

Launching Conventional Deep Geothermal Development Projects in Oil and Gas Dominated Regions of Canada

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Keywords

Alberta, Canada, Oil and Gas, low enthalpy geothermal, sedimentary basin, direct use, geothermal investment, holistic geothermal, Alberta No. 1

ABSTRACT

Deep, conventional geothermal heat and power projects face a number of challenges in Oil and Gas (O&G) dominated parts of Canada, in particular Alberta. These challenges are outlined and range from a sparse, highly dispersed population to a robust existing heating infrastructure in the form of Natural Gas pipelines. Against the backdrop of these general challenges, in Alberta the de-regulated electricity market, low cost of power (average pool price for electricity in Alberta in the last 12 months was CDN\$52.19/MWh) and the low cost of natural gas (NG) used primarily for space heating (2020 average price of NG was CDN\$1.90/GJ), offer further hurdles to securing capital investment in projects. Despite challenging economics, Alberta No. 1 (ABNo1) can show commercial viability in its financial forecast by including not just electrical generation, but thermal heat sales as well as carbon offset credits. The recent (March 25, 2021) ruling by the Supreme Court of Canada on the validity of a federally imposed Carbon tax is a boon to the project and others in Canada. However, even with these three revenue streams, raising capital for geothermal projects remains a challenge. Much attention is now focused on blue hydrogen (produced from NG) to help hydrocarbon dominated provinces derive additional value from their traditional resource base, however, it results in the production of waste CO₂ that must be sequestered. In Alberta, ABNo1 has partnered with academia and government to investigate CO₂ sequestration at geothermal facilities, developing mutually beneficial processes that will support the build out of both a geothermal and hydrogen industry by creating revenue for geothermal projects while satisfying hydrogen compliance needs. In this way, ABNo1 hopes to garner another revenue stream and attract more attention to conventional geothermal development as a solution to helping Canada reduce its GHG emissions and garner more Environmental-Societal-Governance (ESG) credits in O&G dominated regions.

1. Introduction

Alberta No. 1 (ABNo1) is Alberta's first conventional geothermal power and heat project (Hickson et al. 2020). Located 10 km south of Grande Prairie near the hamlet of Grovedale (Figure 1), the project was announced for partial funding through the Canadian federal government's Emerging Renewable Power Program (ERPP), administered by Natural Resources Canada, August 23, 2019. Since that time, the project has been seeking capital to match and augment the federal funding to complete what is expected to be a minimum 10 MWe power and 985 TJ (2.7×10^5 MWh) thermal project, with two additional sites for further expansion (Figure 1).

