People for Energy and Environmental Literacy (PEEL)

Lesson Plan 8 Assignment

Date: December 2022
Version 1.0

PEEL is supported by the Community Environment Action Program. This project is offered in partnership with GreenLearning Canada Foundation, provider of free online education programs about energy, climate change and green economy.

ASSIGNMENT – GEOTHERMAL ENERGY INVESTIGATION – Advanced

Introduction

Canada has an abundance of geothermal resource, but a geothermal power plant has yet to be built in the country. In the lesson, geothermal energy resource maps showed that Alberta has the potential to harness the earth's energy for heating and electricity. This assignment will focus on the Alberta context for geothermal energy projects, investigating the province's geothermal energy opportunities and obstacles. You will explore Alberta's geothermal energy options and form an opinion on the technology's viability.

Instructions

Inquiry & Analysis

In small groups, research the geothermal binary cycle (also called the organic Rankine cycle or ORC) and how it converts geothermal energy into electricity. Answer the questions below to help guide your investigation and assessment of the viability of geothermal energy options in Alberta.

Conclusion and Resources

Based on the research completed in this assignment, briefly explain (approximately one page) why you think geothermal is or is not a viable electricity generation technique in Alberta at present and in the future. Describe measures that may help Alberta adopt geothermal energy, factors that put Alberta at an advantage in the industry, and other geothermal options that may be applicable. Support your argument(s) with citations and references where possible. Share your findings as a class and discuss how geothermal may be implemented in Alberta.

Name: _____ Date: _____

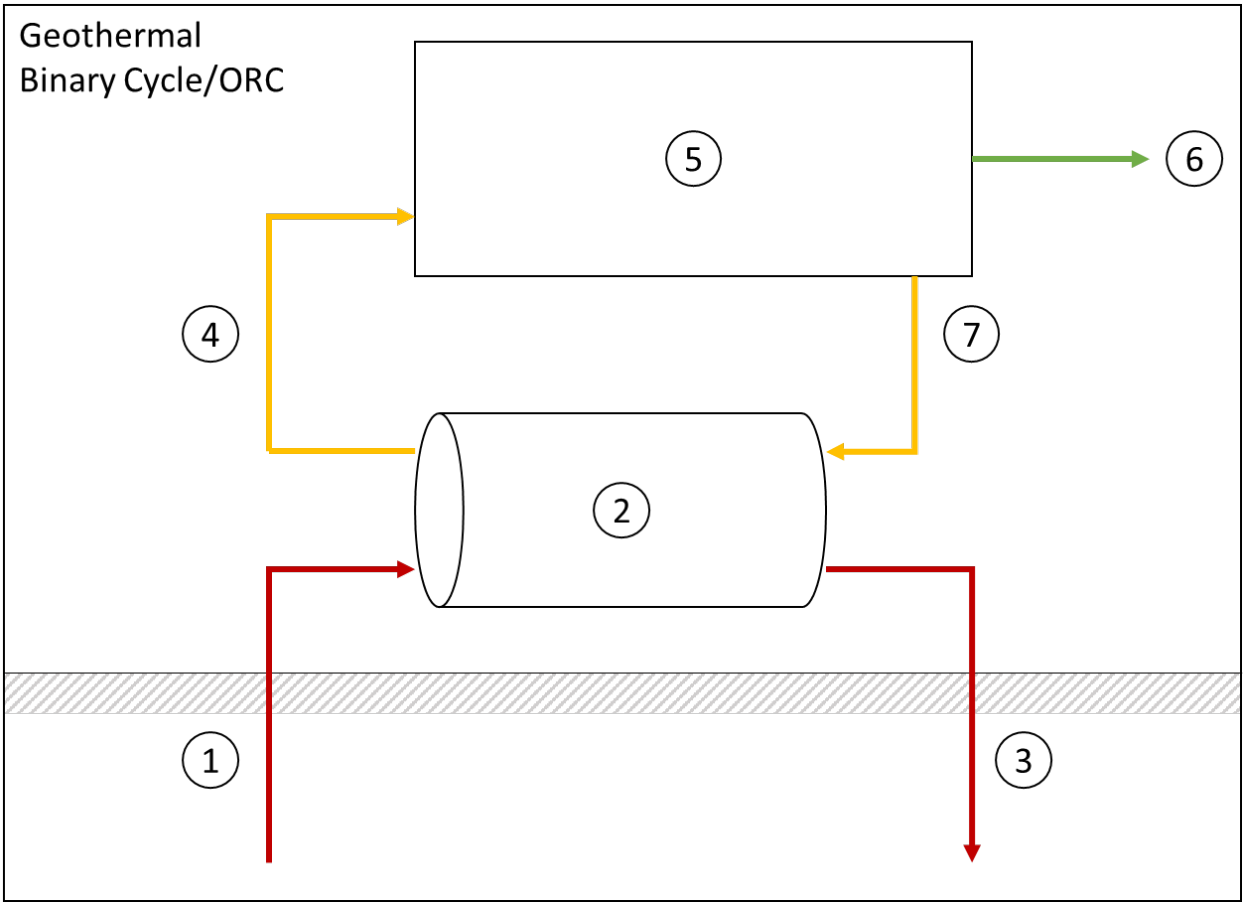
1. A. Use the following table to compare the three methods used to generate electricity from geothermal energy. Rank each technology based on your opinion of its applicability in Alberta.

