The Feasibility of Repurposing Oil and Gas Wells for Geothermal Applications

Emily J. Smejkal, Catherine J. Hickson, Katherine Huang, Phil Harms and Dan Kalmanovitch.
Terrapin Geothermics Inc., GEOSEIS Inc.

Summary

In regions where oil and gas extraction has been on-going for decades, there is an inventory of wells that range from fully abandoned (plugged and well head removed), to suspended, to operational. In Alberta, there are over 450,000 wells (Alberta Energy Regulator, 2022) that have been drilled since the early decades of the 20th century (Figure 1). The financial states of companies who hold these assets have changed through time and many previously owned wells are now "orphaned." Orphan wells may range in status from abandoned to operational, but the most important aspect is the lack of a viable company that can be held responsible for the reclamation of the wells and surface disturbance (pad, roads, pipelines, etc.) (Alberta Energy Regulator, 2022). All wells have a liability associated with them to ensure safe and environmentally responsible abandonment and reclamation. In Alberta, this liability is estimated at $100 billion dollars (McNeill, 2018). Given the potential reclamation costs and re-utilization possibilities of these and future wells, we outline the investigative process of reviewing, analyzing, and assessing suspended and active wells in Alberta for their geothermal potential.

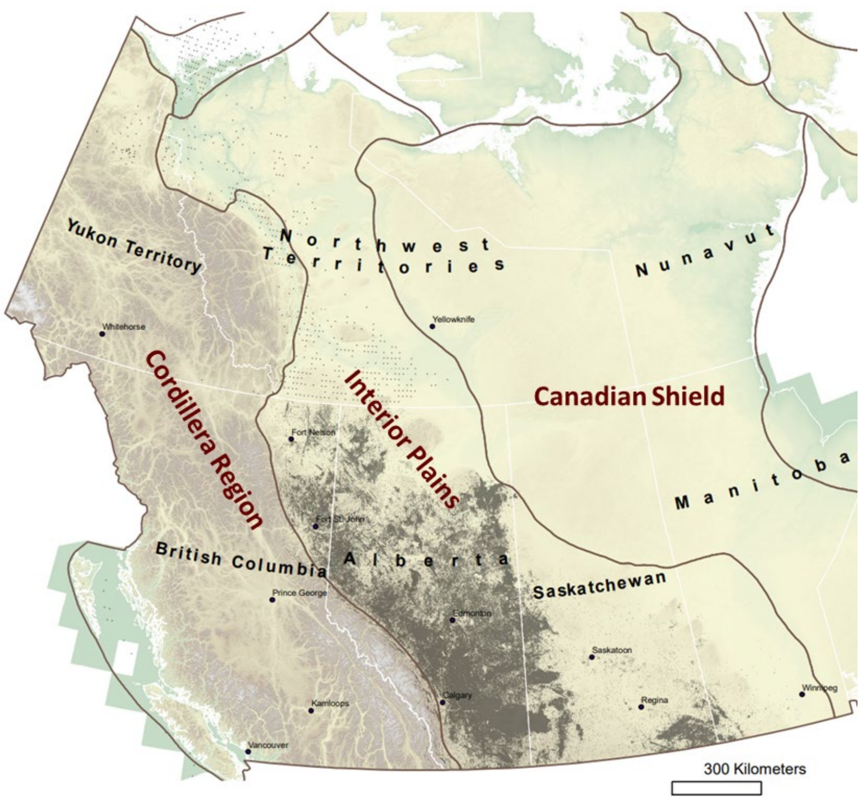

Figure 1: Map of Western Canada showing all oil and gas wells drilled. Image courtesy of GEOSEIS.

Workflow

Repurposing can refer to a variety of activities with respect to oil and gas well sites. The surface rights, facilities, equipment, and subsurface exploitation rights all have potential to be repurposed (Cameron & Morrison, 2020). Our team will focus on the potential for oil and gas wells or pools to be converted to geothermal energy extraction. Many factors must be considered to create a robust screening and ranking system for candidates, which include wells and pools of wells. Our Phase 1 work will use a multidisciplinary approach using publicly available downhole and production information to evaluate the candidates. This first pass will remove wells with known downhole problems (corrosion, casing damage, vent flows, etc.) from further consideration. Orphan wells will be included in the initial filtering, but we expect that very few will meet the requirements for repurposing. However, these wells provide important data about the subsurface conditions at the location where they were drilled. This information will be important in informing the decision as to the potential of that site, even if the well itself cannot be used.

