

- Primary: 10 years with up to two five-year extensions
- Drilling: Five years
- Production: 35 years with up to a 55-year extension

The primary term covers exploration activities and developers are required to complete the following work during the first 10-year term (43 CFR 3207.11):

- Spend at least $40 per acre on development activities including:
  - Drilling
  - Geophysical and geochemical surveys
  - Testing
- Submit a report every three years outlining the activities completed, expenses, and results to the Bureau of Land Management.

To use the five-year extensions of the primary term, developers must spend at least $15 per acre on development activities including:

- Drilling
- Geophysical and geochemical surveys
- Testing

Additionally, following the first five-year extension, developers must spend $25 per acre on the same development activities for the second five-year extension, and must submit a yearly report outlining the activities completed, expenses, and results to the Bureau of Land Management.

The Bureau of Land Management will allow developers to pay them the equivalent value if they have not met the required spend amounts during the primary lease period. If the developer fails to meet the requirements of the primary lease period, the lease will expire, and the geothermal resource ownership will revert to the federal government (43 CFR 3207.12).

The developer is granted a drilling lease extension after the primary lease expires if the developer is currently drilling or will begin drilling within one year. A drilling extension can be granted following the primary lease term or one of the two primary lease extensions (43 CFR 3207.14). In total, developers have up to 25 years to fully characterize and develop a geothermal resource for production during the primary lease tenure.

The production tenure period is 35 years with up to a 55-year extension. To qualify for production tenure, developers must show the Bureau of Land Management that they have a geothermal well generating commercial geothermal energy, or that it can generate commercial geothermal energy. This includes a characterized geothermal resource, obtaining appropriate permits and agreements for electricity generation and transmission. Developers must also prove they are making diligent efforts towards utilizing the geothermal resource. Should the developer fail to prove they have met the above requirements, the lease will expire, and the resource rights will return to the federal government (43 CFR 3207.15).

INSIGHTS FOR CANADA

Geothermal regulation in the United States varies widely across states, reflecting the complexities of a federal system where jurisdictional responsibilities often overlap. As geothermal development accelerates, U.S. states are working to align their regulatory frameworks with their specific governance structures. Canada faces a similar challenge and must develop a regulatory approach that is both consistent across provinces and territories and adaptable to these distinct legal and environmental contexts.

> *The U.S. experience demonstrates that a burdensome and time-consuming permitting process can significantly hinder geothermal innovation and development—particularly on federal lands.*

Like the U.S., Canada's federal system involves layered jurisdictional authority, which can lead to regulatory fragmentation. The U.S. experience demonstrates that a burdensome and time-consuming permitting process can significantly hinder geothermal innovation and development—particularly on federal lands. In response, the U.S. is now implementing policy reforms to streamline these processes (Sercy, 2024). Canada has the opportunity to learn from this experience and adopt a more coordinated, efficient regulatory framework from the outset.

Ulubelu Geothermal Power Plant in Lampung, Indonesia.

4.2. INDONESIA:

Automation and comprehensive post-operation regulations bring speed and certainty

Indonesia, situated on the Ring of Fire, estimates that it contains about 40 percent of the world's conventional geothermal potential. There are 252 geothermal sites located along volcanic formations, with an estimated potential of 27 gigawatts electric (Asian Development Bank & the World Bank, 2015; Suharmanto et al., 2015). As of 2023, Indonesia is the second-largest producer of geothermal energy, with an installed capacity of over 2,300 megawatts (ThinkGeoEnergy, 2024). Challenges in Indonesia's geothermal energy sector can be categorized into upstream and downstream issues. Upstream challenges include limited resource data during auctions, deterring investment due to high financial risks, and substantial initial exploration costs, often exceeding USD$25 million, with significant losses if exploration fails. Additionally, nearly 42 percent of geothermal potential is in conserved or protected forest areas, previously restricted under mining regulations. To address these issues, the government introduced a Geothermal Fund to reduce resource risks and financial barriers, although its

FIGURE 7:

Indonesia contains 40 percent of the world's hydrothermal geothermal potential and is the second-largest geothermal power producer

(ThinkGeoEnergy, 2025)

stringent requirements impede its effectiveness. The Geothermal Law also reclassified geothermal as a non-mining activity, allowing operations in protected areas under environmental service permits. Downstream challenges included unattractive electricity tariffs that initially discouraged developers and a monopoly power market structure. These issues were mitigated by the Ministry of Energy and Mineral Resources' Decree No. 17/2014, which introduced higher benchmark prices for geothermal electricity, enabling price negotiations and ensuring fairness for both developers and the power utility (Setiawan, 2014).

Another significant barrier has been the complex permitting process (Setiawan, 2014). In 2024, the Indonesian government took decisive steps to streamline this process by reducing permit processing time for geothermal projects from 18 months to just five days. They did this by implementing the Online Single Submission (OSS) facility and by simplifying requirements for initial permits, such as the Suitability of Spatial Utilization Activities (KKPR) and Environmental Impact Analysis (AMDAL) permits (Cariaga, 2024a).

RESOURCE DEFINITION

Resource: The resource is defined as heat and applies to both surface and subsurface resources.

Source, temperature, and depth: No temperature, depth, or source of resource is specified. This definition would include heat storage.

Use: The resource can be used for heat or power generation.

In Indonesia, "Geothermal is a source of heat energy contained in the hot water, steam, and rock along with other associated minerals and gases that are genetically inseparable in a geothermal system" (Law No. 21 of 2014 on Geothermal, 2014). The resource is defined as the heat and not the fluid or rock. This definition does not include a source and would include heat storage. It does not prescribe depth or temperature and would include both surface and subsurface resources.

The government regulates geothermal resources, which it recognizes as a national asset, to promote sustainable national development, enhance energy security, and reduce dependence on fossil fuels. Geothermal exploitation in Indonesia is divided into two categories: direct and indirect utilization. Direct utilization is the immediate application of geothermal energy for non-electrical purposes, such as industrial activities, agribusiness, and tourism. Indirect utilization is the secondary use of geothermal energy for electricity generation.

RESOURCE OWNERSHIP

Ownership: The resource is owned and controlled by the state.

Granting rights: Geothermal permits are granted by the Ministry of Energy and Mineral Resources by public tender.

Lease size: Specific lease size is determined by the government on an individual basis.

Multi-commodity extraction: Is not specified.

Geothermal resources in Indonesia are controlled by the state. Geothermal development rights are usually awarded via public tenders, with leases providing exclusivity to one developer for exploration and exploitation. The specific characteristics of each geothermal site determine lease area size and depth. The New Geothermal Law of 2014 separates geothermal activities from mining, eliminating the mining classification and its related regulations (Law No. 21 of 2014 on Geothermal, 2014). This change permits geothermal projects to function in protected and conserved areas with government approval.

RESOURCE TENURE

Tenure type	Permitted activities	Timeline
Exploratory (geothermal permit)	Geological, geophysical, geochemistry, test drilling, and feasibility studies.	Five years, extendable up to two years
Exploitation (geothermal licence)	Development drilling, construction of power plants, production and utilization of geothermal energy.	30 years, extension based on evaluation
Post-operation	Environmental restoration and site rehabilitation, land use and compensation, settling of financial obligations, decommissioning of infrastructure, compliance with government approval, and final reporting.	None specified

Geothermal development in Indonesia starts with obtaining a Geothermal Permit, which allows entities to conduct geological, geophysical, and geochemical surveys, as well as test drilling and feasibility studies. This permit is granted for a five-year period that can be extended by up to two years based on the progress and results of assessments. Following successful exploration, entities must obtain a Geothermal Licence. The permit holder does not have exclusive rights to a licence, which is typically awarded via a public bidding process. This licence authorizes the exploitation phase, which includes comprehensive activities such as development drilling, geothermal power plant construction, and geothermal energy production and utilization. The Geothermal Licence has an initial term of 30 years and may be extended based on performance. After geothermal operations, licence holders must complete environmental restoration, site rehabilitation, land-use resolutions, financial settlements, infrastructure decommissioning, and final compliance reporting to ensure compliance with environmental standards and regulatory requirements.

INSIGHTS FOR CANADA

By implementing automated spatial analysis in applications, Indonesia has successfully reduced initial permitting times from 18 months to just five days. This streamlined and automated approach during the initial exploration phase mitigates risks during the most critical stage of development. However, geothermal projects transitioning to exploitation still require thorough analysis by government officials. Canada could adopt a similar semi-automated method for initial permitting, which would help lessen the regulatory staffing demands for geothermal projects.

Indonesia also incorporates a comprehensive and detailed post-operation (or decommissioning) phase within its regulations. This ensures that all geothermal projects are adequately reclaimed, restoring the environment to its original condition. This is particularly crucial now that the government is issuing geothermal permits and licences in environmentally sensitive areas. By outlining post-operation requirements in the regulations, developers are required to factor these activities into their budgets and plans. When crafting regulations in Canada, establishing clear expectations and financial accountability for decommissioning can ensure that developers take responsibility for post-operation reclamation, preventing the burden from falling on either the government or the environment.

Geothermal power station in Negros, Philippines.

4.3. PHILIPPINES:

Clear, technology agnostic regulation speeds development

The Philippines leverages its strategic location along the Pacific Ring of Fire to harness its geothermal energy potential. As the third-largest producer of geothermal energy globally, the country had installed capacity exceeding 1,900 megawatts as of 2023 (ThinkGeoEnergy, 2024). These resources, located at depths of up to three kilometres, are primarily concentrated in high-temperature volcanic fields and moderate-temperature reservoirs, with temperatures ranging from 150 to 300°C (Benito et al., 2005; Halcon et al., 2015). Through its geothermal development, the Philippines has gained valuable experience that has shaped its policies, particularly in how it works with Indigenous Cultural Communities and host communities. Regular assessment of social acceptability and harmonized renewable energy policies have proven essential in addressing conflicts and minimizing project delays (Ratio et al., 2019).

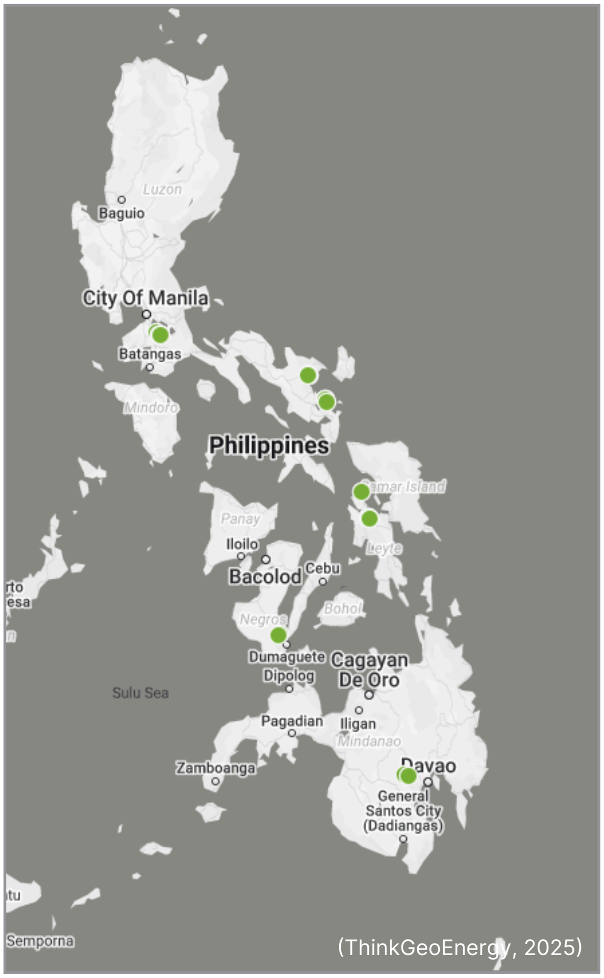


FIGURE 8:

The Philippines leveraged its location on the Pacific Ring of Fire to become the third-largest producer of geothermal power

RESOURCE DEFINITION

Resource: Resource is defined as energy and applies to subsurface and surface resources.

Source, temperature, and depth: No exact temperatures or depths are outlined in the law, but the source must be naturally occurring and would not apply to heat storage.

Use: The resource can be used for both heat and power.

The Philippines defines its geothermal resource as the energy derived or derivable from and produced within the earth by natural phenomena, including steam, water vapour, and any mixture of these heated by underground energy (Geothermal Energy, Natural Gas and Methane Gas Law, 1967). Using energy as the resource definition includes heat, fluid, and pressure. This makes the definition technology agnostic and flexible enough to not become outdated as new resource extraction methods are invented. The definition does not specify a depth and would include both surface and subsurface energy. No resource temperature is specified, but only naturally generated energy is included. This means that heat storage operations would not be included in this definition.

RESOURCE OWNERSHIP

Ownership: The resource is owned by the state.

Granting rights: The state grants developers licences; landowners may explore their own land without a permit, provided it is for personal use.

Lease size: Permit area shall not exceed 5,000 hectares.

Multi-commodity extraction: Is allowed.

Philippine law (Geothermal Energy, Natural Gas and Methane Gas Law, 1967) states that all geothermal resources, regardless of their location on public or private lands, are owned by the state. Owning surface land for agriculture, industry, or other uses does not grant ownership or rights to the geothermal resources below. However, landowners may use geothermal energy from their land for personal purposes without a permit, and existing domestic users at the time of the law's enactment (1967) may continue their usage unless otherwise directed by the Director of Mines.

Geothermal resources can only be explored, developed, and used with permits and leases from the government. Granting of these leases depends on meeting qualifications, providing required evidence, and following public notification rules. A lessee has exclusive rights to explore, drill, and use geothermal resources in the designated area and subsurface zones for the duration of the lease. Multi-commodity extraction is allowed under certain conditions. Minerals combined with steam, water, or vapour can be extracted without being subject to the Mining Act, if the extraction is incidental to geothermal energy operations.

Recent policy changes now allow foreign companies to participate in large-scale geothermal exploration, development, and utilization in the Philippines under the third Open and Competitive Selection Process. Foreign investors must meet specific conditions to participate. These include a minimum investment of USD$50 million, which qualifies the project as large-scale, and adherence to a Financial and Technical Assistance Agreement (Department of Energy, 2020).