Technology	**Reservoir Temperature (°C)**	**Is the water liquid or steam? What happens when it reaches the surface?**	**Specialized fluids, equipment, additional steps and considerations, etc.**	**Alberta Ranking**
Dry Steam				
Flash Steam				
Binary Cycle (ORC)				

1. B. Explain your technology rankings.

2. Fill out the following table, describing the equipment, materials, and processes labelled in the Geothermal Binary Cycle/ORC diagram (on the next page).

Step	Equipment/Materials	Process Description
1		
2		
3		
4		
5		
6		
7		



3. What potential environmental impacts are associated with geothermal electricity generation? How does this compare with other methods of electricity generation?

4. What other ways can geothermal energy be harnessed in Alberta? How can this be applied to your school, home, and community? What benefits may these solutions provide?

5. Why might the geothermal ORC process be a good fit for Alberta? What existing conditions and infrastructure may help Alberta implement geothermal ORC sooner and with less risk?

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6. List three to five challenges facing Alberta's implementation of geothermal electricity generation. What are some ways each challenge may be mitigated?

Challenge	Mitigation

Alberta

Grading

N = Not Meeting Expectations M = Meets Expectations C = Commendable E = Exceptional

Rubric

Criteria	N	M	C	E
Formulates or reformulates a vital problem, question or issue.	Fails to identify or summarize a problem, question or issue.	Summarizes a problem, question or issue. Some aspects are confused, and key details are missing or overlooked.	Clearly and precisely formulates or reformulates the vital aspects of a problem, question or issue as it relates to the context.	Vital aspects of the problem, question or issues are clearly and precisely formulated or reformulated identifying integral relationships essential to analyzing the problem, question or issue as it relates to the context.
Gathers, assesses and analyzes relevant information, data and robust evidence.	Information, data or evidence are simplistic, or unrelated to the problem, question. Information or data are repeated without question and evidence is dismissed without adequate justification. References not provided.	Appropriate information, data or evidence is provided. Information or data are selective but largely unexamined in terms of accuracy, relevance and completeness. Provided vague references about sources of information.	Appropriate information, data or evidence is provided and are thorough, fully analyzed and reported. Information, data or evidence and its source is questioned in terms of accuracy, relevance and completeness. Provided references about sources of information.	Information, data or evidence gathered are extensive, furthering insight into the problem, question or issue. Information, data or evidence and its sources are fully analyzed and evaluated as to accuracy, reliability and relevance. Variables are effectively compared using clear graphical trend. Provided detailed references about sources of information.

Arrives at well-reasoned interpretations & conclusions.	Provides a simplistic interpretation & conclusion with no consideration of implications	Demonstrates and presents simplistic interpretations & conclusions. Basic discussion of implications.	Exemplifies: • plausible interpretation, • consideration of assumptions, • reasoned judgment and conclusions based on evidence, and • consideration of implications that reach beyond the immediate situation	Exemplifies: • plausible, coherent working theories, • well-reasoned judgment and conclusions based on evidence with an examination of different viewpoints, • an analysis of assumptions, • a thorough examination of implications, and • compares biome analyzed to alternate group to provide increased depth of investigation
Integrates global systems concepts to help explain findings	Minimal integration of concepts from the lesson into analysis and interpretation.	Integrates some components of the lesson into analysis and interpretation but relationship to data set is marginally developed.	Integrates multiple concepts from the lesson and begins to relate concepts to analysis and interpretation provided.	Integration a wide range of concepts from the lesson, in a novel way, to provide a multifaceted explanation (support or oppose) of results obtained. Provides a holistic understanding of the lesson.
Communication and teamwork	Works alone to answer questions related to the topic under consideration.	Shares ideas with others related to the topic under consideration to build collective understanding of the topic.	Interacts with others in figuring out complexities related to the ideas of the topic under consideration.	Synthesizes data using multiple interpretations of evidence. Builds coherently on ideas to promote improved collective understanding of a topic.