Following the initial screening for downhole problems, wells the candidates will then be evaluated for fluid production and downhole temperature. To be viable for geothermal heat generation, the candidates need to produce fluids at high flow rates (>10L/s) and temperatures of at least 40ºC (Butler, 2010). A list of potential screening criteria is shown in Table 1.

Category	**Criteria**	**Requirements**
Engineering	Well Depth	> 2 km
Engineering	Historical Production Rates	Fluid rate (all fluids) > 864 m^3/day (10 L/s)
Engineering	Well Age	Younger is better
Engineering	Casing Integrity	Good cement bond, no scaling, no corrosion, no casing breaks
Engineering	Produced Fluids	Oil/water > gas
Engineering	Well Orientation	Horizontal > vertical
Engineering	Casing Diameter	Larger > smaller
Geographic	Well Location	Community proximity, infrastructure proximity, environmental considerations
Geographic	Surface Facilities	Utilities tie in, road access, pad size, existing facilities
Geologic	Bottom Hole Temperature	> 70ºC (but temperatures as low as 40ºC may be useful)
Geologic	Potential Reservoir Formation	Fractured limestone > Limestone > Sandstone > Shale
Geologic	Completed Formation	High porosity and permeability
Regulatory	Well Status	Well is not abandoned, well has been inactive < 12 months, well is not suspended
Regulatory	Well Owner	Interested in green energy transition
Regulatory	Environmental	No past leaks/spills (liability issues)

Table 1: A list of potential screening criteria an oil or gas well to be repurposed for geothermal energy use.

Only candidates that both meet the screening criteria and can be re-entered at a low cost will be considered for Phase 2 of the study. This phase will create a prioritized list of candidates, using a multidisciplinary geospatial approach. Candidates will be targeted for a variety of potential uses such as co-production, wellbore re-entry, and direct heat production (Figure 2). They also must be near communities or industrial centers to ensure a market for the geothermal energy generated. Rural, remote, and Indigenous communities stand to benefit most from geothermal energy use. Direct use projects (Figure 2) such as greenhouses, drying facilities, aquaculture and community heating have many potential socio-economic benefits for these communities (Hoicka & MacArthur, 2018). Community and industry engagement will be key to ensuring successful repurposing of oil and gas infrastructure.

Once a short-list of candidates has been established, each will need to be tested to verify their geothermal potential. This will involve casing and cement inspection, bottom hole temperature measurements, cased hole logging, and produced fluid analysis. These analyses will require the cooperation of the wellbore operator and the Alberta Energy Regulator. Because the wells in Alberta were drilled and completed for oil and gas extraction purposes, existing public data may not capture their geothermal potential.