RESOURCE TENURE

Tenure type	Permitted activities	Timeline
Exploratory (permit)	Geological, geophysical, test drilling, feasibility studies, and production testing	Three years, extendable up to a maximum of seven years
Production and utilization (lease)	Geothermal resource extraction, injection, and re-injection of fluids, production drilling, and facility construction.	25 years with a single 25-year renewal
Post-operation	Well closure, site rehabilitation, financial and reporting obligations	None specified

According to the Geothermal Service Contract (Department of Energy, n.d.), geothermal development in the Philippines starts with the pre-development stage (exploration stage), which can last up to seven years from the contract's effective date. The renewable energy developer performs feasibility studies, geoscientific surveys, and exploratory drilling to confirm resources, leading to the submission of a declaration of commerciality to verify the resource's viability. If this declaration is not submitted and approved by the Department of Energy (DOE), the contract will expire automatically, but until then the developer retains exclusive exploration rights. Once commerciality is confirmed, the project moves to the development stage, lasting up to 25 years with a possible renewal for an additional 25 years. This stage includes building and installing production facilities, testing and commissioning geothermal plants, and connecting to the grid, with exclusive rights to develop and use the geothermal resources. The final phase, decommissioning, starts when the contract ends and involves carrying out an abandonment and termination plan. This includes decommissioning facilities, restoring the surface, and transferring any remaining data and assets to the Department of Energy. Equipment left on site will be considered property of the state.

INSIGHTS FOR CANADA

The Philippines' definition of a geothermal resource classifies it as energy. This definition is technology agnostic, all-encompassing, and would include heat, fluid, and pressure. This is likely the reason the country has not had to amend its definition of geothermal resources since regulations were established in 1967. By defining its geothermal resource as energy (in the form of heat and/or pressure), Canada can futureproof its geothermal regulations to include all geothermal extraction technologies.

The Philippines has also effectively included stakeholders in geothermal development, especially Indigenous Cultural Communities and host communities, which has improved public trust and reduced socio-political conflicts. Three notable case studies illustrate the country's approach to overcoming challenges (Box 2; Ratio et al., 2019):

BOX 2:

Geothermal case studies in the Philippines

Tiwi Geothermal Project (Albay)

The Tiwi geothermal complex, the Philippines' first large-scale geothermal power project, faced environmental, health, safety, and political challenges due to the absence of clear regulations and social frameworks. Legislative support through the Department of Energy Act of 1992 successfully resolved these challenges, providing financial benefits to host communities and improving social acceptance. Additionally, in 2000, an education campaign targeted local communities and schools, promoting safety practices, raising awareness of geothermal operations, and enhancing communication through workshops and surveys for teachers and municipal representatives.

Makiling-Banahaw Geothermal Complex (Laguna-Batangas)

The Makiling-Banahaw geothermal complex, located 70 kilometres southeast of Manila, faces challenges with encroachment, pilferage, right-of-way conflicts, and dissatisfaction with royalty distribution. Socio-political and jurisdictional disputes further delayed activities, while residents' concerns over odours and noise reduced support for expansion. To address this issue, the developer used a Community Impact Review to address security, cultural, and economic concerns during project planning. Combined with a stakeholder engagement plan, this approach has improved relationships with local communities.

Mindanao Geothermal Project (Mt. Apo)

The Mindanao Geothermal Project encountered challenges due to its location in a national park, on an ASEAN heritage site, and in the ancestral land of Indigenous Peoples. Concerns about violating park laws and international commitments were resolved when the Department of Environment and Natural Resources clarified that energy development within parks is allowed, and the Department of Foreign Affairs confirmed that the ASEAN agreement was not legally binding. To support sustainable development, the project incorporated biodiversity inventories, Environmental Impact Assessments, and Environmental Risk Assessments to address potential risks. Given the project's sensitivity, a third-party Environmental Impact Assessment was conducted, and consultations with tribal leaders led to agreements on crop compensation, local employment, environmental safeguards, and recognition of ancestral land rights. Traditional ceremonies were also performed to align the project with local cultural practices.

While relying on stakeholder engagement has sometimes caused project delays, the practice has improved public trust and reduced project opposition. By regulating geothermal flexibly, the Philippines has adapted to development challenges and public opposition. This flexibility should be mirrored in Canada's geothermal regulations to allow for adaptation as new technology and unexpected roadblocks are encountered.

Separator at a geothermal power plant in Buharkent, Türkiye.

4.4. TÜRKIYE:

Effective public communication reduces project opposition

Türkiye's geothermal potential is closely linked to its geological setting, particularly the West Anatolian extensional tectonics (Serpen & DiPippo, 2022). This region features a significant heat source and a broad graben system that facilitates geothermal water circulation, supporting the country's geothermal resources, with an installed capacity of 1,700 megawatts (ThinkGeoEnergy, 2024). The deepest geothermal reservoir was accessed through drilling that reached depths of up to 4,500 metres, with temperatures of 240°C (Mertoglu et al., 2019).

Geothermal power plant installations in Türkiye have increased due to two key economic factors: affordable drilling and a strong feed-in tariff program. Türkiye's drilling industry is supported by competition among private and state-owned companies and has used idle oil and gas drilling rigs. The Turkish government initially introduced a feed-in tariff program to provide financial incentives for investment and development (Serpen & DiPippo, 2022). Growth had slowed and nearly stopped by 2021, however, due to two main factors: lower financial

FIGURE 9:

Türkiye harnessed its oil and gas expertise, a hot resource, and public funding to develop its geothermal power

(ThinkGeoEnergy, 2025)

incentives and the maturation of geothermal discoveries. The reduction in the feed-in tariff program has made geothermal projects less economically viable. Much of Türkiye's geothermal resource has already been developed, and few opportunities remain with current technology (Serpen & DiPippo, 2022).

Public opposition and environmental concerns have also slowed progress. This opposition has been driven by misinformation regarding geothermal energy's health and environmental impacts. Claims that geothermal operations cause cancer, reduce agricultural productivity, or release harmful wastewater and gases have fuelled opposition. Improper reinjection practices and legal issues regarding environmental reports by smaller developments have damaged the sector's reputation (Serpen & DiPippo, 2022).

RESOURCE DEFINITION

Resource: Defined as heat and applies to naturally occurring and artificially introduced fluids.

Source, temperature, and depth: The resource includes both naturally occurring and artificially introduced heat, in both the surface and subsurface. It includes any heat at temperatures greater than the local average annual surface temperature.

Use: No use case is specified, and this definition could apply to all uses of the resource.

A geothermal resource is defined in the law on geothermal resources and mineral waters as "Locations that have temperatures constantly higher than the annual atmospheric average temperature of the region with the effect of the temperature of the earth's crust depending on the geological structure, that may contain melted materials and gas in an amount higher than the surrounding water resources, where water, vapor and gas naturally erupt or are naturally extracted along with places where water, vapor and gas are obtained via heating by the earth's crust or heated dry rocks through man-made structures underground" (Government of Türkiye, 2007).

This definition characterizes the resource by heat and applies to both naturally occurring and artificially introduced fluids used to harvest that heat. The wording around the resource temperature covers all heat that is higher than the annual average surface temperature of the area. This definition will cover both shallow (geo-exchange or ground source heat pumps) and deep geothermal developments as no depth is defined. It includes minerals and gases that are dissolved in or occur with the geothermal resource. The definition also applies to manufactured structures underground and would therefore include shallow heat storage, closed loop (advanced geothermal) systems, and enhanced geothermal systems.

RESOURCE OWNERSHIP

Ownership: The resource is owned by the state, not the surface landowner.

Granting rights: The state grants Turkish citizens or companies rights to the resource.

Lease size: Maximum of 5,000 hectares granted to a single entity.

Multi-commodity extraction: Unclear if this is permitted.

Geothermal resources are regulated by the state, falling under its governance and execution, and are not included in land ownership rights. Rights to these resources are granted through licences issued by the state, encompassing both exploration and operational licences. The maximum exploration lease area is set at 5,000 hectares, with rights granted to a single individual or legal entity. These rights are non-transferable to multiple entities unless they are explicitly assigned or terminated under legal provisions.

RESOURCE TENURE

Tenure type	Permitted activities	Timeline
Exploratory	Geochemical, geophysical, test drilling, and production testing	30 years with optional 10-year renewals
Operating	Geothermal resource extraction, injection, re-injection, production drilling, and facility construction.	30 years with optional 10-year renewals
Post-Operation	Well closure, environmental restoration, and site cleanup.	None specified

The Law on Geothermal Resources and Mineral Waters (Government of Türkiye, 2007) divides geothermal resource development into exploration, operation, and post-operation. Three-year licences with a one-year extension are issued during exploration. Geochemical, geophysical, test drilling, and resource evaluation can be conducted during this phase, with production limited to testing. An operating licence authorizes resource extraction, reinjection, facility construction, and well expansion if these activities follow project plans and receive administrative approval. Operational licences last 30 years, with 10-year renewals available. Post-operation activities include well closure, environmental restoration, and site cleanup. After licence termination, state control of facilities and wells ensures resource conservation and safety (Government of Türkiye, 2007).

Licences are issued in response to an application. Should there be more than one application for a site, the project with the fastest development and highest investment value will be awarded the licence. The legislation also mandates the conservation of the resource reservoir. Developers must operate in a way that does not waste the geothermal resource and that protects the environment (Government of Türkiye, 2007). Mandating resource conservation ensures geothermal energy remains a renewable resource and is not depleted with development.

INSIGHTS FOR CANADA

Türkiye demonstrates the importance of fostering public trust through proactive and transparent community engagement. Clear, evidence-based communication regarding environmental and health matters has proven effective in reducing project opposition (Serpen & DiPippo, 2022). Projects that offer social benefits—such as job creation, local infrastructure enhancement, and utilizing waste geothermal water for agriculture—demonstrate how geothermal energy can improve the quality of life in local communities. Türkiye has responded to public acceptance challenges related to the reinjection of geothermal fluid with environmental compliance and education initiatives. Canada can draw lessons from Türkiye's experience balancing geothermal project development, environmental stewardship, and community welfare.

4.5. NEW ZEALAND:

A thriving geothermal sector can honour treaties and Indigenous resource claims

New Zealand's position on the tectonic boundary of the Indo-Australian and Pacific plates offers substantial geothermal energy resources. This geothermal activity comes from high heat flow in the crust at the tectonic plate boundary, making it suitable for geothermal energy use. Geothermal systems in New Zealand are located one to three kilometres underground, with reservoir temperatures ranging from 200°C to 300°C. High-temperature systems are important in New Zealand's energy sector, with an installed geothermal capacity of 1,042 megawatts, positioning the country as a leader in geothermal energy production (New Zealand Geothermal Association, n.d.-a). As of 2021, 18 percent of New Zealand's electricity is provided by geothermal resources, which the country has been developing since 1958 (Bevash et al., 2017; Energy Efficiency & Conservation Authority, n.d.).

(ThinkGeoEnergy, 2025)

FIGURE 10:

Geothermal power plants in New Zealand cluster around the best geologic conditions

RESOURCE DEFINITION

Resource: Defined as a fluid and may apply to both naturally occurring and introduced fluids.

Source, temperature, and depth: The resource is heated by the earth, but no depth is specified and applies to both surface and subsurface fluids above 30°C.

Use: No use case is specified, and this definition could apply to all uses of the resource.

The Resource Management Act 1991 defines geothermal fluid as water heated by natural earth processes to temperatures above 30°C, while water below this temperature is classified as freshwater (New Zealand Parliament, 1991). Geothermal systems in the country are classified by temperature into three types:

- High-temperature systems (200-350°C), associated with magmatic activity and covering areas up to 50 square kilometres.
- Moderate- to low-temperature systems, with maximum temperatures of 140°C at drillable depths and typically non-magmatic.
- Very low-temperature systems, prevalent throughout the country and near ambient temperatures.

The Act defines the resource as the geothermal fluid that transports heat and would apply to both naturally occurring and artificially introduced fluids. It does not specify a depth but applies to subsurface and surface fluids over 30°C. It does specify that the resource is one heated by the natural processes of the earth and would not apply to heat storage.

RESOURCE OWNERSHIP

Ownership: The resource is owned by the Crown (government) but honours Indigenous claims.

Granting rights: The Crown grants licences to developers.

Lease size: Is site-specific.

Multi-commodity extraction: Is allowed.

In New Zealand, common law does not recognize ownership of subsurface geothermal resources, including underground water or geothermal fluid, until they are extracted (Bevash et al., 2017; Traverse Environmental, 2021;

White et al., 1995). Once the geothermal fluid is discharged or produced to the surface, ownership of geothermal energy belongs to the Crown (the New Zealand Government) (Geothermal Energy Act, 1953). New Zealand legislation views geothermal fluids and energy the same as water. The Crown can then grant licences to developers for the use of geothermal energy. The Resource Management Act regulates the use of geothermal resources, and outlines development guidelines (New Zealand Parliament, 1991).

BOX 3:

Geothermal resource ownership case study

The 1840 Treaty of Waitangi is an agreement between the British Crown and the Indigenous Māori peoples of New Zealand. The Treaty of Waitangi Act heightened focus on resource ownership, recognizing Māori claims that geothermal resources and their surface manifestations are *taonga* (treasured possessions) with spiritual significance (Treaty of Waitangi Act, 1975). Under common law, geothermal resources lack absolute ownership, but Māori claims have been upheld in several cases.

Ngawha Springs case:

The Tribunal found that land and resource rights had largely been lost through historical land sales, though claimants retained control over land around the hot springs. The springs, recognized as *taonga* (treasured possessions), allowed claimants to protect them from exploitation, granting significant influence over future resource use despite undefined ownership of deeper geothermal resources (White et al., 1995).

Rotorua geothermal field case:

The Tribunal determined that local Māori tribes are the appropriate authority to evaluate development impacts on geothermal resources and cultural values. This decision grants tribes the ability to develop resources or veto external projects (White et al., 1995).

These cases, and others, highlight Māori influence over resource management, in collaboration with district and regional governments, even without established ownership.

RESOURCE TENURE

Tenure types: Vary by region and defined by resource type, not development stage.

Permitted activities: All necessary activities for development, regulated by the Resource Management Act.