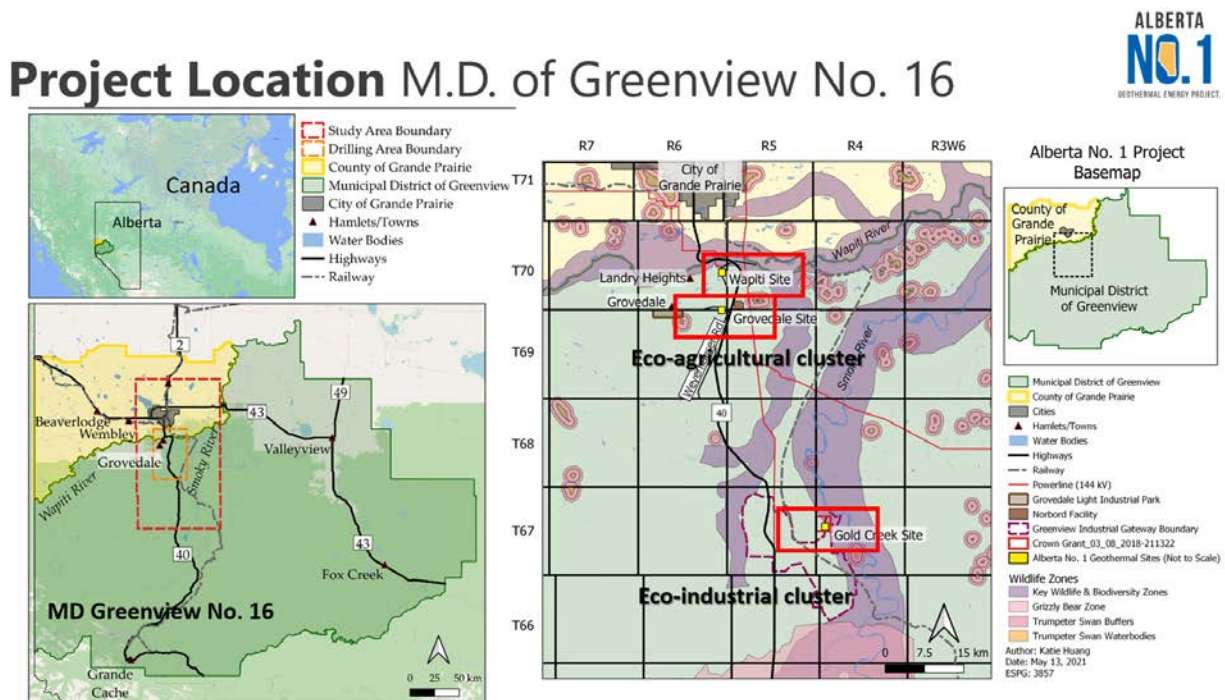


Figure 1: Alberta No. 1 is in north central Alberta and has three development sites under review. The sites are associated with future eco-industrial and agricultural opportunities.

The project is held by No. 1 Geothermal Limited Partnership and Terrapin Geothermics is the originator and major shareholder of the partnership. Terrapin Geothermics secured CDN\$25.4M of ERPP funding with support from the Municipal District of Greenview #16 (MDGV). Early supporters of the project, Edmonton based construction giant PCL, committed CDN\$6M to the project. The province of Alberta has introduced new geothermal framework legislation (Bill 36) and tweeted about the project (Figure 2). The project continues to seek investment capital to support a first-of-kind project and help mobilize future private investment to develop a robust industry to support Alberta's energy transition.

The greatest hurdle to building a robust geothermal industry in Alberta is the de-regulated low cost of power (average pool price for electricity in Alberta in the last 12 months is \$52.19/MWh) and the low cost of locally produced and refined NG (2020 average price of NG was \$1.90/GJ) that is used as the primary fuel for space heating and is anticipated to be the input fuel for 75% of Alberta electrical generation facilities by 2039. (Alberta Electric System Operator, 2019) Additionally, oil and gas (O&G) is the major economic driver for Alberta with 11% of total government revenue came from O&G resources in fiscal 2018/19; in 2018 \$11.7 billion in capital spending went to the oil sands and the industry has paid \$70 billion to the Alberta Government over the last 10 years (2009-2019) (Industry Across Canada 2021).

In addition to the revenues generated from the O&G sector, the Government of Canada estimates that CDN\$1.1billion was spent on energy research, development, and deployment by government in 2018-2019 (NRCAN 2019). However, for geothermal to compete and grow into an industry against this O&G dominated backdrop and show commercial viability in Alberta, the project's financial forecast must include not just power generation, but thermal heat sales as well as carbon offset credits (Figure 3).

Geothermal Support from Alberta



Figure 2: Premier Jason Kenney has tweeted about ABNo1, and Alberta's Department of Energy has introduced new geothermal legislation in the form of Bill 36.

Cost of Heat (and carbon)

How much would it cost (Canadian dollars) in fuel to heat the same amount of water?

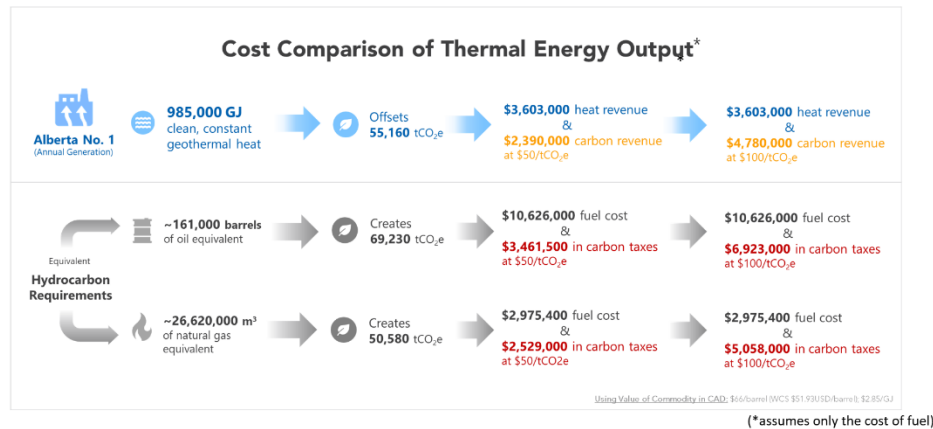


Figure 3: Hypothetical costs for companies consuming oil or natural gas in carbon taxes to produce the same amount of thermal energy as ABNo1’s phase one development.