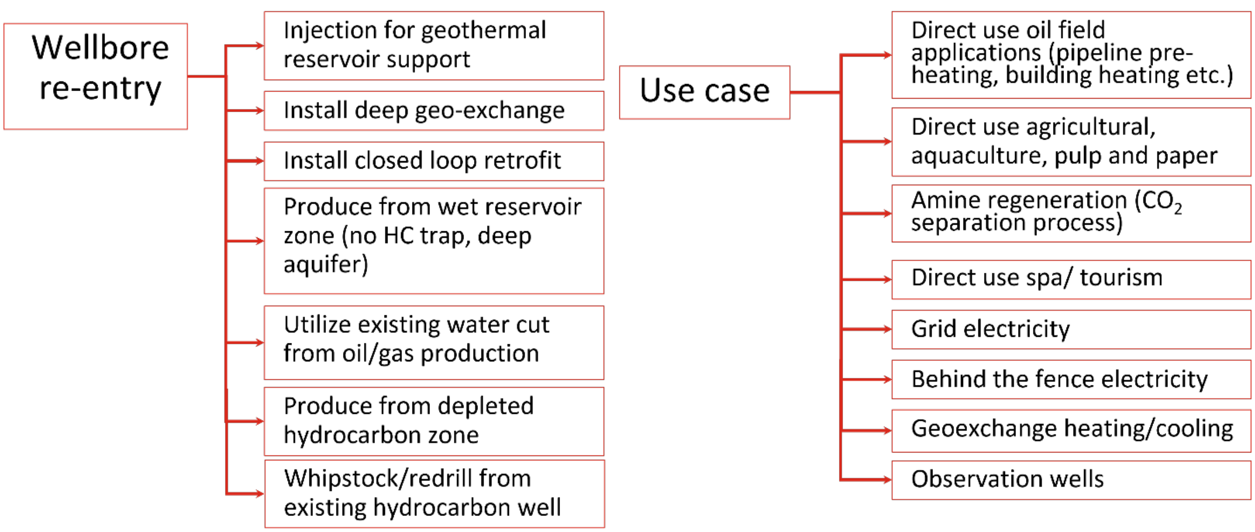

Figure 2: Repurposing options for existing oil and gas wells and potential uses for the captured geothermal energy.

Work to re-purpose existing oil and gas wells is already underway worldwide (Figure 3) (Duggal, et al., 2022). The Huabei Field in China has been operating a pilot power plant on the coproduction of oil and geothermal since 2011. It produces 400 kW gross power coproduction, 310 kW of which is geothermal (Xin, Liang, Hu, Kewen, & Li, 2012). Recently, the DOE announced funding for a project in Nevada, U.S.A., which is a partnership between Transitional Energy and Grant Canyon Oil & Gas (Office of Energy Efficiency & Renewable Energy, 2022). In this repurposing project the operator maintains the well liability of the existing oil wells, and the pool is repurposed for coproduction, and eventually transitioned to renewable geothermal power (Tansitional Energy LLC, 2022). In Alberta, Canada, Futera Power has developed a natural gas / geothermal coproduction power plant using existing natural gas wells to generate 21 MW of electricity, 30% of which will come from geothermal energy (Futera Power, 2022).

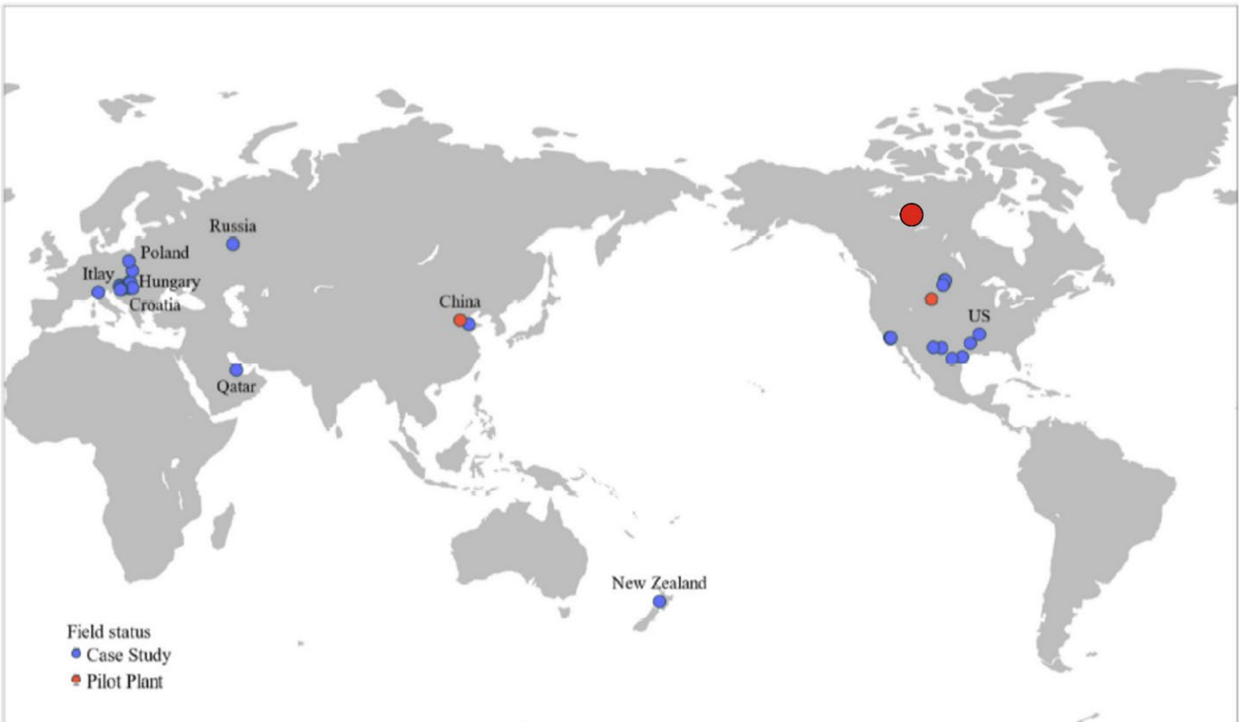

Fig. 1. Worldwide hydrocarbon fields analysed for geothermal operation.

