The AMBACHTSHEER Letter
Sustainable Pension Design • Effective Pension Management

August 2023

WINNING THE GLOBAL BATTLE AGAINST HEAT:

A PLAN FOR HOW *GEOTHERMAL POWER GENERATION* CAN STILL PLAY A CRITICAL ROLE

"This year is quickly becoming the new record holder for global heat. Current projections are for the global average temperature to increase 2.7C by 2100. Putting it bluntly, even with all existing emissions cutting policies by governments around the world, humans are losing the battle against heat….but humans can also change these models' trajectories….."

Bloomberg Green

*"If **geothermal systems** can be successfully proven out at scale, if flexible operating modes can be similarly validated, its role would be that of a Swiss Army Knife complement to wind and solar power."*

Zero-Carbon Energy Systems Lab

Revisiting Last Year's Geothermal Story

Our **August 2022** *Letter* went off the 'pension design, governance, and investing' track with the title "Fixing Global Warming: A Possible Solution Getting Too Little Attention From Pension Funds". Its essence was to argue, as the Zero-Carbon Energy Systems Lab did recently, that geothermal heat at scale and in flexible operating modes could solve the world's looming carbon-free energy shortfall problem. However, the *Letter* cited a *Cascades Institute*[i] study that listed the remaining challenges that would have to be overcome for this to become true. In summary:

- There is enough heat emanating from the earth's core to satisfy humanity's zero-carbon electricity needs many times over into the indefinite future.
- The essence of the generation process is to convert this heat to geothermal power which in turn would drive electricity-producing turbines. This conversion process is already producing electricity in the few locations where the earth's heat is close to the surface (e.g., Iceland).
- However, current drilling technologies cannot go down deep enough (i.e. at least 10kms) to access the earth's heat on a much wider, cost-effective, continuous basis. Increasing drilling speed is critical.
- New 'ultra-deep geothermal drilling' technologies are needed to access this heat to feed the already-existing electricity-generation infrastructure around the world currently being powered by fossil fuels.
- Why bother when we are already generating electricity from zero emission power sources such as wind, solar, and nuclear? Because all three have material shortcomings (e.g., weather variability, energy storage systems, power density, nuclear disposal, rare earths access).
- Equally importantly, we are not at 'ground-zero' with the R&D status of new 'ultra-deep geothermal drilling' technologies. Three promising technologies termed 'microwave', 'plasma', and 'percussive' are already under development.

KPA ADVISORY SERVICES LTD

To address the remaining implementation challenges related to the wide-spread availability and use of geothermal power, the *Cascade Institute* proposed an *Ultradeep Geothermal Project* with three components:

Component 1

- Assess the current state of ultradeep geothermal drilling technologies.
- Assess the feasibility of major, near-term advances of various ultradeep drilling and well completion technologies and their potential to provide the cost reductions necessary to make ultradeep geothermal cost competitive with other sources of net-zero electricity.
- Identify key levers for achieving the needed speed increases/cost reductions, and high-level strategies for achieving those.

Component 2

- Build a "Community of Intent" around ultradeep geothermal in Canada and beyond.
- Coordinate and engage with the fragmented landscape of stakeholders with interest in ultradeep geothermal (and the energy transition more broadly).
- Develop a rough consensus within this community of common goals and create a shared understanding of opportunities, obstacles, and potential strategies for accelerating R&D and investment.

Component 3

- Create an R&D and Investment Roadmap.
- Build, with stakeholders, a strategy outlining next steps for R&D and investment.
- Clarify the target state for cost-effective deep hard rock drilling (key cost/financial aspects, technical attributes, organizational structure, etc.).
- Identify the key technology, R&D, organizational, and other gaps that need to be filled to achieve this target state. Other gaps will likely include regulatory, governmental, and financial support.
- Develop a prioritized list of R&D and uncertainty-reduction activities associated with filling these gaps and identify the resources requirements and next steps for each.

So ended the August 2022 *Letter*.

One Year Later

Exciting progress has been made to implement *Cascade Institute*'s Project agenda since the publication of the August 2022 *Letter*. For example, *KPA Advisory Services* helped organize a workshop for major pension funds last Fall to familiarize their investment professionals with the ultra-deep geothermal power opportunity. Geologist, retired energy business executive, and *CPP Investments* advisor on renewable energy Steve Bell played an important role in making this workshop successful.

At the same time, *Cascade Institute* itself has taken significant steps to launch the 3-Component *Ultra-Deep Geothermal Project* summarized above. For example, a 7-member Advisory Board was established earlier this year. Also, startup funding from the *Ivey Foundation* has led to hiring *Geothermal Project Research Lead* Rebecca Pearce. She started in May. Rebecca has a PhD in geophysics and has both research and industry experience in the geothermal field.

A June 2023 status report by *Cascade Institute* restated and updated *Project* progress made to-date this way:

Phase 1: Research, analysis, and community building (2023-2026)

1. Assess the current state of ultradeep geothermal drilling technologies (*fully funded*): The *Cascade Institute Research Lead* has started to conduct a feasibility study of major, near-term advances in ultradeep drilling technologies that will clarify the decision landscape for investors, policymakers, and firms.

2. Co-develop R&D Roadmap and pursue high-impact research opportunities (*partially funded*): Researchers will develop a prioritized list of R&D activities associated with ultradeep geothermal, conduct gap analyses, and identify the actors capable of carrying them out. *Institute* researchers will then pursue the most urgent and high-impact research questions emerging from the Roadmap, especially those questions pertaining to the complex interactions between technological, social, and political systems.
3. Build a *Community of Intent* around ultradeep geothermal: Led by a *Stakeholder Engagement Coordinator*, the *Institute* will convene a series of "Dialogues" with stakeholders from government, industry, finance, academia, and civil society around the world - and develop a comprehensive stakeholder map, which will help these actors visualize the constellation of groups working on various aspects of geothermal power.