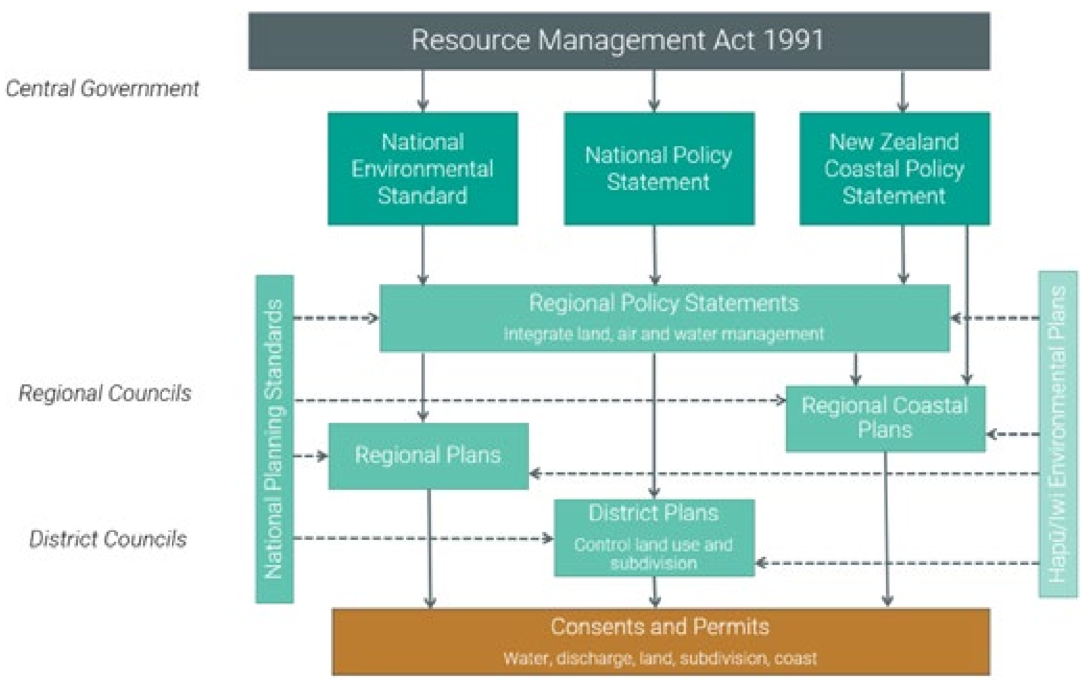
Timeline: Maximum 35-year licences

Governance

Regional and district councils govern geothermal resources, according to the Resource Management Act. Regional councils manage natural and physical resources, emphasizing soil conservation, water quality, and quantity, ecosystem maintenance, and reducing natural hazards, especially in geothermal resource management. District councils manage land use and development impacts, including noise control, land contamination, biodiversity, and infrastructure for geothermal resource access, to ensure sustainable and responsible development. Figure 11 shows the roles of each council in the Resource Management Act.

FIGURE 11:

Regional and district councils govern New Zealand's geothermal resources



(Traverse Environmental, 2021)

Permitting

The regional and district plans outline what specific consent and permits are required for various types of resource development. They authorize the use and development of geothermal resources through resource consents under the Resource Management Act. For example, the Waikato Region, which hosts 10 of New Zealand's 16 geothermal power plants, outlines five types of geothermal development (Waikato Regional Council, n.d.):

- Development systems allow for sustainable and efficient use.
- Restricted development systems allow activities that do not harm surface characteristics.
- Research systems are set up for scientific investigation, with restricted resource extraction until more is understood.
- Protected systems maintain geothermal features of cultural and scientific importance, limiting resource extraction and harmful land use practices.
- Small systems with isolated springs allow limited use and are unsuitable for electricity generation.

Each classification uses a specific management strategy to align resource use with environmental protection and sustainability. Tenure and permits are granted, specific to each application for resource development. There is no specific exploration tenure for geothermal resources, but exploitation tenure is granted for a maximum of 35 years.

INSIGHTS FOR CANADA

New Zealand's geothermal energy framework effectively balances resource development, cultural preservation, and environmental management. While the country has comprehensive resource regulations, it allows regional districts to handle permitting for these resources. Each permit is specific to a site and lacks a structured licensing system, which increases risks for developers due to the absence of a clear permitting process and timelines. Canada would benefit from a more structured licensing system with clearer processes and timelines.

New Zealand's regulations have previously faced challenges in recognizing Māori rights. The Resource Management Act (1991) creates a framework that promotes local governance and Indigenous involvement in decision making. This model may offer Canada, with its own colonial legacy, valuable insights for Indigenous participation, development, and resource ownership.

Table 4 illustrates the differing perspectives on geothermal resource ownership between European and Māori cultures, highlighting the significance of the Treaty of Waitangi, which recognizes Māori claims to the geothermal resource, as a foundational document. In pursuing geothermal developments, Canada should engage with Indigenous groups in alignment with its existing treaties.

TABLE 4:

Māori and European perspectives on geothermal (White et al., 1995)

	Māori	European
Ownership	Collective: assets belong to tribes (*iwi* or *hapū*), emphasizing communal rights and responsibilities.	Individual: absolute ownership rooted in English law, where land and resources are treated as personal assets that can be traded or developed.
Significance	Cultural and spiritual: geothermal features are considered *taonga* (treasures) of ancestral and spiritual importance.	Economic development: prioritizes resource extraction and use for financial and industrial gain.
Legal	Rights asserted through historical claims, the Waitangi Tribunal, and recognition of *taonga*. Focus on stewardship and communal interests.	Governed by property laws and individual rights established under English law and reinforced by the Treaty of Waitangi.
Others	Guardianship: emphasizes *kaitiakitanga* (stewardship), sustainable management, and preservation for future generations in line with cultural traditions.	European perspective often overlooks the cultural and spiritual significance of the land to Māori, leading to tensions and disputes over resources.

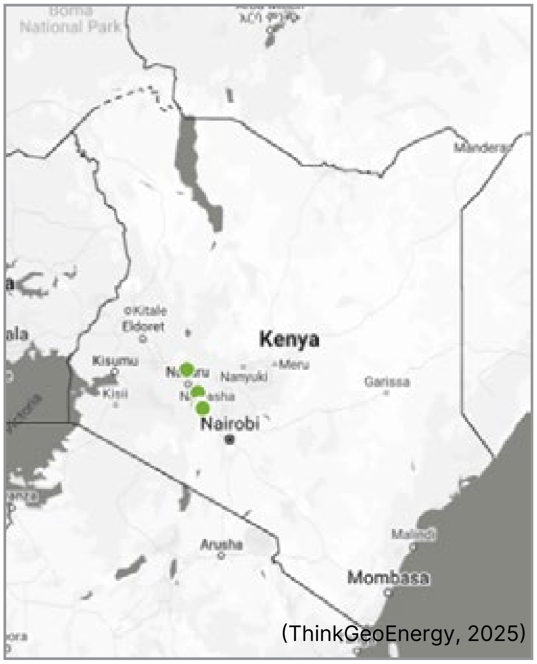
Pipelines of Olkaria Geothermal Power Station in the Hell's Gate National Park, Kenya.

4.6. KENYA:

Public funding can unlock private investment and create an industry

Kenya's geothermal resources, primarily located along the Kenya Rift Valley, have an estimated potential exceeding 10,000 megawatts of electricity (Omenda, 2014; Simiyu, 2008). As of 2023, the country had an installed geothermal capacity of 985 megawatts (Cariaga, 2024b). The geothermal resources from the wells drilled ranged from depths of 1,000 to 3,000 metres, with temperatures ranging between 250°C and 350°C (KenGen, n.d.). The geothermal power generation systems, which began operations in 1981, include dry steam power plants, flash steam power plants, and binary cycle power plants (Bevash et al., 2017; KenGen, n.d.; Patel, 2024).

In 2008, the government formed the state-owned Geothermal Development Comd develop geothermal resources for electricity generation (Geothermal Development Company, n.d.). This state-owned exploration company, along with the state-owned power provider, Kenya Electricity Generating Company, has helped to de-risk the country's geothermal resources. Geothermal energy now provides more than half of the country's electricity. Now that these state-owned entities have derisked geothermal power production, private developers are investing in the industry through Private-Public Partnerships (Cariaga, 2024c).



(ThinkGeoEnergy, 2025)

FIGURE 12:

Geothermal energy provides more than half of Kenya's electricity

RESOURCE DEFINITION

Resource: Defined as heat and applies to naturally occurring and introduced fluids.

Source, temperature, and depth: The source only defines naturally occurring heat and would not apply to artificially stored heat. No depth or temperature is specified.

Use: No use case is specified, and this definition could apply to all uses of the resource.

The Geothermal Resources Act of 1982 defines a geothermal resource as "any product derived from and produced within the earth by natural heat; and includes steam, water and water vapour and a mixture of any of them that has been heated by natural heat whether as a direct product or resulting from other material introduced artificially into an underground formation and heated by natural heat" (Geothermal Resources Act, 1982).

This definition does not specify any depth or temperature of the resource. It does clarify that the resource is heat produced naturally within the earth and therefore would not apply to heat storage. It would apply to both naturally occurring and artificially introduced fluids being used to carry the heat.

RESOURCE OWNERSHIP

Ownership: The resource is owned by the government.

Granting rights: The Minister of Energy grants licences.

Lease size: No size is defined, but the lease must follow drilling regulations.

Multi-commodity extraction: Is permitted for mineral extraction, but not for oil or gas.

Geothermal resources, owned by the government, include steam, water, water vapour, and other substances naturally heated within the earth. To gain the right to explore and extract these resources, project developers must obtain a geothermal licence from the Minister of Energy. Rights to and extraction of multiple commodities are permitted if the byproduct is a mineral, with licences subject to modifications to include mining leases for byproduct recovery. While the maximum lease area for exploration or production is not explicitly defined, operations must follow specific approvals, depth specifications, and safety measures outlined in drilling regulations. Leases are exclusive to a single developer for designated subsurface zones, granting rights for exploration, production, and related construction on the licensed land (Geothermal Resources Act, 1982).

RESOURCE TENURE

Tenure type	Permitted activities	Timeline
Survey	Surface surveys only	None specified
Exploration	Test drilling, surveys, geothermal potential, and limited testing	One year with one renewal
Exploitation—subsurface rights issued as licence	Drilling, testing, extraction, infrastructure construction, and operations	30 years with optional five-year extension
Decommissioning	Decommissioning, reclamation, and remediation	None specified

Kenya's geothermal development includes exploration, exploitation, and decommissioning. The exploration stage includes surveys, investigations, test drilling, and locating geothermal resources. The permit lasts for one year and can be renewed for another year. The rights granted during the exploitation stage include access to licensed land for exploration, drilling, extracting geothermal resources, and building necessary infrastructure. Licences are issued for up to 30 years and can be renewed for five more years. During decommissioning, after the licence expires or is forfeited, the licensee must ensure the land is safe and may need to remove machinery and infrastructure (Geothermal Resources Act, 1982).

INSIGHTS FOR CANADA

Geothermal regulations in Kenya currently lack specific size requirements for licensed areas and have ambiguous timelines and criteria for the survey, exploration, and decommissioning phases of development. This ambiguity has resulted in land access disputes for geothermal resource development, impeding project progress (Wetang'ula, 2014). To prevent similar conflicts, Canada should establish clear lease-of-rights regulations and maintain consistent permitting processes.

Recently, Kenya has begun to tackle some of these challenges through policy reforms and public investment. This initial governmental funding has supercharged the geothermal sector, attracting significant private investment. A notable example is Microsoft and G42's 2024 announcement of a $1 billion investment in a geothermally powered data centre in the country (G42, 2024). Canada could adopt a similar strategy of public investment to catalyze a thriving private industry.

Cerro Prieto geothermal power plant, located in Mexicali, Baja California, Mexico.

4.7. MEXICO:

Mandated decision timelines drive project predictability

Mexico possesses significant geothermal resources, with an installed capacity of 976 megawatts of electricity as of 2023 (Cariaga 2024d). The country's geothermal potential is associated with the Mexican Volcanic Belt and the Gulf of California tectonic plate spreading junction (Campos Enríquez & Urrutia-Fucugauchi, 1992). The installed electricity capacity has seen little growth in the last 10 years. High capital costs, complex technology, limited expertise, and a shift toward gas-fired electricity have hindered geothermal expansion. Geothermal energy has significant potential, with 24,700 megawatts estimated from enhanced geothermal systems (EGS). Twelve hundred megawatts of additional capacity

FIGURE 13:

Mexico is working to expand geothermal power generation

(ThinkGeoEnergy, 2025)

is currently permitted, but only 50 megawatts are currently under construction, with the remainder in early stages (Richter, 2019). Mexico is proposing updates to its Geothermal Law to streamline regulations, simplify exploration permits, and introduce a "Various Uses" permit for non-electrical applications (Cariaga, 2025).

RESOURCE DEFINITION

Resource: The resource is defined as water owned by the Nation, in a liquid or vapour state, naturally occurring at approximately 80°C or higher in a hydrothermal geothermal reservoir

Source, temperature, and depth: The resource is classified as water at or above 80°C and is naturally found. It does not specify a depth or temperature.

Use: The resource can be used for generation of electricity and other applications

Mexico defines geothermal water as: "Water owned by the Nation, in a liquid or vapour state, that is found naturally at a temperature of approximately 80°C or higher in a hydrothermal geothermal reservoir, capable of transporting energy in the form of heat, and that is not suitable for human consumption" (Government of Mexico, 2014). This definition specifies that geothermal resources only include water and vapour hotter than 80°C, both in the subsurface and at the surface. It also clarifies that only hydrothermal reservoirs are included in this definition, meaning that enhanced and advanced geothermal systems, as well as heat storage, would not be considered geothermal resources. However, the Geothermal Energy Law does include processes for permitting and developing non-hydrothermal geothermal resources.

RESOURCE OWNERSHIP

Ownership: All subsurface lands and resources are owned by the state and are regulated and managed by the Secretariat of Energy.

Granting rights: Permits and concessions are granted by the Ministry of Energy following application.

Lease size: Exploration permits cover up to 150 square kilometres; concessions for exploitation cover a reduced area, depending on the proven geothermal resource.

Multi-commodity extraction: Are allowed and must be reported to the Secretariat of Energy and may require additional authorizations.

In Mexico, geothermal resources are mainly governed through the Geothermal Energy Law (Government of Mexico, 2014; Martin, 2015; Richter, 2017), which regulates the use of heat from geothermal deposits. Entities interested in developing geothermal energy projects in Mexico must obtain the following authorizations:

- Registration: For reconnaissance activities, including initial observation and exploration. The Secretariat of Energy must make registration decisions within 10 business days.
- Permit: For advanced exploration activities. Developers are required to drill between one and five exploratory wells during this stage. The Secretariat of Energy must provide a permitting decision within 45 business days. Developers are required to submit an annual technical report to the Secretariat.
- Concession: For the extraction and exploitation of geothermal resources, if applicable. The Secretariat of Energy will have 15 business days to make a decision on granting the exploitation concession.