2. Challenges for Securing Capital Investment

In its search for capital, ABNo1 has encountered several obstacles, unfortunately universal in the geothermal world. Perceived significant front-end risk, together with high initial capital requirements are not attractive to risk-adverse investors. This is true even in the Alberta marketplace where there is an abundance of evidence that temperatures sufficient for geothermal power production exist. (Figure 4). On the other hand, the rising value of carbon credits are a significant boon to geothermal project financial modelling, providing a significant “third” revenue stream aiding in the commercial viability of projects (Figure 5).

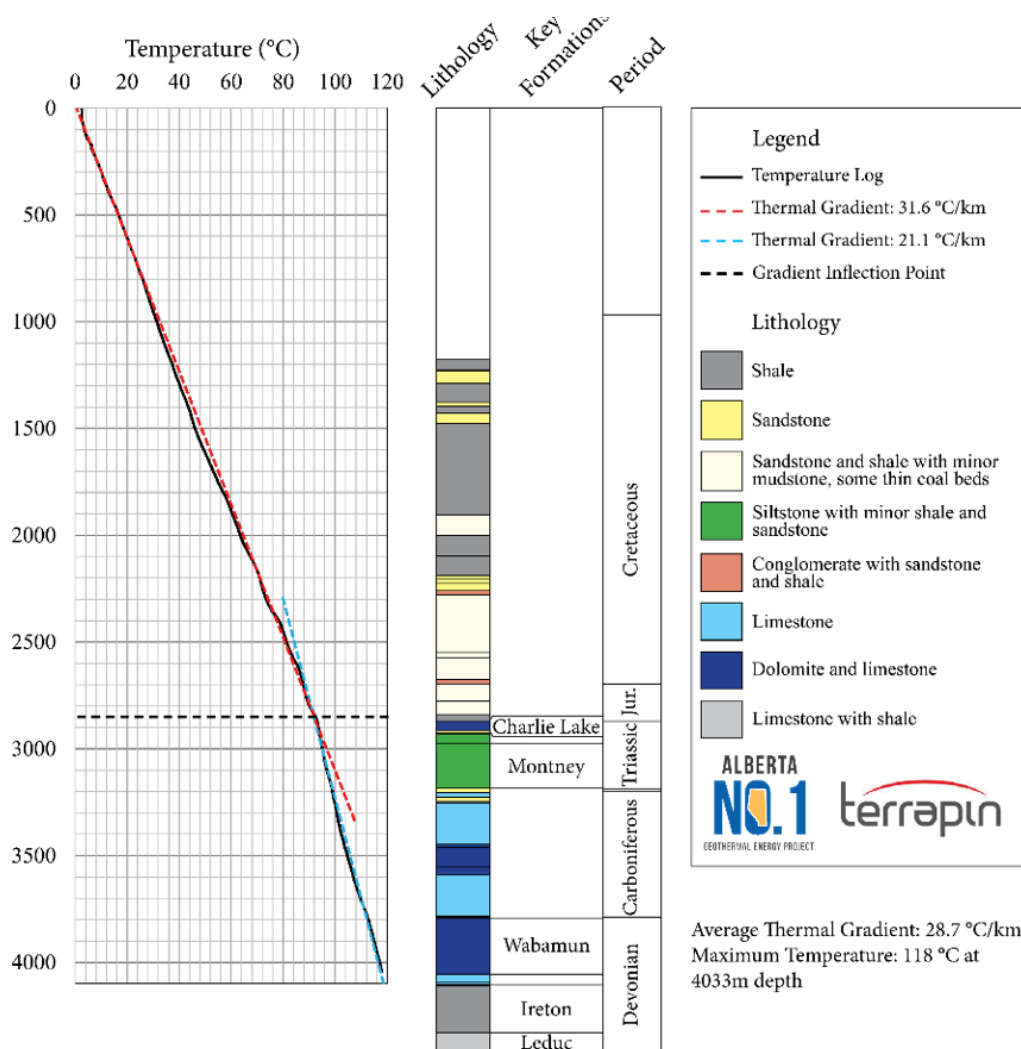


Figure 4: A temperature log (Huang et al. 2021; Champollion et al. 2021) of a disposal well idle for 2 years returned a bottom hole temperature of 118 °C at 4,000m.

Upside Opportunities

Increase in Carbon Pricing



Canada's carbon price can provide even greater value for investors.