Phase 2: Community co-ordination and R&D catalysis (2024-2026)

1. Establish an *Innovation and Policy Office* in Ottawa: The *Cascade Institute* will set up an Ottawa office led by an *Innovation and Policy Director*. The *Innovation and Policy Office* will coordinate new partnerships and projects emerging from the ultradeep geothermal community, catalyze investment in R&D, and help build the supportive regulatory infrastructure for geothermal R&D around the world - but especially in Ottawa and western Canada. The *Innovation and Policy Director*, with support from the *Stakeholder Engagement Coordinator*, will work with stakeholders in government, industry, and the communities most likely to benefit from geothermal R&D and pilot projects to develop strategies for de-risking early-stage investment as well as helping new projects navigate the regulatory and intellectual property environment.
2. Establish an *Intellectual Property Lab*: The development of key technologies for ultradeep drilling and well completion is slowed by the opaque and balkanized nature of the intellectual property (IP) landscape. While patents often promote technological innovation and risk-taking, the urgency of the energy transition demands greater transparency and collaboration. The *Intellectual Property Lab* will develop and hold IP as a public asset and use it strategically to encourage transparency and pro-social behavior from firms. The *Lab* will require the participation of leading engineers and technologists - the same individuals who could potentially patent and commercialize their ideas themselves. The *Cascade Institute* will therefore work with advisors, including experts in IP law, to create a quasi-philanthropic model for the *Lab* that will incentivize participation. After designing the *Lab* and recruiting participants, the *Cascade Institute* will convene workshops to identify and purchase the most promising IP.

What can the pension fund community do to pitch in and support these efforts? That is the question we address next in both macro and micro contexts.

How Pension Funds Can Pitch In

The macro 'pitch in' context was set out in the **May 2023** *Letter* titled "Really Integrating 'Net-Zero' Into Pension Fund Investing: What It Will Take". Guided by the Montgomery-Van Clieaf book "Net-Zero Business Models", the *Letter* made four key points:

1. Understand the Technical Foundations of 'Net-Zero' Business Models (e.g., GHG Protocols, Reporting Standards, Scopes 1, 2, 3 Emissions Definitions, Carbon Intensity Measurement, Science-Based Emission Reduction Targets).
2. Understand the Four Corporate Pathways to 'Net-Zero' (i.e., Eco-Efficiency, Business Model Transformation, Eco-Start Ups, Eco-System Transformation).
3. Understand the Organizational Change and Systems Thinking Requirements for

Corporations to Successfully Navigate the 'Net-Zero' World (e.g., in corporate governance, in operating skills, in stakeholder communications).

4. Understand the Organizational Change and Systems Thinking Requirements for Pension Funds themselves to Successfully Navigate the 'Net-Zero' World (e.g., in pension fund governance, in analytical skills, in stakeholder communications).

The micro 'pitch in' context is much more granular. Its focus should be on addressing the question: what can our fund do now to better understand, and possibly get involved in making 'ultra-deep geothermal' a viable investment opportunity? The good news is that such investment opportunities have already started to appear. Here are three examples:

1. *Quaise*: spun out of *MIT* in 2018. Technology is based on breakthrough fusion research that combines conventional rotary drilling and high-power millimeter waves to reach 20km depths. Targets to harvest energy from a pilot well by 2026. With proven success, the company plans to convert existing coal power plants in the USA and around the world to be powered by its ultra-deep fusion-based technology. The company has raised USD$75 million this far through venture financings.
2. *Eavor*: founded in Calgary in 2017. Technology is based on a closed-loop structure that generates power from a geothermally-heated fluid that circulates in a loop. Proof of concept was started by building an *Eavor-Lite* facility in Alberta in 2019. Since then, the technology has advanced to an *Eavor-Deep* facility in New Mexico, funded by VC as well as established fossil fuel producers. Recently, *Eavor* has received a €92 million grant from the *European Innovation Fund* to build an *Eavor-Deep* facility in Germany. It has also reached a €1 billion financing agreement with *Deep Energy* to finance at least five further projects using the *Eavor-Deep* technology. It plans to licence its technology to other infrastructure construction organizations through IP-based agreements.
3. *Fervo*: founded in Houston in 2017, with intellectual support from the *Stanford University Geothermal Program*. Based on a technology called "Modern Organic Ranking Cycle", its essence is a directional multiple-well drilling strategy guided by fiber-optic cables that provide accurate analytics, and optimizes water flow distribution down to hot rocks and back up to power electricity generation. An AI-enhanced power generation project for *Google* is targeted to open in 2028. Meanwhile, a recently-completed commercial pilot project in Nevada has been characterized as "*the most productive enhanced geothermal system in history*". So far, US$200 million in capital has been raised from 28 investors, including *CPP Investments*. According to its Sustainable Investments Head Bruce Hogg, "*Fervo represents a compelling opportunity to invest in a company that is working to unlock the potential of clean, reliable geothermal energy at a sustainable price point*".

With *CPP Investments* leading the way, the time has clearly come for other thought-leading pension funds to take the geothermal energy opportunity seriously.

Keith Ambachtsheer

Endnote:

i. *The **Cascades Institute**, based at Royal Roads University on Vancouver Island, addresses the full range of humanity's converging environmental, economic, political, technological, and health crises. It identifies and helps implement high-leverage interventions to rapidly shift humanity's course towards fair and sustainable prosperity.*

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