DEEP GEOTHERMAL SUPERPOWER:
Positioning Canada for a breakthrough in next-generation geothermal systems
March 19, 2024

If Canada is to achieve its climate goals through decarbonization and energy diversification, it must pursue and rapidly implement technological breakthroughs in energy resources.

Ultradeep geothermal power is an emerging form of renewable, dispatchable baseload power that is immune to climate variability. It involves creating artificial reservoirs of fluid deep underground that tap Earth's massive quantities of heat to produce electricity. Around the world, bold R&D programs are rapidly advancing this technology, but **Canada is on the cusp of losing its competitive advantage**.

We outline here the case for ultradeep geothermal power and offer a **strategic plan for Canada to capture this technological opportunity**, leveraging our world-class expertise and human and financial capital in oil and gas, mining, and subsurface resource development.

Background

Geothermal power is currently limited to unique geological locations that have high subsurface heat gradients coupled with existing water reservoirs accessible within four kilometres of the surface. Canada does have such conventional "hydro-thermal" resources in the western provinces and territories. They remain largely unexploited due to logistical, regulatory, and financial challenges.

But the true opportunity for geothermal power for Canada and the world lies in ***un*conventional**, **next-generation geothermal technologies**. These systems would generally require drilling to **much greater depths of seven to 10 kilometres or more through hard rock, to reach temperatures of 150°C and ideally over 400°C.** If such wells could be drilled economically, geothermal power could be produced virtually anywhere in the world, **unlocking an energy resource thousands of times larger than humanity could ever need**.

This opportunity is being recognized worldwide. **Major government-funded research initiatives are underway** in the United States, China, Japan, and the EU. They focus primarily on how to drill into hard rock formations cost-effectively; a secondary aim is to create reservoirs that can sustain the 40-plus-year lifespans of geothermal plants.

Ultradeep geothermal power has many advantages:

- It could potentially provide massive amounts of baseload, dispatchable electricity.
- Its small surface footprint will enable deployment in urban centers, rural communities, and retrofitted power stations.
- It will generate zero GHG emissions and consume relatively limited amounts of water.
- It takes advantage of mature power-generation and transmission technologies.
- Its commercialization will use transferrable expertise and personnel from volatile energy sectors, especially O&G.

- Its capacity factor (the ratio of actual energy output to the theoretically maximum output) is generally greater than 90%, which compares favourably to the capacity factors of intermittent renewable energy sources (solar and wind) that are often less than 30%.
- It offers hybrid capabilities, such as heat production, CO2 sequestration, and energy storage.

The main challenge to commercialization is the cost of drilling deep wells through hard rock. High upfront CAPEX costs deter investment and cripple research initiatives. Meanwhile, complex and slow permitting processes and absent or ill-fitting regulatory frameworks stifle project momentum.

How Canada Can Capture this Opportunity

Permitting and regulatory obstacles can be addressed through aggressive policy intervention. The technical challenge of drilling cost is more fundamental. Based on recent experience outside Canada, we believe **drilling costs can be cut in half within the next decade**. But a viable Canadian effort in ultradeep geothermal requires **an integrated, collaborative public-private partnership**.

We therefore propose a CAD $550 million program to construct four interconnected, in-field test sites at established geothermal locations in Canada, with the total investment shared about evenly between public and private sectors.

The test sites would conduct essential research into deep, hard-rock drilling, aiming to dramatically lower CAPEX costs. Each would aim to be commercially viable, generating about 50 megawatts of power for local or regional consumption. **The test sites would share data and lessons with one another to accelerate innovation and decrease risk**.

Each site would be allotted up to **CAD $125 million** to cover drilling costs, reservoir preparation, and surface facilities. To ensure accelerated R&D, site prerequisites are:

- verified, high-potential geothermal heat gradient;
- secured drilling permits and subsurface rights;
- constrained tectonic stress fields that can facilitate drilling tests;
- support from local communities;
- location outside of environmentally sensitive areas or vulnerable ecosystems; and,
- proximity to industrial or domestic users.

Each site would address research challenges that align with the operator's technical skills and specializations. For example, one could focus on closed-loop systems, another on conventional versus percussive drilling systems, while yet another focuses on the performance of CO_2 as a circulating working fluid.

In parallel, federal and university research institutes and laboratories would be funded (up to CAD $50 million) to characterize the physical, thermal, and mechanical properties of rock under the extreme pressures and temperatures of deep wellbores, to understand how best to develop fracture networks in deep crystalline rock, and to model the techno-economics of power production from these challenging reservoirs.

The proposed test sites and research programs would immediately vault Canada to a world-leading position in what is poised to be an essential future energy technology.