Geothermal activities that are of public interest get priority over all other development except oil and gas development. The holder of the exploration permit has exclusive rights to apply for an exploitation concession, up to six months before the permit's expiry. If they do not apply for a concession to the area covered by the exploration permit, the concession is put up for public bid.

RESOURCE TENURE

Tenure type	Permitted activities	Timeline
Reconnaissance	Aerial photography, remote sensing, taking and analysis of rock samples, geochemical and geohydrological sampling.	Eight months
Exploration	Site development, associated civil works, installation of machinery and equipment, and drilling and completion of geothermal exploration wells.	Three years with three-year extension
Exploitation	Drilling of wells, construction,	30 years with optional five-year extension

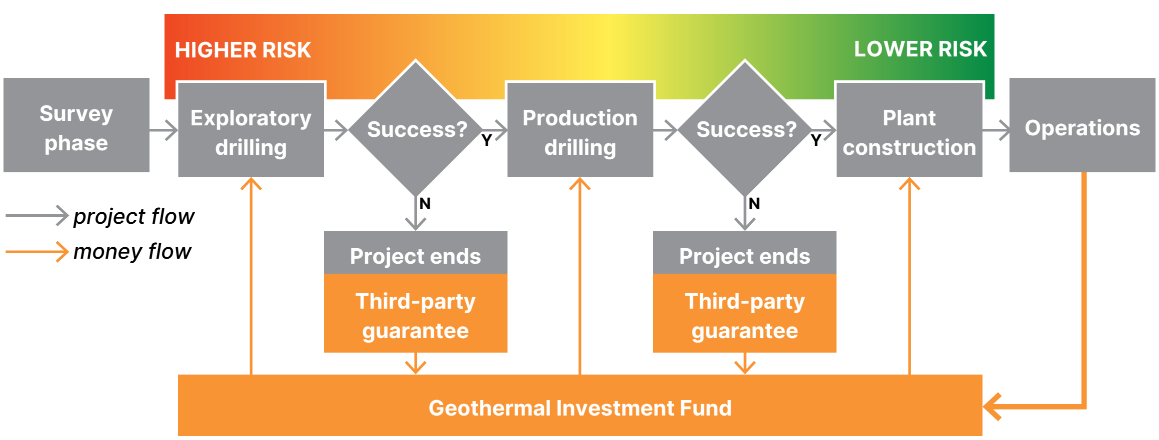
The Geothermal Energy Law (Government of Mexico, 2014; Martin, 2015; Richter, 2017) assigns the Secretariat of Energy as the authority in charge of overseeing and promoting geothermal resource exploration and use. The Secretariat oversees the issuance of registrations, permits, and concessions for geothermal energy development and exploitation in the country. In the exploration stage, developers can drill exploratory wells and assess subsurface resources under a permit valid for three years, which can be extended for another three years. The exploitation stage includes drilling production wells, building infrastructure, and moving into the operations stage, where geothermal fluids are used for electricity generation or other purposes under a 30-year exploitation concession, which can be renewed for additional terms.

Geothermal energy development in Mexico consists of three stages: reconnaissance, exportation, and exploitation (Figure 14) The Geothermal Energy Law also stipulates that for hydrothermal geothermal developments, “geothermal water must be reinjected into the deposit from which it was extracted, in order to maintain the renewable nature of the resource” (Government of Mexico, 2014). This regulation ensures the sustainability of the geothermal reservoir over time.

FIGURE 14:

Mexico has three main stages of geothermal development

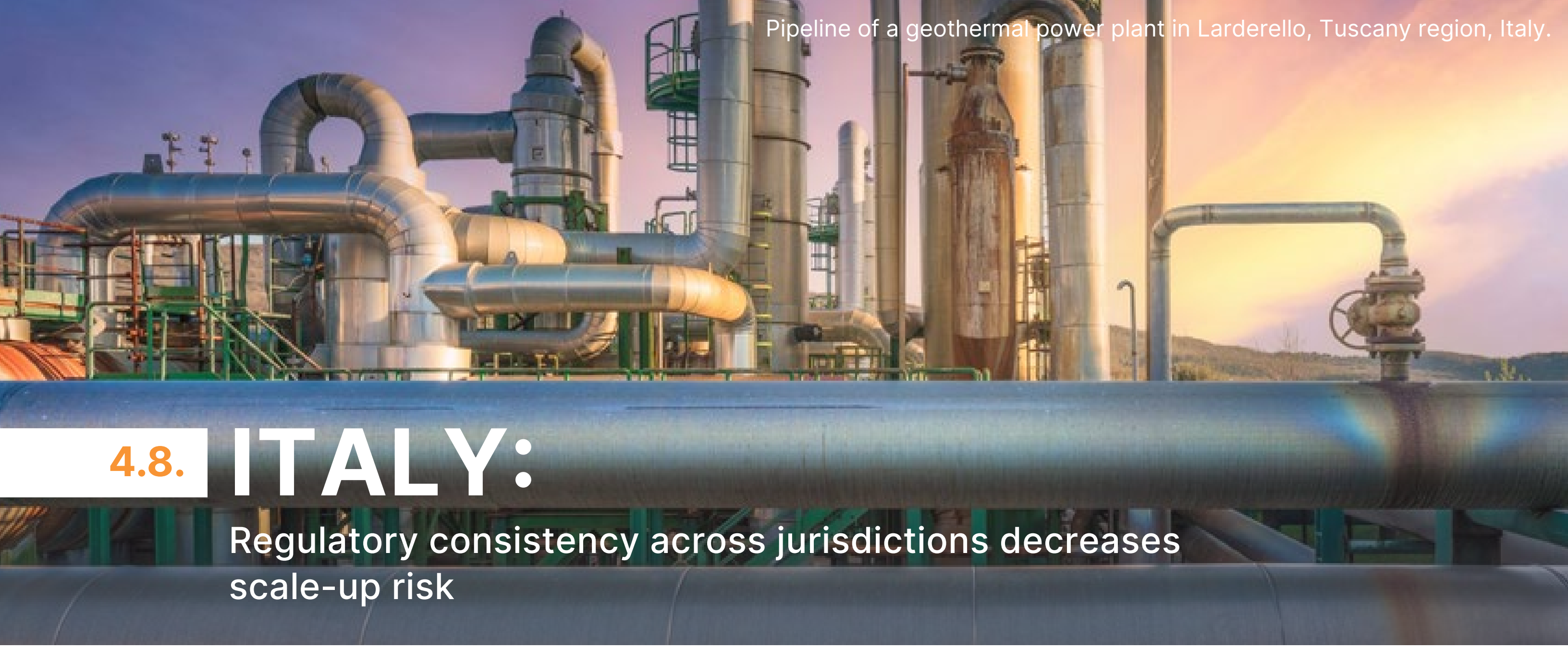
STAGE 1: **Survey**	STAGE 2: **Exploration**	STAGE 3: **Geothermal production**
• Requires registration with SENER • Activities: Surface surveying and geological sampling • No other permit necessary besides registration	• Requires permit from SENER • Activities: Resource assessment, exploratory wells • Local community consultation may be required • Additional well drilling permit required • Exploration permits last 3 years, can be renewed • Grants exclusive rights • May require environmental impact assessment	• Requires licence from SENER • Activities: Production well drilling, geothermal resource utilization • Local community consultation may be required • Additional water and power production licences required • Production licences valid for 30 years, can be renewed • Grants exclusive rights • Requires environmental impact assessment



Adapted from Flores-Espino et al., 2017.

INSIGHTS FOR CANADA

The Geothermal Energy Law establishes guidelines for resource management, yet restrictions on private sector involvement and reduced international support have impeded progress. Nonetheless, the law offers a clear framework for geothermal resource development, including specified timelines for permits. Each decision regarding permitting development by the Mexican geothermal regulator must be made within a timeframe of 10 to 45 days, depending on the development phase. These timelines are similar to those observed in the Canadian oil and gas sector. Efficient timelines enhance project predictability and help mitigate investment risks. Canada should ensure that its geothermal regulatory process incorporates decision timelines and could look to Mexico as a model in this regard.



Pipeline of a geothermal power plant in Larderello, Tuscany region, Italy.

4.8. ITALY:

Regulatory consistency across jurisdictions decreases scale-up risk

The first geothermal electricity was produced in Larderello, Italy, in 1904 using natural dry steam occurring at the surface (Burgassi, 1987). Significant volcanic activity in Italy gives the country easy access to high temperatures close to, or at, the surface (ENEL Spa, 2024). These resources are used for both direct heating and power generation. The Italian government aims to promote the use of its renewable geothermal resources and has enacted policies to support this development (Cariaga, 2024c). The industry association estimates that it currently takes developers up to 82 months to permit and construct a geothermal power project in Italy, and highlights the need to decrease this time (*Rete Geotermica*, 2024). Work is ongoing to increase the country's geothermal power capacity, with 44 geothermal projects, and 800 megawatts of capacity, currently under development (Cariaga, 2024a).

FIGURE 15:
Italy produced the world's first geothermal power in 1904

RESOURCE DEFINITION

Resource: The resource is defined as a fluid and includes both surface and subsurface fluids.

Source, temperature, and depth: Resources are governed by temperature range: above 150°C, 90-150°C, and below 90°C. There is no source included in the definition, which could include heat storage.

Use: Resources can be used for heat or power.

Geothermal resources in Italy are defined in three categories (Decreto Legislativo 11 Febbraio 2010, n. 22—Normattiva, 2024):

- *High-enthalpy* geothermal resources are those characterized by a temperature of the fluid found above 150°C.
- *Medium-enthalpy* geothermal resources are those characterized by a temperature of the fluid found between 90°C and 150°C.
- *Low-enthalpy* geothermal resources are those characterized by a temperature of the fluid found below 90°C.

The Ministry of Economic Development and the Ministry of Environment and Protection of Land and Sea regulate medium- and high-enthalpy geothermal resources, and published a guideline for use in 2016 (Saralli, 2016). Small, local-use geothermal resources are defined as resources generating less than two megawatts thermal and less than 400 metres in depth, and are exempt from geothermal power regulations (Decreto Legislativo 11 Febbraio 2010, n. 22—Normattiva, 2024). This definition of geothermal resources does not distinguish between surface and subsurface resources. This is likely because historically, Italy has used surface geothermal resources for power generation. The resource definition does not specify the heat source, so heat storage may be included in this definition.

RESOURCE OWNERSHIP

Ownership: The resource is owned by the state but managed by regional governments.

Granting rights: Either regional governments or the state grant rights through licences and concessions.

Lease size: Size is project-specific and defined by the regional government.

Multi-commodity extraction: Allowed, but additional permits are required.

In Italy, geothermal resources have been deemed mineral resources of public interest and are therefore the property of the Italian state or relevant region. A lease of resource rights can be awarded to a developer by either body, depending on the location of the geothermal resources. Before 2011, only the government was permitted to develop geothermal resources. New legislation removed this monopoly, and private development is now permitted (Decreto Legislativo 11 Febbraio 2010, n. 22—Normattiva, 2024).

Tenure to geothermal resources in Italy can be granted through exploration permits and exploitation concessions. Developers must apply for tenure, and if competing applications are received, tenure is awarded based on the developer's competence and experience. Tenure is granted exclusively to a single developer.

RESOURCE TENURE

Tenure type	Permitted activities	Timeline
Exploration permit	All resource characterization activities	Four years with two-year extension
Exploitation concession	Any use of geothermal fluids	30 years with 20-year extension

An exploration permit covers a maximum area of 300 square kilometres and is granted for an initial four-year term, with a possible two-year extension. Developers may not exceed a total area of 1,000 square kilometres per region and 5,000 square kilometres countrywide. These permits are intended for the identification and characterization of the geothermal resource.

Exploitation concessions are granted for the same area as the exploration permit. Developers have the exclusive right to apply for an exploitation concession for the first six months following the discovery of a geothermal resource. After six months, any developer may apply competitively for an exploitation concession over the permit area.

Exploitation concessions are granted for 30 years, following the approval of a geothermal project work plan that includes:

- a geothermal project management plan for the long-term sustainability of the resource
- a risk-management plan
- an environmental impact assessment
- a landscape and historical review
- if necessary, an agreement with local municipalities

- sufficient capital or insurance to cover site reclamation
- demonstrated developer competence and experience to execute the work plan.

Developers are required to submit an annual report to the licensing authority as part of their tenure requirements. At the end of the 30-year concession, developers may apply for a 20-year exploitation extension.

Individual geothermal developers are not permitted to operate greater than 50 megawatts of electricity, across a maximum of three power plants, including pilot plants. Concessions can be revoked following two years of inactivity or at any time if the developer does not have “adequate technical and economic capacity to carry out a geothermal project of national interest.”

Should oil or gas be found during geothermal resource exploration or exploitation, it must be immediately reported to the Ministry of Economic Development and Ministry of Environment and Protection of Land and Sea. The discovery of oil or gas may result in the issuing of a new mining title to these resources. If this occurs, the geothermal developer will be reimbursed for the direct and indirect costs of their permit or concession.

Should the geothermal resource be deemed a public utility by the government, jurisdiction of the resource will be given to the municipality (Decreto Legislativo 11 Febbraio 2010, n. 22—Normattiva, 2024; Direttiva Direttoriale 1 Luglio 2011—Ministero Dell’ambiente e Della Sicurezza Energetica, 2011).

INSIGHTS FOR CANADA

Despite a long-standing history of geothermal power production, Italy has recently fallen from third to eighth globally. This decline may be attributed to the monopoly that the Italian government maintained over the country's geothermal resources until 2011, which prohibited private firms from launching power projects. Even after the recent privatization of geothermal resources, however, there has been little increase in power capacity (IRENA, 2023). The industry association representing geothermal developers in Italy, Rete Geotermica, has suggested that lengthy government permitting processes and geothermal power quota limits are deterring private investment (*Rete Geotermica*, 2024). Depending on location, geothermal resources are allocated to either the national government, regional government, or municipalities, which can lead to confusion and conflicting regulations.

In Canada, provinces and territories already have authority over subsurface resources and energy, and geothermal resources should also fall under their jurisdiction. By legislating similar regulations across the provinces and territories, Canada can ensure consistency, minimize confusion, and therefore minimize development risks.