(Adapted from Galileo Guide to Assessing Critical Thinking, 2008)

ANSWER KEY

1. A. Use the following table to compare the three methods used to generate electricity from geothermal energy. Rank each technology based on your opinion of its applicability in Alberta.

Technology	**Reservoir Temperature (°C)**	**Is the water liquid or steam? What happens when it reaches the surface?**	**Specialized fluids, equipment, additional steps and considerations, etc.**	**Alberta Ranking**
Dry Steam	170-350 degrees	Steam (gas) Expands in turbines and generates electricity	Condenser, excess steam may be emitted	Not feasible
Flash Steam	170+ degrees	Liquid Large pressure change in flash tank vaporizes water	Flash tank, condenser	Not feasible
Binary Cycle (ORC)	95-182 degrees	Liquid Heats up organic fluid in the heat exchanger	Organic fluid with a boiling point (BP) lower than water, heat exchanger	Best

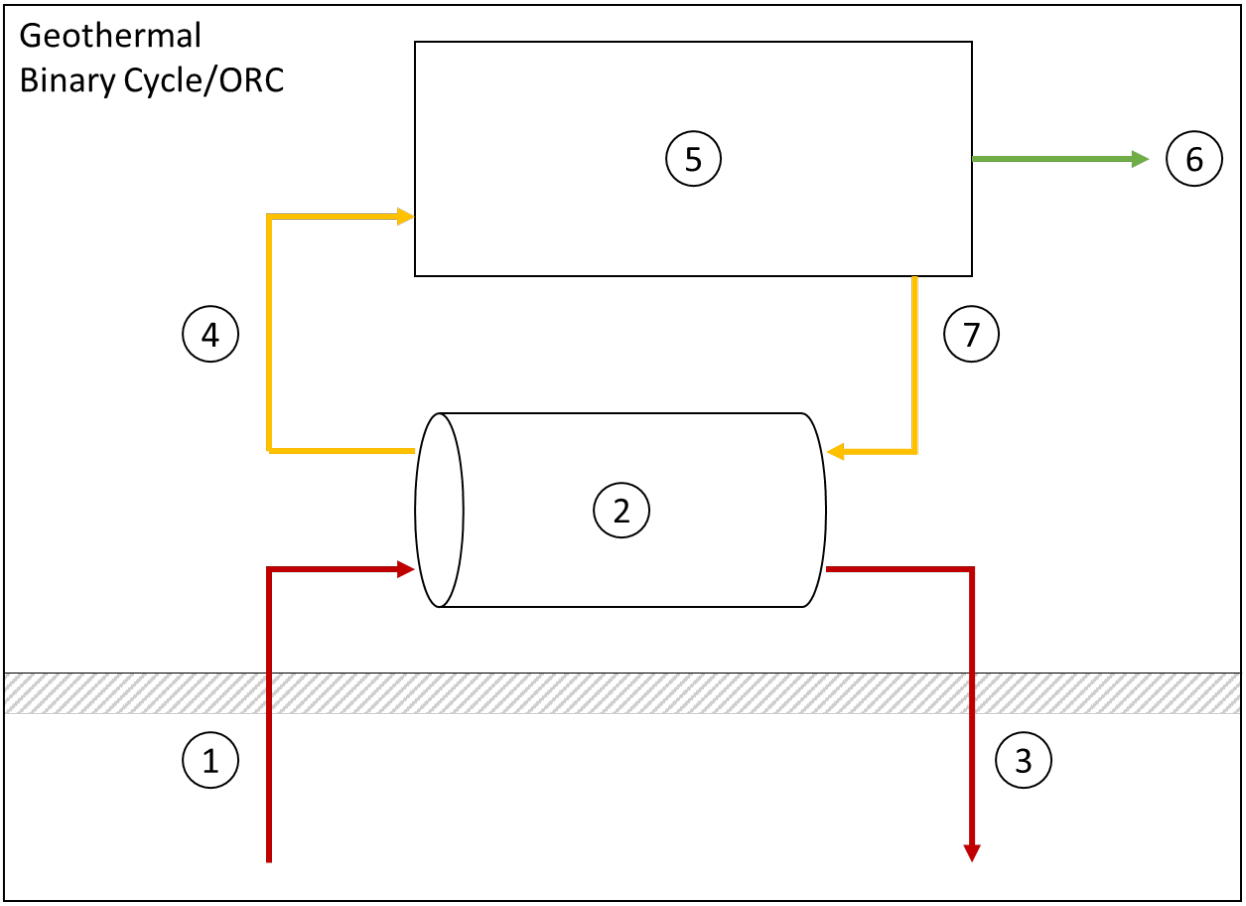
1. B. Explain your technology rankings.