	Upside Case (\$170/tCO ₂)	Base Case (\$50/tCO ₂)
Project IRR	22.6%	16.0%
Equity IRR (if held in perpetuity)	30.0%	20.0%
Operating EBITDA	\$17,223 in 2025	\$13,384 in 2025
EV Increase	\$38,390	



Figure 5: The importance of carbon credits to project financing is significant.

2.1 Marketplace challenges for geothermal development in Alberta and Canada

1. Low cost of domestic electrical power (legacy power, most of which is renewable hydro, exceptions are remote, off grid communities on diesel/propane generation).
2. Low cost of thermal energy (direct competition with low-cost, already installed NG).
3. Federal, Provincial and Territorial stances on carbon pricing is shifting.
4. Value of the Oil and Gas (O&G) industry to provincial and federal economies, with Alberta being the most dependent on O&G revenues. O&G industries rank #2, #4, #8 and #9 in the top ten industries by revue in Canada (IBIS World, 2021).
5. Canadian oil and natural gas provided \$105 billion to Canada's gross domestic product (GDP) in 2020, supported more than 500,000 jobs across the country in 2019 and provided \$10 billion in average annual revenue to governments for the period 2017 to 2019.
6. Geothermal must be positioned as a holistic industry, with significant depth and breadth of reach for the economy (Figure 6).

The Holistic View Eco-industrial Development

Integrated eco-industrial clusters focused on sustainable green energy

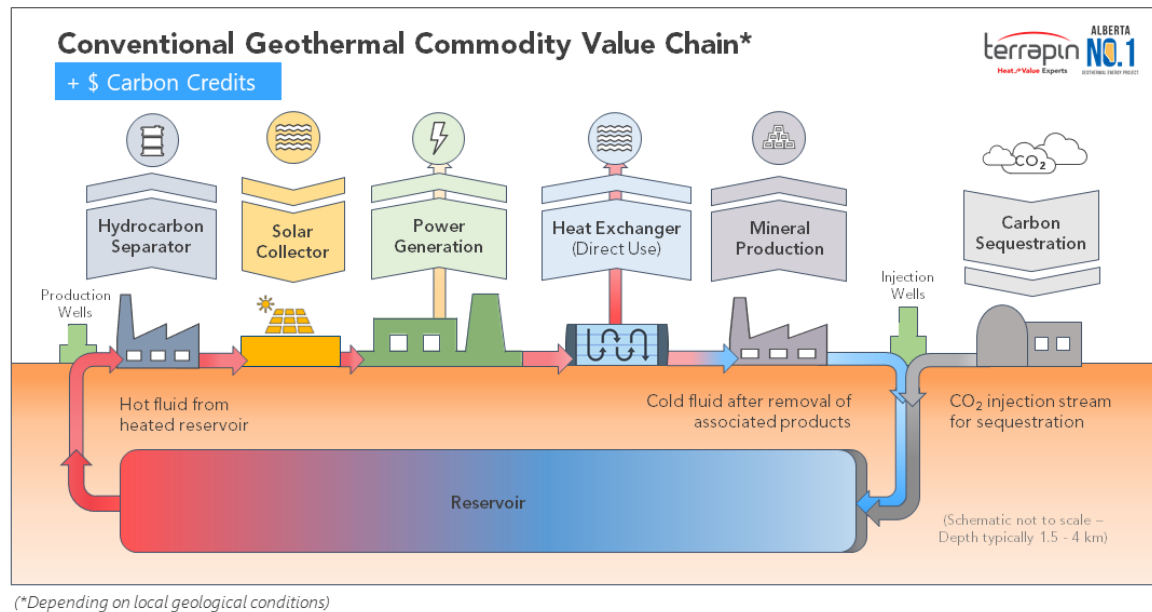


Figure 6: A view of geothermal development potential expanded beyond just heat and power to build a robust industry, supportive of O&G and Alberta's energy transition.

3. What is stopping Canada from being a leading producer of geothermal energy?

As outlined above, there are a number of specific hurdles for Canada to embrace conventional geothermal energy development. In addition to those outlined above its sparse, widely distributed population already serviced by low-cost legacy power is a challenge.

Distraction from other new trending technologies (e.g., Lithium extraction/production, blue hydrogen, Carbon Sequestration, unconventional geothermal, Small Modular Nuclear Reactors (SMNR)) have investors weighing the potential future investment returns against geothermal. And competition with low cost of wind and solar installations remains an issue.