Krafla Power Station, the largest geothermal power station in Iceland.

4.9. ICELAND:

A dedicated regulatory body provides clarity and predictability.

Iceland is located at the spreading junction of two tectonic plates and above a volcanic hot spot. The spreading of these plates and the hot spot brings geothermal heat to the surface. Icelanders have used this resource for generations; it is a part of their cultural heritage. The country increased use of its geothermal resources, starting in the 1970s, to save money on imported fossil fuels. That energy now provides over 60 percent of the country's heat and power (Orkustofnun, 2024). Iceland uses geothermal heat as a utility, primarily through district heating, and uses over 2.3 gigawatts of thermal energy each year (Global Geothermal Alliance, 2021). The country also has 754 megawatts of geothermal power installed (ThinkGeoEnergy, 2024).

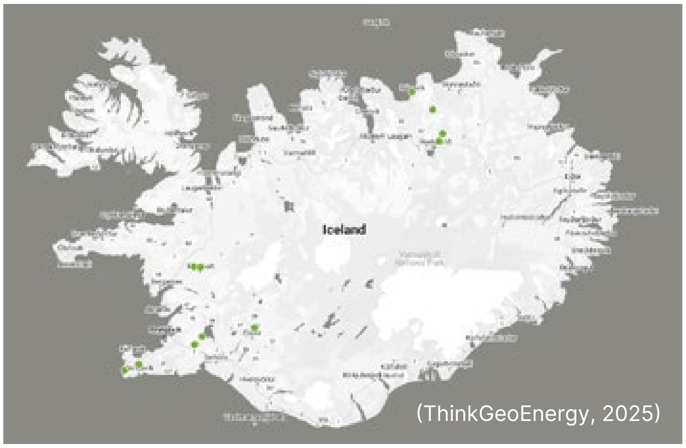


FIGURE 16:
Iceland uses geothermal energy for both heat and power

RESOURCE DEFINITION

Resource: The resource is defined as heat generated by the earth and includes both surface and subsurface heat.

Source, temperature, and depth: There is no temperature or depth defined, but the definition stipulates heat generated by the earth and would not apply to heat storage.

Use: The resource can be used for heat, power, and microorganism research.

In Iceland, geothermal energy is defined as "reserves of energy in the bedrock and a constant flow of heat from the bowels of the earth which does not constitute groundwater." Groundwater is "water below the ground in a contiguous mass, immobile or free flowing and generally fill all openings in the stratum in question and which is extracted for purposes other than to transmit heat to the surface of the earth or to utilize its potential energy" (Icelandic Ministry of Industries and Innovation, 1998). This distinction between groundwater and geothermal resources is important because both resources are present in both the surface and subsurface. This definition is clear that the geothermal resource is heat generated naturally by the earth and would not apply to heat storage. It does not define a temperature or depth and would apply to both surface and subsurface heat.

The National Energy Authority (*Orkustofnun* in Icelandic) is responsible for regulating Iceland's geothermal resources for both heat and electricity. All data generated through the prospecting and utilization of geothermal resources is collected and managed by the National Energy Authority (Orkustofnun, 2024).

RESOURCE OWNERSHIP

Ownership: Resources are owned by the surface landowners (either private or the state).

Granting rights: The National Energy Authority issues licences for exploration, utilization, and power generation, regardless of land ownership

Lease size: No specific size limitations.

Multi-commodity extraction: Unclear if this is permitted.

Subsurface geothermal resources in Iceland belong to the surface landowners:

- **Private land:** The private landowner owns the underlying resources and can lease them to developers.
- **Public land:** Resources underground belong to the Icelandic state unless others can prove ownership rights. Developers can lease these rights from the government.

Resource rights are granted to a single owner, and licences for geothermal development are required for both public and private land. Private landowners are permitted to use geothermal energy on their property to generate direct heat up to 3.5 megawatts thermal without permission. Private landowners are not permitted to sell their geothermal resources but are permitted to lease them to a developer. The Minister of Industry may expropriate geothermal resources from landowners in conflicting situations and within municipal boundaries. Landowners may choose to be compensated for expropriated resources in a lump sum or annual payments (Icelandic Ministry of Industries and Innovation, 1998). All geothermal electricity production is governed by the Electricity Act (2003). There is no specified size of subsurface geothermal lease, but all geothermal activity greater than 3.5 megawatts thermal, must be licenced, regardless of whether it is on private or public lands. Only Icelandic citizens and companies are permitted to develop geothermal resources (Bevash et al., 2017).

RESOURCE TENURE

Tenure type	Permitted activities	Timeline
Prospecting	All resource characterization activities	1 to 15 years
Utilization	Any use of geothermal energy greater than 3.5 megawatts thermal	Up to 65 years
Power plant	Surface power facility construction an operation	10 years, renewable

A prospecting licence is required for prospecting for geothermal resources on public lands but is not required for prospecting on private lands. Private landowners are required to provide plans for prospecting to the regulator. A prospecting licence permits any surveys that can be used to determine the quantity and potential yield of a geothermal resource. These could include drilling, geophysical surveys, surface water sampling and analysis, and rock sampling and analysis. Developers are required to submit an annual report to the National Energy Authority with the results of all work completed. This data is confidential during the term of the licence. A utilization licence will not be issued for either private or public lands unless a prospecting licence has previously been issued.

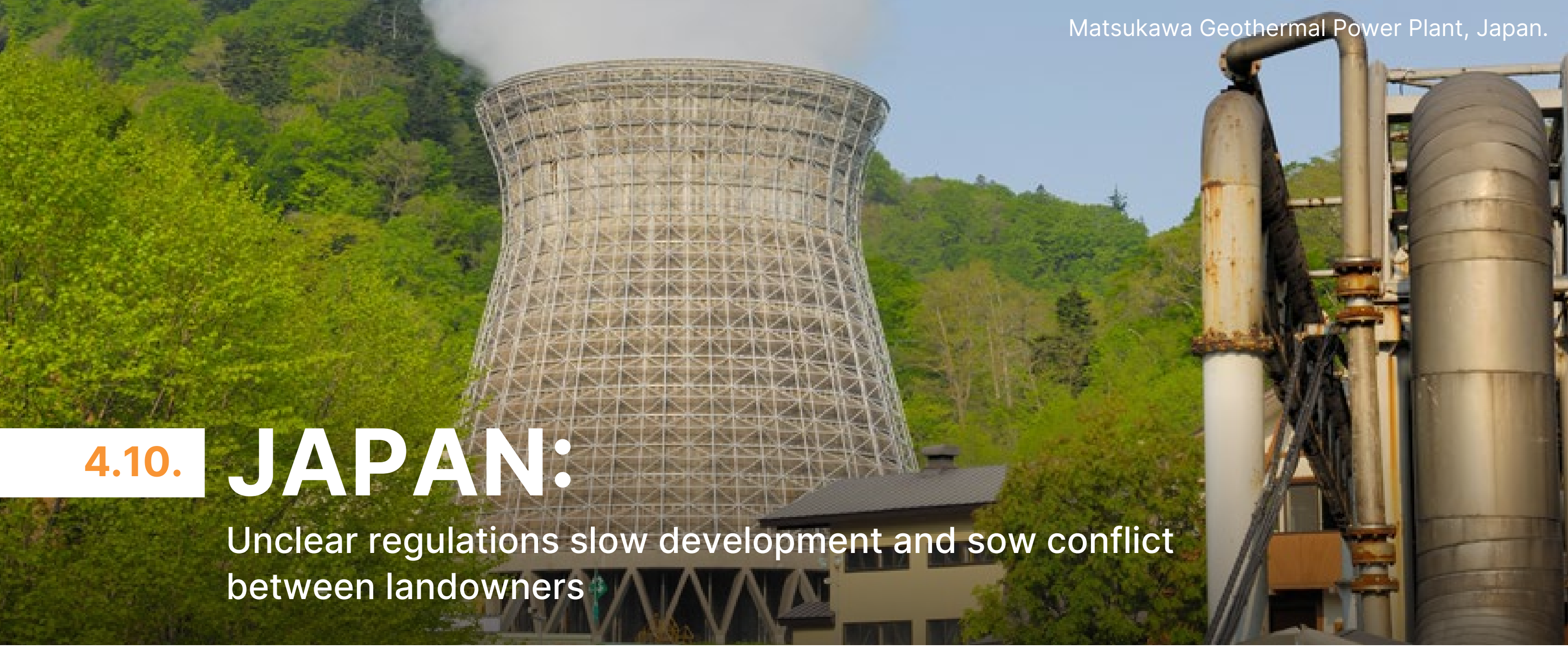
A utilization licence is required for all geothermal developments, whether they occur on private or public land. Developers are permitted to use geothermal resources on private lands with a prior agreement on compensation and surface access. If the developer was not the same party that completed resource surveys during the prospecting licence, the holder of the prospecting licence may claim the cost of these surveys from the developer. Municipalities have pre-emptive rights to geothermal utilization licences within the boundaries of the municipality for heating utility usage. A developer has three years to begin using the geothermal resource. If they are unable to meet these criteria, the utilization licence will be cancelled. The developer must submit an annual report to the National Energy Authority with the results of all work completed—this data is confidential for the term of the licence. Utilization licences are granted for up to 65 years (Icelandic Ministry of Industries and Innovation, 1998). If more than one megawatt of geothermal electricity is generated, a power generation licence is also required (Electricity Act, 2003).

During the term of the utilization licence, the developer must ensure efficient exploitation and ensure that production does not exceed levels deemed necessary. This is regulated to ensure the long-term sustainability of Iceland's geothermal resources (Ketilsson et al., 2015).

> *Iceland shows that a single, independent, geothermal-specific regulator works well—and such an approach might make sense for Canada or specific provinces one day.*

INSIGHTS FOR CANADA

Iceland is a world leader in harnessing geothermal energy thanks to its comprehensive direct heat infrastructure, and the nation is increasingly tapping into its geothermal resources for electricity generation. A dedicated regulatory body oversees all geothermal development, emphasizing resource sustainability. While numerous laws and regulations govern geothermal activities in Iceland, they have not impeded growth. In fact, demand for geothermal power—which the county has only recently started expanding—currently exceeds the available supply (Ragnarsson et al., 2021). This highlights the benefits of having a specialized regulatory authority for geothermal resource management. Iceland shows that a single, independent, geothermal-specific regulator works well—and such an approach might make sense for Canada or specific provinces one day. But in the short term, Canada can integrate with existing regulators because of the small number of projects. Canada has few geothermal projects in development, so regulation could be integrated within the frameworks of existing regulators, much like the approaches taken by Alberta and British Columbia with their respective energy regulators.



Matsukawa Geothermal Power Plant, Japan.

4.10. JAPAN:

Unclear regulations slow development and sow conflict between landowners

Japan sits on the Pacific Ring of Fire, and its volcanic activity gives it the third-largest geothermal potential in the world. Despite this, the country is the tenth largest geothermal power producer (JOGMEC, 2022). The primary reason for Japan's lagging geothermal power development is that 80 percent of its geothermal resources exist within protected natural parks. There has also been public concern that the use of geothermal resources for power could impact hot springs (Government of Japan, 2024). Japan has long used geothermal resources for direct heat, with hot springs making up the majority of this use (Kasumi Yasukawa et al., 2020). The Government of the Japan aims to double its geothermal power production by 2030, shorten project development time by two years, and resolve the issue of co-location of geothermal resources and natural parks (Baseload Capital, 2022; Ministry of Economy, Trade and Industry, 2021).

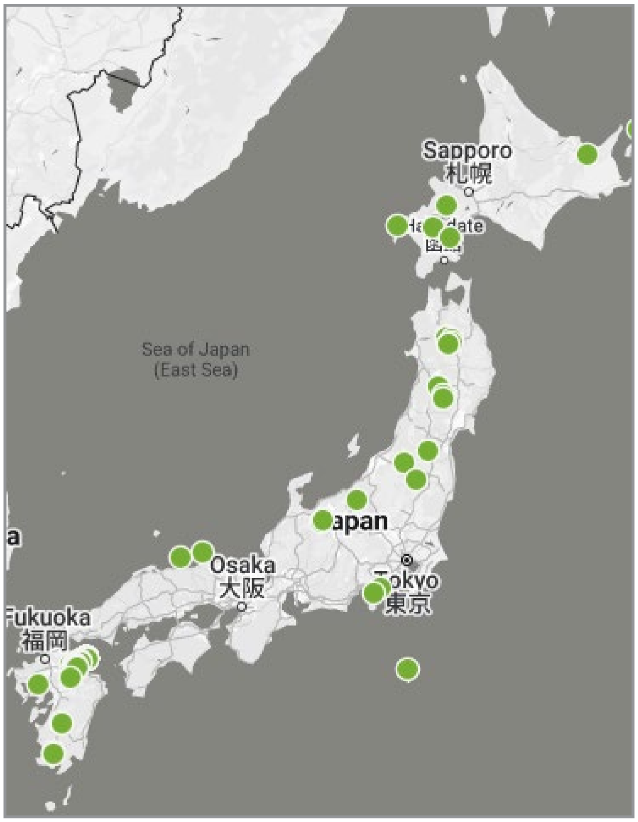


FIGURE 17:

Japan has the third-highest geothermal potential, but ranks tenth in power production

RESOURCE DEFINITION

Resource: The resource is defined as heat and includes both surface and subsurface heat.

Source, temperature, and depth: There is no temperature or depth defined, but the definition stipulates existing underground heat, so would not apply to heat storage.

Use: The resource does not have a defined use and would apply to both heat and power developments.

Japan defines a geothermal resource as "the heat existing underground as a heat energy source, or steam or hot water that sprung out from underground" (JOGMEC, 2021). This definition would include both surface and subsurface geothermal resources. JOGMEC is working to derisk geothermal development with government-funded geophysical surveys, exploration well drilling, production well drilling, well testing, and commercial operations. They are also providing financial assistance in the form of subsidies, loans, feed-in tariffs, and liability guarantees (JOGMEC, 2016).

RESOURCE OWNERSHIP

Ownership: The subsurface deeper than 40 metres is managed and leased by the government.

Granting rights: Local governments oversee subsurface leasing, while surface landowners control the upper 40 metres of the subsurface.

Lease size: Not specified.

Multi-commodity extraction: Unclear whether it is permitted.