Figure 3: Map showing worldwide hydrocarbon fields that have been analyzed or piloted for geothermal operation. (Duggal, et al., 2022)

Conclusions

The lower CAPEX and shorter, less complicated development timeframes of these repurposing projects are more amenable for targeted smaller communities to initiate. With the substantial number of oil and gas wells in Alberta, there are major benefits for evaluating the potential for repurposing to geothermal. Even if the well cannot be repurposed, the information gained through the drilling and production of that well is valuable, as is the disturbed site and access route (including pipeline right aways) that the well sits on. By reusing these disturbed sites, cost saving is possible, and the environmental footprint of the project is reduced.

While it will be possible to repurpose some wells; it will require detailed, multidisciplinary work to find viable candidates. Thankfully, much of the data required for this analysis is publicly available. Numerous pools in Western Canada are on the fringe of power production potential and have high direct use heat potential. Synergies between these energy sources and industrial operations could be a win-win for geothermal development and oil and gas operations, especially where grid electrification is unavailable.

Acknowledgements

This work has been submitted for Federal funding under the Smart Renewables and Electrification Pathways Capacity Building program SREPPS https://www.nrcan.gc.ca/climate-change-adapting-impacts-and-reducing-emissions/green-infrastructure-programs/smart-renewables-and-electrification-pathways-program/23566, but was not successful. The team has recently submitted the proposal to another funding agency.

References

Alberta Energy Regulator. (2022, 01 17). *Alberta Energy*. Retrieved from https://www.alberta.ca/oil-and-gas-liabilities-management.aspx

Butler, S. K. (2010). Geothermal Power Capacity from Petroleum Wells – Some Case Histories of Assessment. *Proceedings World Geothermal Congress 2010.* Bali, Indonesia.

Cameron, K., & Morrison, L. (2020, 09 20). *Bennett Jones Blog*. Retrieved 03 01, 2022, from Bennett Jones: https://www.bennettjones.com/Blogs-Section/Wellsite-Repurposing-Projects-Part-1-Benefits-and-Advantages

CeraPhi energy. (2021, 09). *LinkedIn*. Retrieved from https://www.linkedin.com/feed/update/urn:li:activity:6844184886006300672/

Duggal, R., Rayudu, R., Hinkley, J., Burnell, J., Wieland, C., & Keim, M. (2022). A comprehensive review of energy extraction from low-temperature. *Renewable and Sustainable Energy Reviews*.

Futera Power. (2022). *Futera Power*. Retrieved 03 01, 2022, from Futera Power: https://www.futerapower.com/

Hoicka, C., & MacArthur, J. (2018). From tip to toes: Mapping community energy models in Canada and New Zealand. *Energy Policy*. Retrieved from https://www.researchgate.net/publication/326000191_From_tip_to_toes_Mapping_community_energy_models_in_Canada_and_New_Zealand

McNeill, J. (2018, 11 20). *Pembina Institute*. Retrieved from https://www.pembina.org/blog/alberta-government-has-transparency-problem-when-it-comes-oil-and-gas-liabilities

Office of Energy Efficiency & Renewable Energy. (2022, 01 12). *Energy.Gov*. Retrieved from https://www.energy.gov/eere/articles/doe-awards-84-million-accessing-geothermal-potential-abandoned-oil-and-gas-wells

Transitional Energy LLC. (2022, 01 14). *Transitional Energy Press Releases*. Retrieved 03 01, 2022, from Transitional Energy: https://transitionalenergy.us/media

Xin, S., Liang, H., Hu, B., Kewen, & Li, K. (2012). ELECTRICAL POWER GENERATION FROM LOW TEMPERATURE CO-PRODUCED GEOTHERMAL RESOURCES AT HUABEI OILFIELD. *PROCEEDINGS, Thirty-Seventh Workshop on Geothermal Reservoir Engineering.* Stanford: Stanford University.