Just as not all of Canada is equally endowed with wind and solar resources; geothermal is also not ubiquitous. The most extensive resources lie in the Western Canada Sedimentary Basin (WCSB) where the O&G industry have a strong presence with significant built infrastructure and revenues. In other provinces, the robust development and investment in large scale impoundment hydro has led to strongly regulated markets and/or monopolistic power companies.

Many jurisdictions are focused on stabilizing the economic conditions to support the traditional O&G industry. O&G remains an important driver for several provinces (such as Alberta) who are heavily dependent on O&G revenue. This is leaving little room for geothermal as an unconventional energy source in the marketplace.

Context

1. The understanding of the public concerning “geothermal energy” is misdirected to high temperature systems and power generation due to global marketing of geothermal using examples from such jurisdictions as Iceland, New Zealand, and Indonesia.
2. Much of Canada (>60%) underlain by crystalline rocks (e.g., granite) that requires Engineered Geothermal Systems (EGS) strategies that are still in research and development stage. Currently there is very limited applicable research being funded in Canada for EGS systems though announcements such as the Geothermal Energy Lab at the University of Calgary may lead to significant developments in future years.
3. There are specific and important differences between geothermal and O&G exploration and extraction that are essential for successful geothermal developments. Though Canada has a highly skilled labour force, there are limited domestic geothermal upskilling opportunities for O&G employees.
4. In Canada there is confusion with “geoexchange” systems (*aka* geothermal heat pumps) which are common in many parts of Canada. In fact, Canada is one of the leading countries in the world in geoexchange systems led by the Canadian GeoExchange Coalition (2021).
5. Limited experience with, and need for, district heating systems. Legacy buildout is NG piping to low density individual residences and commercial facilities.

Political

1. Until recently no developments in power generation.
2. Resource emphasizes Western Canada, leaving out opportunities for Central and Eastern Canada.
3. Development costs in Northern Canada contribute to extremely high CAPEX for projects and limited baseline data available upon which to base decisions.
4. Lack of clarity in regulatory frameworks across the country. (e.g., new Bill 36 in Alberta).
5. Low density of population and low payback on heat only projects.
6. Focus on end-of-life remediation liabilities for geothermal assets, rather than facilitating industry development, due to ongoing concerns with legacy O&G industry.
7. Focus on opportunities for lithium extraction from well field brines and the potential value of the raw material for transforming O&G focused economies.
8. Strategies for reaching net zero and supporting the O&G industry do not currently include geothermal. However, the necessity of Carbon capture and sequestration, especially if a significant blue hydrogen industry is developed, creates significant potential for geothermal developers.
9. Significant educational efforts are required to show the potential build-out of geothermal projects in Canada and how geothermal can support O&G as well as attract new industry.

Investment

1. Private equity not ready to invest in early phase projects – risk profile seen as too high for the reasons outlined above.
2. Proving market rate of return with low power prices and/or low thermal energy price and uncertainty over the long-term carbon tax rate.

3. Project longevity not yet proven in the WCSB.
4. Domestic investors still uncertain about the technology and do not see a pathway to multiple projects

4. Opportunities for Attracting Capital Investment

Geothermal developers can do more to position geothermal as “the greenest of green energies”, emphasizing that it is the only one that is base load, dispatchable, and provides thermal energy as well as electricity. In addition, having an upfront option for a “failed” exploration or production/injection well through using the well for CO₂ sequestration and/or O&G waste disposal provides investors with a route to financial security.

Boosting the importance of energy security and highlighting opportunities to mitigate system reliability concerns due to the significant buildout of intermittent generation sources is a topic that should be emphasized. This, along with promoting Geothermal as part of the energy mix required by Alberta and Canada going forward to decarbonize the economy are important attributes to assist in attracting capital. Emphasizing that many solutions are going to be needed and geothermal is very complimentary for provinces with an O&G based economy (Another tool in the toolbox)

Geothermal developers need to more clearly demonstrate how to use orphaned wells and their associated infrastructure (showing a clearer path to use of existing surface disruption) in development. They also need to more clearly show a pathway to multiple projects for industrial heating, commercial/residential direct use, and power generation. The possibility of investigating alternative commodities (Li extraction and CO₂) as well as hydrocarbon separation as a “holistic” view of geothermal development (Figure 6) should be emphasis as an up-side for investors.

Essential in a decarbonizing world is ensuring that geothermal is positioned as carbon zero and emphasizing that it can be carbon negative when paired with CO₂ sequestration. Geothermal’s role in helping companies reach their carbon reduction goals will be critical over the coming years.