In Japan, the subsurface deeper than 40 metres is not privately owned, while the surface landowner owns the subsurface to 40 metres depth (Goldhill & Fitzgibbon, 2021; Zaini et al., 2017). Ownership of the deep subsurface does not belong to the surface owner, and the government uses a licensing scheme to grant rights for development. The process for leasing geothermal rights as a developer is unclear. Geothermal likely falls under the Ministry of Economy, Trade, and Industry of Japan, which is responsible for regulating oil, gas, and mining activities, but is not explicitly mentioned (Hiroaki Takahashi, 2024; Joyce et al., 2024).

RESOURCE TENURE

Tenure type	Permitted activities	Timeline
Exploration	All non-drilling activities	No permit required
Exploitation—drilling	Drilling and testing	Two years
Exploitation—power plant	Drilling, testing, and operations	Indefinite

If it is assumed that Japan's Ministry of Economy, Trade, and Industry regulates deep geothermal resources, similarly to oil and gas, then a similar tenure process may be used. Two types of tenure are awarded for oil and gas extraction: exploration and exploitation. Exploration tenure allows for all exploration activities except drilling and does not require a permit. An exploitation drilling tenure covers the drilling and testing of geothermal wells and is granted for two years. An exploitation tenure for power production includes drilling, testing, and operations and has an indefinite timeline (Bevash et al., 2017; Joyce et al., 2024).

INSIGHTS FOR CANADA

Compared to Canada, Japan possesses a considerably larger hydrothermal resource and a higher thermal gradient, rivalled only by certain areas in Alberta and British Columbia. However, the country has a limited amount of installed geothermal power, primarily due to the challenges associated with developing resources within protected surface lands and public concerns regarding the degradation of hot spring resources. Although the government has provided financial incentives for geothermal power since 2012, insufficient public support, a lack of clarity in geothermal regulations, and a slow permitting process have hindered progress.

> *Japan possesses a considerably larger hydrothermal resource and a higher thermal gradient, rivalled only by certain areas in Alberta and British Columbia.*

Japan has set a goal to increase its geothermal power share by 2030 and is taking steps such as public outreach, deregulation, and government-funded exploration to expedite development. Japan's low public support illustrates the necessity of Canadian stakeholder engagement throughout all phases of geothermal project development. Canada can also learn from Japan's unclear regulations and slow permitting processes.

4.11. Summary

The success of these 10 countries indicates that effective regulation is a crucial ingredient for the growth of a geothermal industry. Key insights from various countries include the importance of clear ownership, predictable development processes, and the necessity for regulations to be technology agnostic and adaptable. A summary of the key insight for each country is shown in Table 5.

TABLE 5:
International insights for geothermal regulations

Country	Key insights
United States	Template regulations can bring consistency across jurisdictions.
Indonesia	Automation and comprehensive post-operation regulations bring speed and certainty.
Philippines	Clear, technology agnostic regulation speeds development.
Türkiye	Effective public communication reduces project opposition.
New Zealand	A thriving geothermal sector can honour treaties and Indigenous resource claims.
Kenya	Public funding can unlock private investment and create an industry.
Mexico	Mandated decision timelines drive project predictability.
Italy	Consistency in regulations across jurisdictions decreases scaleup risk.
Iceland	A dedicated regulatory body provides clarity and predictability.
Japan	Unclear regulations slow development and sow conflict between landowners.

5. Recommendations and guidelines for effective geothermal regulation in Canada

With only a few jurisdictions across the country currently equipped with regulatory frameworks, Canada must draw lessons from countries that have successfully developed their geothermal energy resources. By adopting successful strategies from other countries, Canada can create a clear and consistent regulatory environment that supports the growth of its geothermal energy sector. In this section, we present six general recommendations derived from the analysis of the top 10 geothermal power producers. We then introduce specific guidelines and model language to aid in drafting subsurface geothermal regulations in Canada.

5.1 General recommendations for regulation development

1. **Precisely define the resource.** Is the geothermal resource defined as heat, the fluid carrying the heat, the energy stored as pressure, or simply the energy in the subsurface? A clearly defined resource prevents conflict between geothermal developers.

2. **Be technology agnostic.** Technology in the geothermal industry is evolving rapidly (Blankenship et al., 2024). Regulations need to be specific regarding which resources they include, but agnostic on the technology that is extracting that resource. Overly specific technology definitions can confine developers to outdated technologies rather than bolster innovation. The Philippines' technology agnostic definition from 1967 has never had to be amended.

3. **Establish efficient, clear, and consistent processes and permit requirements**. Many leading global geothermal power-producing countries have amended their regulations to streamline and simplify geothermal development (Collins, 2024; Flores-Espino et al., 2017; Sercy, 2024; Cariaga, 2025). Regulations that are clear and consistent minimize uncertainty and create a lower-risk environment for geothermal development. In Canada, where each jurisdiction has control over its own geothermal resource, consistency between jurisdictions will enable rapid deployment of geothermal technologies across the country. The current inconsistency in Canada is a significant impediment to the growth of the geothermal market across Canada.

4. **Define a maximum acreage of awarded rights to avoid resource monopolies.** Most countries provide both a maximum lease size and a maximum resource rights acreage per developer to ensure fair and equitable resource access.
5. **Set realistic timeframes for tenure to allow flexibility for proponents while avoiding speculative resource grabs.** Most countries use a tenure process that allows flexibility to accommodate development timelines, while also enforcing a minimum level of activity within a specified timeframe to prevent developers from holding onto properties without progressing on development.
6. **Enshrine early public outreach to build trust and support.** Regulators and developers can engage the public to address concerns and communicate the benefits of geothermal. Effective outreach also encourages community support and collaboration, leading to more successful and sustainable geothermal projects.

These recommendations are primarily aimed at provinces and territories that have not yet developed geothermal regulations. However, jurisdictions with existing regulations may find them useful in improving their regulations and ensuring consistency with other jurisdictions. This consistency can attract investments, as developers gain confidence in a stable and predictable regulatory environment.

Collaborative efforts among provinces and territories will not only streamline processes but also facilitate the sharing of best practices, ensuring the responsible and efficient development of geothermal projects, ultimately benefiting both the economy and the environment. A unified approach to geothermal energy development must, however, be balanced against the need to be adaptable and responsive to regional priorities. By aligning efforts across jurisdictions, Canada can harness its geothermal potential more effectively, contributing to a sustainable and diversified energy landscape.

The guidelines presented below are for subsurface development only. Surface infrastructure permitting, construction, and interconnections should be occurring concurrently with subsurface development. This concurrent planning and permitting will streamline development and is a recognized best practice in the geothermal industry (Thomsen & Dowty, 2024).

5.2 Guidelines for defining the resource in regulations

To be effectively regulated, a geothermal resource must be clearly defined. This definition should be technology agnostic, include all potential uses, and should define what is being extracted and where it can be extracted from.

TABLE 6:
Do Canada's existing geothermal regulations have a clear resource definition?

Criteria	British Columbia	Alberta	Nova Scotia
Technology agnostic	✘ *temperature-specific*	✔	✔
Possible uses	✘	✘	✘
What is being extracted?	✔	✔	✔
Where can it be extracted from?	✘	✔	✔

Model geothermal **resource** definition:

A geothermal resource is energy in the form of heat and/or pressure, below the base of groundwater protection, and includes all dissolved or entrained minerals that may be extracted from the medium used to transfer that energy. This energy can be used to generate heat and/or electricity.

This definition will apply in the following ways:

- **Depth:** Below the base of groundwater protection. Groundwater (or potable water) is defined as non-saline water with less than 4,000 parts per million (or milligrams per litre) of total dissolved solids. Estimates on the depth of groundwater are available through the *Canada groundwater wells, integrated national, provincial, and territorial dataset*.
- **Resource:** Natural and/or human-made energy in the form of heat and/or pressure transported to the surface by working fluid or subsurface fluid. This energy can be co-produced with other subsurface resources provided the developer holds rights to those resources and follows all applicable regulations.
- **Uses:** Heat production and/or power production and/or energy storage.
- It will not include geoexchange/ground-source heat pumps, as these geothermal technologies operate at shallower depths within the groundwater table, and are already included in existing building, water, and environmental regulations.

- It will not include oil and gas, which have extensive regulations throughout the country and are specific to each province or territory.

5.3 Guidelines for defining resource ownership

In Canada, subsurface resources are owned and managed by the provinces. The Northwest, Yukon, and Nunavut Territories govern and manage their subsurface resources, but ownership belongs to the federal government. Each of these jurisdictions must determine how a temporary lease of subsurface geothermal resources is granted, how long it is awarded for, and over what area it is granted.

Model geothermal **ownership** definition:

Lease of rights to geothermal resources is granted by the Crown to the developer and includes the subsurface pore space (naturally occurring and human-made) over a given depth. Developers will apply to the Crown for the lease of subsurface pore space, and the lease of space will be awarded based on the merit of the application, following public notice and a period for additional applications.

This lease of ownership will apply in the following ways:

- Lease of the subsurface is for geothermal energy, but will include all resources found in the leased pore space (fluids, heat, oil and gas, and minerals) assuming those resources are not already leased. The lease will be awarded to a single developer over a specified depth and area. This will include human-made pore space (stimulations) that did not exist naturally before the drilling of a well.
- Extraction of any, or all, of the resources by the lease owner within the pore space is permitted and may be carried out concurrently with appropriate resource rights and permits. A geothermal lease gives the developer the rights to the geothermal energy and any co-occurring resources.

BOX 4:

Co-production of geothermal energy and other subsurface resources

By adopting an inclusive and agnostic definition of geothermal energy, geothermal leases can encompass other valuable subsurface resources such as oil, gas, hydrogen, lithium, and other critical minerals. This approach allows geothermal projects to benefit financially through co-production with these resources, creating additional revenue streams and encouraging hybrid operations. However, these guidelines are designed to complement, not replace, existing regulations for these resources, which are well-established across the country. A geothermal lease primarily grants access for the extraction of heat energy, but the production of additional resources is possible with the appropriate rights and permits. This assumes that the rights to other subsurface resources are not currently leased. If the rights to additional resources are leased, the developers will be responsible for negotiating co-production of the resources.

For instance, if a geothermal developer encounters lithium within their geothermal lease, they would be allowed to produce this resource, provided the rights to lithium are not already leased, they obtain the necessary permits and adhere to existing regulations. Implementing a streamlined dual-permitting process in such scenarios can maximize revenue streams for geothermal projects. Similarly, if an oil and gas developer wished to extract geothermal energy within their lease, they would need to obtain the rights to geothermal resources, follow geothermal regulations and secure a geothermal energy production permit. This dual-permitting approach fosters collaboration and innovation, enhancing the overall efficiency and profitability of subsurface resource extraction.

- Lease of the subsurface will be awarded based on an application by the developer to the Crown. Applications should be made public and additional applications should be accepted for the lease area for a reasonable period of time (e.g., 60 days). Should multiple applications for the lease area be submitted, the Crown will award the lease based on project merit (e.g., financial viability, scientific importance, or public good).
- The areal extent of the subsurface lease will be determined by the Crown based on the geology of the subsurface over the lease area. In order to minimize the impact of geothermal developments on neighbouring leases, each jurisdiction must tailor lease spacing to its unique geology and existing subsurface resources (Horn et al., 2022).
- The vertical extent of the subsurface lease will be determined by the Crown and may be awarded by depth or by geologic formation. The simplest vertical extent of the lease would be from the base of groundwater to the bottom of the Earth's crust, or the bottom of the basement rock. Basement rock is defined as the deepest crystalline, igneous, or metamorphic rocks associated with the Precambrian (Dippenaar & van Rooy, 2014).

Regulations governing rights to geothermal resources should be crafted in such a way as to ensure responsible resource development that balances economic, environmental, and social considerations (Indigenous and Northern Affairs Canada, 2021). We propose that municipalities and Indigenous governments be given the first right of refusal to the subsurface beneath their surface land. This will allow municipalities and Indigenous Peoples the opportunity to develop geothermal projects for the public good. Italy (Section 4.8) and Iceland (Section 4.9) both use this approach to ensure geothermal can be developed as a public utility. Forthcoming Cascade Institute research seeks to fully understand the benefits and hinderances that speculative leasing of the subsurface has on renewable resource development.

We also propose that each jurisdiction set a maximum allowable total lease area per developer. This will help ensure fair and equitable resource access across the jurisdiction and minimize the risk of a resource monopoly.

BOX 5:

Geothermal development on Indigenous Lands

Ownership of the subsurface on Indigenous and Treaty Lands is a complex and evolving subject in Canada. We have outlined how subsurface resource development is currently being carried out on Indigenous Lands (Box 1). These practices may not align with the United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP). Article 26 states, "Indigenous peoples have the right to the lands, territories and resources which they have traditionally owned, occupied or otherwise used or acquired" (United Nations, 2007). It is unclear in Canada if this would apply to subsurface resources. As Canada develops geothermal resources, the subsurface resource rights and claims of its Indigenous Peoples should be considered. The recently issued Geothermal Indigenous Peoples' Declaration could be used as guidance for Canada (Eagle-Bluestone, 2024).

5.4 Guidelines for defining resource tenure

The tenure for geothermal resources outlines how long a lease of rights to geothermal resources are granted to a developer and what activities are permitted during that time. To ensure responsible and fair resource development, a regulator will grant various tenures to a resource during the phases of development. Geothermal project development can be broken into four phases: exploration, development, operations, and decommissioning (Gehringer & Loksha, 2012). Each of these phases will have its own tenure timeline, permitted activities, and renewal process.

Each Canadian jurisdiction will need to establish rules around who can apply for a lease of subsurface pore space. For example, Alberta only permits companies registered in Alberta to apply for a lease of geothermal resources (Directive 089, 2022), while British Columbia will permit any individual or company who applies for a geothermal lease (Geothermal Resources Act, 2010).

Developers should be required to complete a pre-impact environmental site assessment before beginning tenure. This will ensure that the initial surface and subsurface state of the location is known before project development. This data will then be used in the decommissioning tenure to return the site to its pre-disturbed state.

Consultation with local and impacted Indigenous Peoples should also be initiated before tenure. This consultation is required in Canada for conduct that might adversely impact potential or established Indigenous or treaty rights. This engagement should begin before the leasing of a geothermal resource and continue throughout all stages of geothermal project development. This critical stage of geothermal project development should include precise timelines and deliverables that balance the developers' need for streamlined project flow with the community's buy-in. Türkiye serves as an excellent example of how clear, evidence-based communication can reduce project opposition, allowing for predictable project timelines. By adopting similar practices, developers can ensure that projects proceed smoothly while maintaining transparency and fostering community support.