Alberta's geothermal reservoirs contain hot water with temperatures around 120 degrees C. Therefore, the only production can be Binary Cycle (such as Organic Rankin Cycle).

British Columbia has hotter temperatures than Alberta. These are in the interior of BC. These "hot rocks" are related to previous volcanic activity and therefore may have the opportunity to produce electricity using flash steam. The geothermal resource in BC is not well explored. Perhaps in the next decade this exciting opportunity will be developed.

2. Fill out the following table, describing the equipment, materials, and processes labelled in the Geothermal Binary Cycle/ORC diagram (on the next page).

Step	Equipment/Materials	Process Description
1	Production well carrying water between 95-182°C	Hot water is pumped to the surface from the underground reservoir
2	Heat exchanger with hot water on one side, and organic fluid on the other	Water heats up and boils the organic fluid (that has a lower boiling point than water). Cool water and organic vapour exit the heat exchanger.
3	Cool water injection well	Cool water is injected back into the reservoir to be re-heated and re-used
4	Organic vapour	Organic vapour travels from the heat exchanger to the electric turbine
5	Turbines turned by organic vapour	Organic vapour expands and turns the turbines, which are connected to generator to create electricity
6	Electricity	Electricity generated by the turbines leave the generating facility, destined for the electricity grid
7	Cooled/condensed organic fluid	After turning the turbines, cooled/condensed organic fluid returns to the heat exchanger to be re-heated and re-used



3. What potential environmental impacts are associated with geothermal electricity generation? How does this compare with other methods of electricity generation?

- Risk of harm to the environment associated with drilling wells, fracking, chemicals and materials used during drilling and well completion, etc. In Western Canada, there is an opportunity to use existing or abandoned oil and gas wells to potentially reduce the environmental impacts. Management of the thermal reservoir is critical to maintain continuous electricity production.
- Contaminated water (brine) may harm the environment if not properly reinjected.
- Once drilled and completed, geothermal power plants produce little to no CO_2 or other harmful emissions/greenhouse gases.

4. What other ways can geothermal energy be harnessed in Alberta? How can this be applied to your school, home, and community? What benefits may these solutions provide?

- Think about the different uses based on resource quality/temperature
- For lower quality heat resource and shallower systems, consider direct use and ground source heat pumps. This can be used for heating residential homes and for greenhouses. In addition, this heat can be used for district heating in communities and at universities.
- Geothermal may help reduce costs for electricity and heating, greenhouse gas emissions, dependence on diesel in remote communities, etc.

5. Why might the geothermal ORC process be a good fit for Alberta? What existing conditions and infrastructure may help Alberta implement geothermal ORC sooner and with less risk?

- ORC process can be a better fit since there is insufficient thermal resource for flash or dry steam technologies.
- Many existing oil and gas wells in Alberta
    - Lots of data available, which may reduce exploration/resource risk
    - Existing wells may be leveraged for geothermal uses
    - Some remote facilities/communities may benefit from local geothermal electricity/resources
- Complementary skillset and expert labour pool
    - Many skilled professionals from the oil and gas industry could be valuable in the geothermal industry
    - Similar functions, such as reservoir engineering, drilling and completions, production operations, process engineering, geology/geophysics, etc.
    - Current research and development for oil and gas wells may be applicable to geothermal energy production
    - Existing post-secondary institutions with expertise on reservoirs.

6. List three to five challenges facing Alberta's implementation of geothermal electricity generation. What are some ways each challenge may be mitigated?

Challenge	Mitigations
• High up front cost to build geothermal systems	• Research and innovative technology • Grants and incentives
• More expensive compared to other energy sources	• Government funding, incentives • Changes to market structures that favour geothermal
• Unexplored resource and lower thermal resource	• Use existing wells and data to reduce uncertainty • Partner with oil and gas companies for further access and support
• Isolated thermal resource/poor access to transmission lines	• Select sites near customer loads (energy demand) or transmission interconnection points
• Better thermal resource is out of reach (prohibitively deep)	• Research and innovative technology • Partner with oil and gas companies for support and complementary development
• Resistance to change/public perception	• Education on the benefits of geothermal • Discuss the need for additional renewable energy generation as a replacement for high-carbon electricity generation • Promote opportunities for people in a similar profession to adapt their experience to geothermal