Just as the “holistic” view (Figure 6) of a geothermal development is important, promoting the industrial resource park concept (“industrial cluster”) to create synergies with other industries needing green heat and/or power and/or CO₂ sequestration will be increasingly important. Targeting investors that are already intent on investing in renewable technology, reducing GHGs in their projects, or increasing their ESG credits, will be vital. Forming these alliances with other industries will reduce capital costs and ensure financial viability of projects over generational time frames.

5. How Can Governments Support Capital Investment?

In order for geothermal projects to overcome the hurdles in attracting capital investment, particularly in early phase and “first of kind” developments we suggest three possibilities:

1. Loan guarantees to reduce the risk to conventional lenders and access conventional financing earlier than standard at better rates.

2. Financial instruments to attract capital such as the Investor tax credits (US ITC of 26% for investment into waste heat, geothermal, and other clean energy technologies have significantly advanced development conversations on these style of projects in the US).
3. A government-run Green Energy Fund that provides funding for initial commercial developments. Run as a true investment fund that requires returns but can mandate a longer payback period to incentivize desired technologies.

As Canada is dominion with separate provincial, territorial and federal jurisdictional regimes, which of these might be adopted (if any) is unknown at the present time. However, the investment by the Federal Government in geothermal projects is paving the way for demonstration that conventional geothermal has a place to play in Canada's energy mix.

6. Conclusion

Despite strong rhetoric from governments across Canada and in particular the Government of Alberta, supporting the growth of a geothermal industry, it has not “taken off and risen”. However, there are significant positive signals that geothermal energy is starting to emerge as an investment opportunity to help Canada reduce GHGs, diversify its energy mix, support rural and indigenous communities and for corporations to gain ESG credits.

The Federal government support through the ERPP funding envelope has provided support for three projects to forge ahead. Each of these projects is in various stages of development with DEEP Earth (Saskatchewan) leading the way and moving into build out of the well field. Clarke Lake (British Columbia announced March 2021) has begun with entry into an existing high-flow, hot gas well. Alberta No. 1 (Alberta) is still seeking capital investment to begin drilling.

In research and development, Futera Power (Alberta) is working on a hybrid co-production facility and may be the first to produce geothermal electricity in Canada, following in the footsteps of the temporary 1984 production of 250 kW at Mount Meager, British Columbia. Eavor (Alberta) continues research and development on the commercialization of its proprietary “Eavor loop”. The Mount Meager lease, a known high temperature resource north of Vancouver, British Columbia, has been purchased by a new development company, who are working on plans to rebuild the road access and assess the potential of the existing wells and costs for drilling new wells.

In Alberta, the clamor of young professionals to find a place in the “new industry” is deafening and will soon result in corporations embracing geothermal energy as a path to reduce GHG emissions and gain valuable ESGs. Alberta No. 1 is proud to be on the rising wave and to be the first conventional geothermal power and heat project in Alberta.

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REFERENCES

- Alberta Electric System Operator, “AESO 2019 Long-term Outlook”, Sept 2019
<https://www.aeso.ca/assets/Uploads/AESO-2019-LTO-updated-10-17-19.pdf>
- CAPP, “Industry Across Canada”, <https://www.capp.ca/economy/industry-across-canada/>
 accessed July 9, 2021
- Champollion, Y, Hickson, C.J., and Huang, K. “Comparing Temperature Data from Oil and Gas and Geothermal Logs – An AB No.1 Case Study”, *Geothermal Rising, GRC Transactions* 45, 2021.
- Hickson, C.J., Cotterill, D, Huang, K., and Kumataka, M. “Alberta No. 1: The province’s first conventional deep geothermal power project” *Proceedings of the GeoConvention*, Calgary, Canada, September 21 – 23, 2020
- Huang, K., Hickson, C.J., and Champollion, Y. “Preliminary Results of a Temperature Log Using a Deep Disposal Well in the Western Canadian Sedimentary Basin” *Geothermal Rising, GRC Transaction* 45, 2021.
- IBIS World, “Energy and Economy”, <https://www.nrcan.gc.ca/science-data/data-analysis/energy-data-analysis/energy-facts/energy-and-economy/20062>
- NRCAN, “Energy and Economy”, <https://www.nrcan.gc.ca/science-data/data-analysis/energy-data-analysis/energy-facts/energy-and-economy/20062>
- Wikipedia, “Corruption Perceptions Index”,
https://en.wikipedia.org/wiki/Corruption_Perceptions_Index accessed July 9 2021