In addition to Indigenous Peoples, local communities and stakeholders should also be consulted. This consultation should include the communication of project risk and emergency response plans. British Columbia requires such consultation before a lease is granted (British Columbia Energy Regulator, 2023). Even when stakeholder and community engagement is not mandatory, it is still best practice. Stakeholder engagement is directly linked to positive project outcomes for renewable energy development (Climate Investment Funds, 2021).

Prior to applying for a subsurface lease and being awarded tenure by the Crown, developers are allowed to complete pre-drill geothermal exploration. These activities must adhere to existing environmental regulations, and some will require access and/or environmental permits prior to proceeding. Pre-drill activities occur only at the surface and can include (Chunn et al., 2025):

- Geophysical evaluation of the subsurface (e.g. seismic, gravity, or magnetic surveys).
- Evaluation of subsurface geologic data from pre-existing wells (water and/or oil and gas).
- Geochemical evaluation of existing produced subsurface fluids and rock cores.
- Geomechanical evaluation of existing rock cores.
- Outcrop analysis of rocks exposed at the surface.

The proposed guidelines for awarding geothermal tenure are merit-based and will emphasize pre-drill work completed by developers. These pre-drill activities, which can be both costly and time-consuming, will be given significant weighting in the decision-making process for granting subsurface rights. If regulations recognize the value of these preliminary efforts, developers can have greater certainty about their ability to secure a subsurface lease before making substantial investments. This approach encourages thorough and responsible exploration, ultimately benefiting the geothermal industry as a whole.

Once site characterization is completed using existing data, the subsurface must be evaluated by drilling. Subsurface evaluation determines if there is a viable geothermal resource and provides estimates for planning commercial development. A lease for rights to the subsurface pore space must be obtained before the exploration tenure begins. The lease of rights to the subsurface geothermal rights would remain with the original developer throughout the tenure process, assuming all tenure conditions are met.

Model geothermal tenure stages:

While four stages of geothermal development were laid out in Section 2, we recommend combining the exploration and development stages for resource tenure in Canada to streamline the regulatory process, reduce administrative burdens, and accelerate project timelines. By integrating these stages, developers can move seamlessly from initial site characterization to resource extraction, minimizing delays and uncertainties associated with separate permitting processes. This approach encourages early investment in geothermal projects by providing greater assurance of tenure continuity. Additionally, combining these stages fosters innovation and efficiency, enabling developers to leverage next-generation geothermal technologies and methodologies that require less exploration than conventional strategies.

FIGURE 18:

Proposed geothermal tenure stages and timing

Development:
Five years
Five-years renewals

Operations:
30 years
Ten-year renewals

Decommissioning:
Two years
Single site-specific renewal

Development: Five-year initial tenure with optional five-year renewals

During the development tenure, developers are permitted to drill, test, and stimulate geothermal wells. These wells can be small-diameter holes (typically used to evaluate temperature gradients and geology), or they can be large-diameter (typically used to estimate flow rate and productivity). The drilling of these wells would require a permit granted by the regulator, and the developer would be required to follow all rules associated with drilling.

Sandia National Laboratories published a report outlining best practices for geothermal drilling in 2012 (Finger & Blankenship, 2012), but with recent technological advances, these practices should be revisited. The government of Alberta requires drilling operations to adhere to several directives for drilling a well (Alberta Energy Regulator, 2023). Alberta is regarded as a leader in well regulations and their practices are frequently used as a model for other jurisdictions (Lahey, 2016).

Long-term testing of wells (up to 45 days) can be necessary to properly characterize the injection and production potential of geothermal resources (Hole, 2008). These tests would be completed during the development phase of tenure to determine the viability of the geothermal resource and to plan for commercial surface developments.

Should the geothermal well require stimulation, additional permitting may be required. Some jurisdictions offer pre-approval for stimulation, with notification to the regulator, to minimize permitting and accelerate development. Stimulation techniques used in geothermal wells include hydraulic fracturing, acidizing, thermal fracturing, air injection, and nitrogen injection (Mubarok & Zarrouk, 2017). These stimulations are intended to increase the porosity and permeability of the rock in the subsurface by creating new fractures. While these stimulations can slightly increase the risk of induced seismicity (Box 6), events are likely to be low-magnitude and are unlikely to be felt at the surface (National Research Council, 2013). However, a few larger induced-seismicity events have been associated with the stimulation of geothermal wells (Cheng et al., 2022; Zhou et al., 2024). To mitigate this risk, permitting for geothermal well stimulation should reflect current global best practices for induced seismicity risk management (Zhou et al., 2024). Alberta and British Columbia also have strong well stimulation regulations that could also be adapted by other Canadian jurisdictions (Directive 083: Hydraulic Fracturing—Subsurface Integrity, 2024; B.C. Energy Regulator, 2024).

BOX 6:

Geothermal energy and induced seismicity

Seismicity refers to the shaking of the earth (i.e., earthquakes) caused by the movement of tectonic plates, fractures, and volcanoes. These processes occur naturally and vary in magnitude, which is measured on the Richter scale. The magnitude of these events is location-specific, and the local magnitude (M_L) calculation was standardized by Boreman and Dewey in 2014 (Bormann & Dewey, 2014).

Induced seismicity refers to earthquakes that are caused by human activities and can occur during mining, oil and gas, and geothermal operations and can pose a risk to infrastructure, property damage, and public safety (Boroumand & Maghsoudi, 2016). Geophysicists can predict the conditions at which induced seismicity is likely to occur. It is the responsibility of regulators to ensure that regulations mandate a scientific assessment of the induced seismicity risk for projects. This assessment should encompass the entire lifecycle of development—drilling, stimulation, operation, and abandonment.

Deep geothermal developments have the potential to induce seismicity in three main ways during operations:

Drilling: Conventional geothermal operations often target subsurface faults to access large volumes of hot fluid. During drilling, the forces acting on these faults can be altered, causing movement and seismicity (Knoblauch et al., 2019).

Stimulation: To increase the space available for fluid in the subsurface, geothermal wells are stimulated through hydraulic fracturing, whereby large volumes of fluid are pumped into the subsurface at high pressures to create new fractures in the rock. Enhanced geothermal systems have adapted this practice from oil and gas stimulations (Blankenship et al., 2024). These earthquakes typically measure less than 2 on the Richter scale, too small to be felt or cause damage (Schultz et al., 2020; Zhou et al., 2024).

Operations: During operations, geothermal wells move large volumes of fluid through the subsurface. The movement of this fluid in the subsurface can induce seismicity if it is not done within scientifically determined thresholds (Schultz et al., 2020). This is why developers need to understand the geophysical and mechanical characteristics of the subsurface before beginning geothermal development.

Traffic light protocol

Standards and protocols for induced seismicity prediction and monitoring have been developed around the world. In Canada, Alberta requires a risk assessment to identify the presence of any faults that could cause earthquakes within three kilometres of a geothermal well. If a risk of induced seismicity is identified, Alberta requires the use of a Traffic Light Protocol for the geothermal operation. This protocol requires the monitoring and reporting of all seismic events within a 10-kilometre radius of the geothermal operation (Directive 089, 2022). This regulation was adapted from Alberta's oil and gas regulations. The local magnitude scale (M_L) thresholds for each traffic light are set based on geophysical data gathered for the operation area. *Figure 19* shows an example traffic light protocol for the Brazeau area in Alberta.

FIGURE 19:
An induced seismicity

The risk of induced seismicity during geothermal development is low. Less than one percent of hydraulically fractured wells cause earthquakes, and the majority of these events are not detectible by people (Schultz et al., 2020). However, there is a slight risk of greater-magnitude events that can cause damage (Baek et al., 2021). The best way to reduce the uncertainty, and therefore the risk, of induced seismic events is through scientific evaluation of the subsurface. This evaluation can be time-consuming and costly, which is why regulations mandating a scientific risk assessment are necessary (Zhou et al., 2024).

Developers may proceed from the development stage to the operations stage at any time during the tenure by completing a geothermal resource evaluation. This evaluation ensures that the developer can advance the geothermal project to operations, minimizing the risk to the Crown of abandoned subsurface assets, while safely and efficiently operating the geothermal resource for the operation tenure term. This evaluation will include an assessment of:

- The potential of the geothermal resource, based on data gathered during the development tenure.
- The developer's use plans for the geothermal energy at surface.

- The developer's plan and ability to produce the geothermal energy, including:
  - Location and number of wells.
  - Planned surface facilities.
  - Pipeline and/or power connections.
  - Water requirements.
  - Expected surface impacts.
- Subsurface operating parameters to ensure responsible use of the resource (e.g., minimum and maximum pumping rate or reservoir pressures).
- The long-term viability of the geothermal resource based on the constructed project.
- The developer's financial and technical ability to operate and maintain geothermal energy, and properly reclaim the site following operations.
- An emergency response plan for operations that protects the environment, the public, and the resource.
- A risk and impact assessment based on the results of the development tenure activities.

To expedite the development of geothermal resources, surface facilities should be constructed during the development phase. This recognized best practice minimizes the development timeline, capital expenditures, and investment risk (Thomsen & Dowty, 2024). This report does not address regulations for surface developments—we recommend further investigation into this topic.

Should the developer be unable to drill and test geothermal wells during the first five-year development tenure, they can apply for a five-year extension. This extension will be granted at the discretion of the Crown. If the developer can't gather sufficient data during the development tenure—by drilling and testing at least one well—the subsurface lease of pore space will be discontinued, and resource rights would return to the Crown.

Should the developer be unable to construct an operational geothermal resource project during the first 10 years of the development tenure, they can apply for a five-year extension. This extension will also be granted at the discretion of the Crown. Should the developer be unable to complete the work required in both the surface and subsurface within 15 years, the subsurface lease of pore space would be discontinued, and resource rights would return to the Crown.

Developers that are unable to proceed to operation tenure may not transfer the lease to another individual or developer. Should the subsurface lease be discontinued, the developer is required to reclaim, remediate, and decommission all wells and surface facilities constructed during the development tenure in accordance with local environmental regulations at the developer's expense.

OPERATION:
30-year initial tenure with the option for 10-year renewals
During the operation tenure, developers are permitted to produce and inject geothermal fluids from wells in order to use geothermal energy at the surface for heat or electricity.

Regulations for the range of injection pressure and production rates should be established based on the local geology. For example, in the United States, during well operation, fluids are not to be injected at a pressure that will generate new fractures (Environmental Protection Agency, 1994). The injection of geothermal fluids during operation is different than the injection of stimulation fluids during development. The fluid injection pressure at which new subsurface fractures would occur can be calculated based on data gathered during the exploration and development tenure.

The operation of the geothermal surface facility can be regulated under either existing oil and gas facility regulations, or existing power facility regulations. Recommendations for surface geothermal heat or power facility regulation are beyond the scope of this report.

The drilling, testing, and stimulation of additional wells to augment the operations of the geothermal project is permitted during the operation's tenure. Drilling of these wells will require a permit granted by the regulator, and the developer will be required to follow all regulated activities associated with drilling. These regulated activities will be the same as those required to drill a well during the exploration and development tenure.

Additional testing of existing and new wells would be permitted during the operation tenure. This testing allows for the sustainable operation of the geothermal project over the operation tenure.

The stimulation of new and existing wells would also be permitted during the operation tenure. These stimulations would be required to follow the same regulations as activities completed during the development tenure. Stimulation of new and existing geothermal wells can optimize geothermal resource utilization during operations (Mubarok & Zarrouk, 2017)

The operation tenure will have an initial period of 30 years with the option for unlimited 10-year extensions. When a developer applies for an extension of operation tenure, a geothermal project evaluation will be required. This evaluation will ensure that the developer will continue to safely and efficiently operate the geothermal resource for the extended tenure term. The project evaluation for operation tenure extension would be the same as the evaluation to move from development to operation tenure.

Geothermal projects can have long lifespans as geothermal heat is a renewable resource. If the geothermal resource is responsibly managed, projects can remain operational for over 60 years (Geothermal Rising, 2023). By including unlimited extensions for operational tenure, geothermal projects can maximize the geothermal energy produced over time.

At any point during the operation tenure, the developer is permitted to apply to move to a decommissioning tenure.

DECOMMISSIONING:
Two-year initial tenure with the option for a single site-specific renewal
During decommissioning, developers are not permitted to drill, test, or stimulate wells. The only operations permitted during the decommissioning tenure are those that will return the surface and subsurface to its original condition. These operations include well abandonment and surface facility decommissioning, followed by remediation of any environmental impacts and reclamation of the site (Forsyth & Nahornick, 2022). These operations are done at the developer's expense and will be carried out in accordance with local environmental regulations.

An initial two-year tenure will be granted to complete the subsurface abandonment of existing wells. A single, site-specific renewal is permitted with an application by the developer.

The length of the renewal tenure is site-specific due to the variations in the type of well and the complexity of well abandonment in various geologies. Surface installations associated with the well should be included in the decommissioning tenure.

The decommissioning of surface geothermal facilities is not included in the decommissioning tenure. While these activities will likely occur simultaneously with well abandonment, they are governed by each jurisdiction's environmental regulations.

Upon well abandonment, the developer will apply for a reclamation certificate, stating that the subsurface and associated surface installations of the well have met local environmental regulations. Upon granting of this certification, the subsurface lease of pore space will be returned to the Crown.

5.5 Additional guidelines

Permitting and timelines

By establishing a clear, timely, and efficient path through the application process, regulators can encourage more rapid geothermal resource development. The permits required should be based on:

- The size of the geothermal development, with respect to depth, energy produced, and areal extent.
- The use of geothermal energy—heat, power, or both.
- The technology used to extract and harness geothermal energy.
- The location of the development—is it located in a sensitive or protected habitat, near a population centre, or in close proximity to another resource?

We recommend a simple, standard permitting process, with additional permitting required for projects that would be considered high risk based on the considerations outlined above. These timing guidelines are for the permitting process only and are not intended to include the time required to conduct appropriate Indigenous and public engagement.

> *We recommend a simple, standard permitting process, with additional permitting required for projects that would be considered high risk.*

To optimize regulatory processes, we recommend bundling applications, review processes, and approvals wherever possible. This approach consolidates decision-making points, reducing the number of approvals needed and the number of decision makers involved. Facilitating knowledge transfer between regulators and proponents through clear and consistent requirements set out in guides can further streamline the process. By adopting these practices, jurisdictions can enhance regulatory efficiency, promoting timely and effective project development.

Establishing clear and consistent permitting requirements and processes that align with the scale and potential impact of a project is essential for the sector's growth. Proponents and investors should have a comprehensive understanding of project development stages, expectations, timing, decision-making criteria, and compliance costs. Such an understanding provides certainty that meeting the stated requirements will allow progression to subsequent project stages. Streamlining permitting processes and reducing complexity can facilitate faster development of geothermal projects. To improve clarity in geothermal development, provincial and territorial regulations in Canada should establish timelines for permitting decisions, similar to those implemented by Mexico (Section 4.7). These timelines must strike a balance between the necessity for thorough regulatory review and the timelines of developers.

Fees and royalties

To effectively regulate geothermal resources, jurisdictions require sufficient personnel to review applications, issue permits, enforce regulations, and guide developers through the regulatory process. In some cases, the staff of existing regulatory bodies could carry out these geothermal regulatory duties. However, not all Canadian jurisdictions have established regulatory bodies, and this role falls to provincial and territorial staff. To ensure there is capacity to regulate geothermal development, additional staffing requirements can be funded through application, permit, and subsurface lease fees. These fees should be carefully balanced to adequately fund the activities of the regulatory body without dissuading geothermal development.

In addition to fees, some jurisdictions collect a royalty on geothermal energy revenues to fund regulators and generate income. As the Crown is normally the primary owner of the geothermal resource, they are entitled to enact a royalty to receive direct economic benefits. However, royalties were traditionally collected for future generations to benefit from the depletion of non-renewable resources. Because geothermal is a renewable resource, some commentators argue that royalties are unnecessary (McLelland & Burnside, 2021). Presently, Canada has only one operational hybrid geothermal power plant, and the industry is still developing (Huang et al., 2024). The implementation of royalties could be detrimental to the development of future geothermal projects in Canada. While jurisdictions have the right to collect royalties on geothermal energy production, delaying the collection of royalties would be beneficial for the development of a geothermal resource sector in Canada (Crewson & Thompson, 2015).

Liability management

Geothermal regulations need to consider the liability associated with subsurface developments. It is the responsibility of the developer to abandon and reclaim all subsurface installations in accordance with the jurisdiction's regulations. The cost of this abandonment and reclamation is the responsibility of the developer. When the developer is not financially capable of carrying out the abandonment and reclamation, a well becomes an orphan, and responsibility is deferred to the Crown. In 2020, the Government of Canada estimated the current cost of abandoning Canada's existing orphan wells at $361 million, which was forecast to rise to $1.1 billion by 2025 (Forsyth & Nahornick, 2022). The funds to abandon and reclaim these wells are currently provided by a combination of industry, provincial, and federal sources.

There are numerous strategies used globally to cover the cost of abandoning and reclaiming subsurface developments. North American jurisdictions most often require a refundable, upfront security deposit or bond to ensure these costs are covered.

- The Alberta Energy Regulator requires a holistic assessment for all stages of energy development. Based on the results of this assessment, they may require a security bond of up to 100 percent of the site's liability (Directive 088: Licensee Life-Cycle Management, 2024).
- The Government of Saskatchewan evaluates the developer's assets against their liability. If they value of their liability is more than $10,000 greater than their assets, a security deposit payment is required (Ministry of Energy and Resources, 2023).
- The Bureau of Land Management, with governs federal lands in the United States, updated their well bond requirements in 2022. They now require a minimum bond of USD$150,000 for individual sites and USD$500,000 for all sites in a state (Bureau of Land Management, 2024b).

During the development of subsurface geothermal regulations, jurisdictions should account for the liability of developments and mandate mitigation strategies in the regulations.

DEEP Earth Energy Production project site in Saskatchewan (image credit: DEEP).

6. Next steps

Canada has a time-bound opportunity to become a global leader in clean geothermal power, contributing to the nation's clean energy transition. Most of the world's electrical geothermal development occurs in regions with advantageous geological conditions, where effective regulations are already in place. By drawing on lessons from the nations that lead the world in geothermal power production, Canada can establish a first-class regulatory environment for geothermal's rapid expansion.

This report lays the groundwork for developing new and strengthening existing geothermal regulations across the country. In the coming months, the Cascade Institute, with industry, academic, and government stakeholders, will use these guidelines to create a regulatory template for the 10 Canadian jurisdictions currently lacking subsurface geothermal regulations. Additionally, encouraging regulatory reform in provinces with existing regulations will ensure consistency and clarity, further reducing development risks and fostering a cohesive approach to geothermal energy across the nation.

Consistent, clear, and efficient regulations are essential for advancing geothermal development, minimizing uncertainty, and lowering investment risks. By aligning with international best practices and adapting successful strategies, Canada can establish a robust regulatory framework that supports the growth of its geothermal energy sector, supporting Canada's transition to clean energy.

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8. Appendix: Regulatory summary tables by country

United States—federal lands

Rights ownership	U.S. Government
Legislation	Geothermal Steam Act (1970) 43 CFR 3200 (Code of Federal Regulations) 43 CFR 3000.12 Mineral Leasing Act Energy Policy Act (2005) National Environmental Policy Act
Dispositions agency	Bureau of Land Management
Disposition processes	Competitive bid for lands nominated that are prospective for commercial electricity production. Non-competitive (application) for lands that are prospective for direct-use heat only and for lands offered in competitive process that garner no interest.
Disposition types	Lease with: Primary term Initial extension Additional extension Drilling extension Production extension
Maximum area	For leases offered by competitive process, minimum nomination size of 640 acres to maximum size of 5,120 acres. Maximum ownership per state is 51,200 acres. Leases for direct-heat use may be smaller than 640 acres minimum and requested size must be justified.
Duration	Primary term is 10 years. If provided, initial extension is five years. If provided, additional extension is five years. If provided, drilling extension of five years. Production extension granted for a productive lease is up to 35 years and can be renewed for additional 55 years for commercial production.

Fiscal terms	Lease (competitive): $195 application fee $140 nomination fee $0.14/acre minimum, awarded to highest bid amount Lease (non-competitive): Application fee of $505 $1/acre Escalating minimum work commitment: $40/acre by end of the Primary Term $15/acre/year during Initial Extension $25/acre/year during Additional Extension Annual rental: Competitive lease $2/acre first year, $3/acre years 2-10, $5/acre thereafter Non-competitive lease $1/acre for first 10 years, then $5/acre $5/acre for non-competitive lease

Indonesia

Rights ownership	Government of Indonesia
Legislation	Geothermal Law 2014 Energy Law (Law No. 30/2007) Environmental Law (Law No. 32/2009)
Dispositions agency	Ministry of Energy and Mineral Resources
Disposition processes	Licence issuance Geothermal licence (indirect use) Direct-use licence Exploration phase Exploitation phase extension
Disposition types	Geothermal Licence Direct Use Licence Indirect Use Licence
Maximum area	Exploration: 200,000 hectares Exploitation: 10,000 hectares Working Area depends on the Geothermal System present
Duration	Exploration: maximum of seven years Exploitation is 30 years Expiration of licence extension of maximum 20 years
Fiscal terms	Government share: 2% gross value Import duty exemptions, local revenue sharing

Philippines

Rights ownership	Philippine government
Legislation	Republic Act No. 5092: Geothermal Energy, Natural Gas, and Methane Gas Law Republic Act No. 9513 (2008): Renewable Energy (RE) Act of 2008 Presidential Decree No. 1442 (1978): Geothermal Service Contract Law Executive Order No. 462 (1997)
Dispositions agency	Department of Energy (DOE)
Disposition processes	Application for service contracts evaluated by DOE Open and competitive selection process Issuance of geothermal service contract Declaration of commerciality Certificate of confirmation of commerciality Abandonment and termination plan
Disposition types	Pre-development stage: feasibility study, exploratory drilling, and resource validation Development stage: construct facilities and produce geothermal energy Abandonment and surrender rights
Maximum area	None stated
Duration	Pre-development stage: seven years Development stage: 25 years, extendable for another 25 years Decommissioning stage: begins upon termination or expiration of the contract
Fiscal terms	Government share: 1.5% of gross income on geothermal resources Duty-free importation: 10-year exemption from tariff duties Tax Credit on Domestic Capital Equipment and Services: 100% of custom duties and value-added tax Income Tax Holiday (ITH): 7-year tax holiday, including new investment but not exceeding three times Corporate tax rate: 10% of net taxable income after ITH

Türkiye

Rights ownership	Government of Türkiye
Legislation	Law No. 5686: Geothermal Resources and Natural Mineral Waters
Dispositions agency	General Directorate of Mining and Petroleum Affairs (MAPEG)

Disposition processes	Application Licensing: Exploration licence Operating licence
Disposition types	Exploration: Geological and geophysical surveys, drilling, and testing for resource potential Operations: Full-scale extraction, utilization, and reinjection of geothermal fluids; expansion or modification of wells and facilities with administrative approval Post-operation: Closure of wells, implementation of safety measures, and land restoration to prevent environmental harm
Maximum area	Applications for up to 5,000 hectares
Duration	Exploration: three years, extendable by one year. Operations: 30 years, extendable in 10-year increments.
Fiscal terms	Royalty fee: 1% gross income Feed-in tariff of $0.105/kWh Exploration licence: ranges from TRY 1,000-5,000 (approx. USD$50-$250) Licence fee: depending on the size of the project Corporate tax discount: 70% discount on tax, capped at 30% of total project capital expenditure Social security support: Government covers social security premiums for six years (limited to minimum wage levels) Customs duty exemption: No import duties on machinery and equipment for eligible projects.

New Zealand

Rights ownership	Subsurface resource is unowned (common law) Produced or discharged resource: Crown exercises regulatory authority Māori
Legislation	Resource Management Act 1991 Marine and Coastal Area (Takutai Moana) Act 2011 Conservation Act 1987 Exclusive Economic Zone and Continental Shelf (Environmental Effects) Act 2012
Dispositions agency	Regional and district councils Minister for the Environment
Disposition processes	Resource consent Assessment of Environmental Effect System Management Plan
Disposition types	Resource consent
Maximum area	Depending on the reservoir

Duration	Exploration: five years (Crown Minerals Act) Resource consent: 35 years No duration specified: five years (New Zealand Parliament, 1991)
Fiscal terms	Exploration & development fees Corporate tax (28%) Tax incentives (R&D tax incentives Government grants Power purchase agreements (~10-20 years) Emissions Trading Scheme (ETS) Land Lease Agreements (25-50 years)

Kenya

Rights ownership	Government of Kenya
Legislation	Geothermal Resource Act 1982
Dispositions agency	The Minister of Energy
Disposition processes	Application and licensing Exploration and exploitation licences Compliance with operational, safety, and environmental standards Licence modifications for by-product extraction under the Mining Act Licence Transfer or Assignment
Disposition types	Survey: Surface-level surveys; no drilling or resource extraction. Exploration: Includes surveys, geological studies, test drilling, and evaluation of geothermal potential; limited to testing activities only. Exploitation: Rights to drill, construct boreholes, extract geothermal resources, and build necessary infrastructure for resource utilization. Decommissioning: Requires licensees to restore the land to a safe condition upon licence expiration or forfeiture
Maximum area	Not explicitly defined
Duration	Exploration: one year, with the option for a one-year renewal. Exploitation: 30 years, with the option for five-year renewals
Fiscal terms	Application fees Annual rents Royalties Penalties for non-compliance: 10% penalty if rent is unpaid within three months.

Italy

Rights ownership	All geothermal resources, surface and subsurface, are owned by the Italian government.
Legislation	Legislative Decree 11 February 2010, n.22
Dispositions agency	Ministry of Economic Development Ministry of Environment and Protection of Land and Sea
Disposition processes	Exploration permit: by application. Exploitation concession: by application for six months following discovery, but competitive application after six months.
Disposition types	Exploration permit Exploitation concession
Maximum area	300 km^2 A single developer may not own more than 1,000 km^2 per region and 5,000 km^2 countrywide.
Duration	Exploration permit: 4 years with 2-year extension Exploitation concession: 30 years with 20-year extension
Fiscal terms	Exploitation concession annual fee: 350 euro/year per km^2 Production royalties (on >3 Mwe): 0.13 euro per kWh to the municipality, 0.195 euro per kWh to the region Environmental compensation: 4% of plant costs at time of construction to the municipality

Iceland

Rights ownership	State of Iceland on public land, landowner on privately owned land.
Legislation	Act on the Survey and Utilization of Ground Resources (1998) Nature Conservation Act Planning and Building Act
Dispositions agency	Ministry of Industry Ministry of Environment National Energy Authority
Disposition processes	By application, with advertisement of application for utilization licence With opinion of Ministry of the Environment and Icelandic National Energy Authority Landowner required to grant access to valid prospecting or utilization licence-holders
Disposition types	Prospecting licence—provides exclusive right to search for, survey the extent of and potential yield. Utilization licence—authorizes extraction and use of geothermal energy. Only granted for area for which a Prospecting licence was previously issued.

Maximum area	No maximum established in legislation. Licence areas based on application and decision by Minister and are specified in each licence.
Duration	Set out in each licence and includes terms for when work must be started and completed. For up to 2 years following expiry of prospecting licence, the licence-holder has precedence to obtain utilization licence with no prospecting licence issued to another party for the same area. Utilization licence specifies term of operation (up to 65 years) and quantity of energy extracted.
Fiscal terms	Application fee (amount not specified in legislation). Payment for energy extracted under a utilization licence must be negotiated with a private landowner or in the case of public land, with the Minister.

Japan

Rights ownership	Subsurface deeper than 40 metres is unowned but managed and leased by the government.
Legislation	Natural Parks Act (1957), Mining Act (1950), Hot Springs Act (1948), Act on Special Measures Concerning New Energy Use by Electricity Providers (2002).
Dispositions agency	Ministry of Economy, Trade, and Industry of Japan.
Disposition processes	No subsurface geothermal-specific disposition process.
Disposition types	No subsurface geothermal specific disposition types. Oil and gas disposition types: prospecting and digging.
Maximum area	None stated.
Duration	None stated.
Fiscal terms	Electricity Feed-In-Tariff (2012): 28.08 yen/kW (tax inclusive) for 15 years for projects producing 15,000 kW or more; 43.2 yen/kW (tax inclusive) for 15 years for projects producing 15,000 kW or less.