Economic Factors and their Implications for the Development of a Commercially Viable Geothermal Project

Dr. Catherine Hickson P.Geo.

Tuya Terra Geo Corp.

Yellowknife Geothermal Workshop

November 23, 2018

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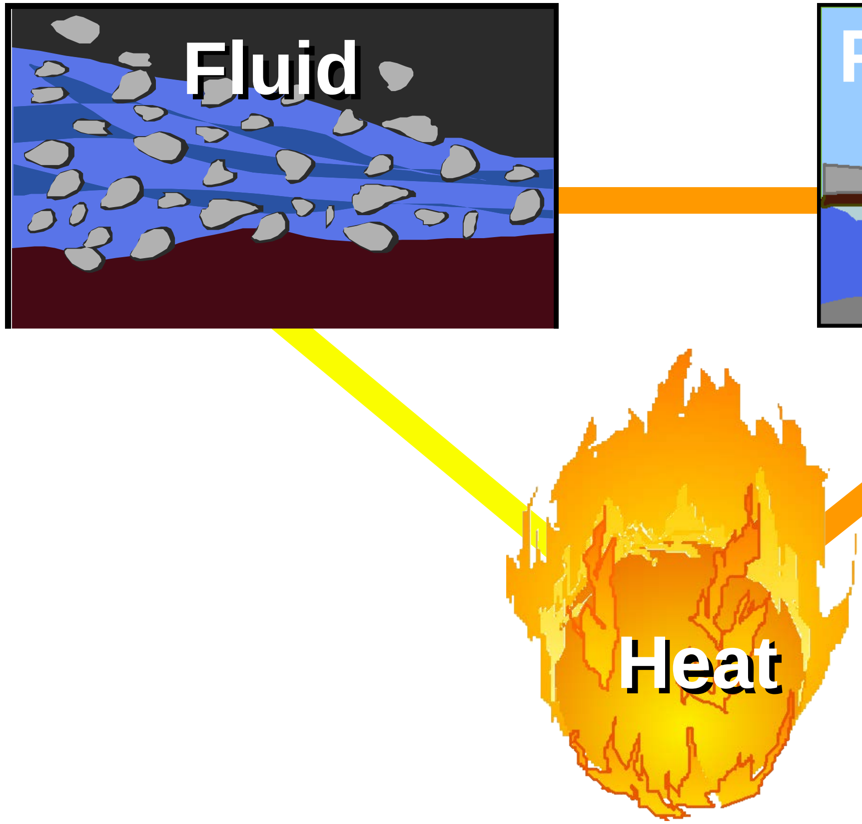
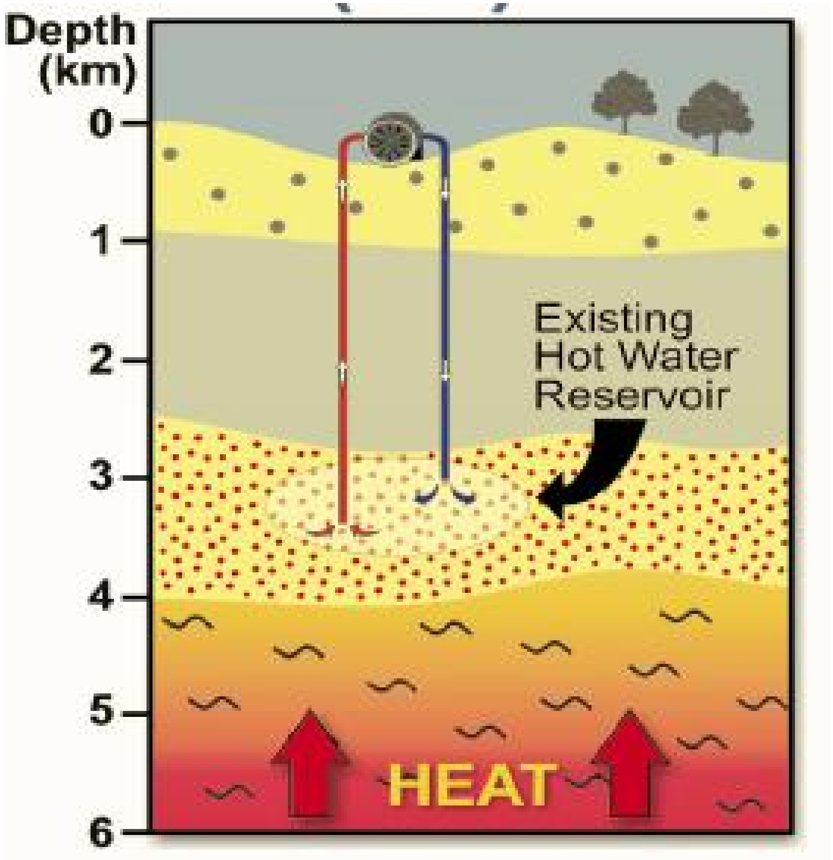
GEOTHERMAL FUNDAMENTALS



Geothermal gradient in NWT = 20°C - 60°C per kilometer of depth. At 5 km temp. could be between 100°C and 300°C



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TEMPERATURE RANGES & DEPTHS

Geo-Exchange

0°C - 20°C

0 - 300 metres

- Also known as ground source heat pumps
- Used to heat/cool residential and commercial buildings
- Exists across Alberta today

Direct Use

20°C - 90°C

500 – 1,500 metres

- Direct use of the heat contained in a sub-surface reservoir for an industrial process such as timber drying, heating process fluids, aquaculture, greenhouses etc.

Power Generation

70°C – 300°C

1,500 – 4,500 metres

- Temperatures hot enough for electricity generation
- Can also do a “cascade use” system that first generates power, then cascades remaining hot liquid into a direct use, industrial application

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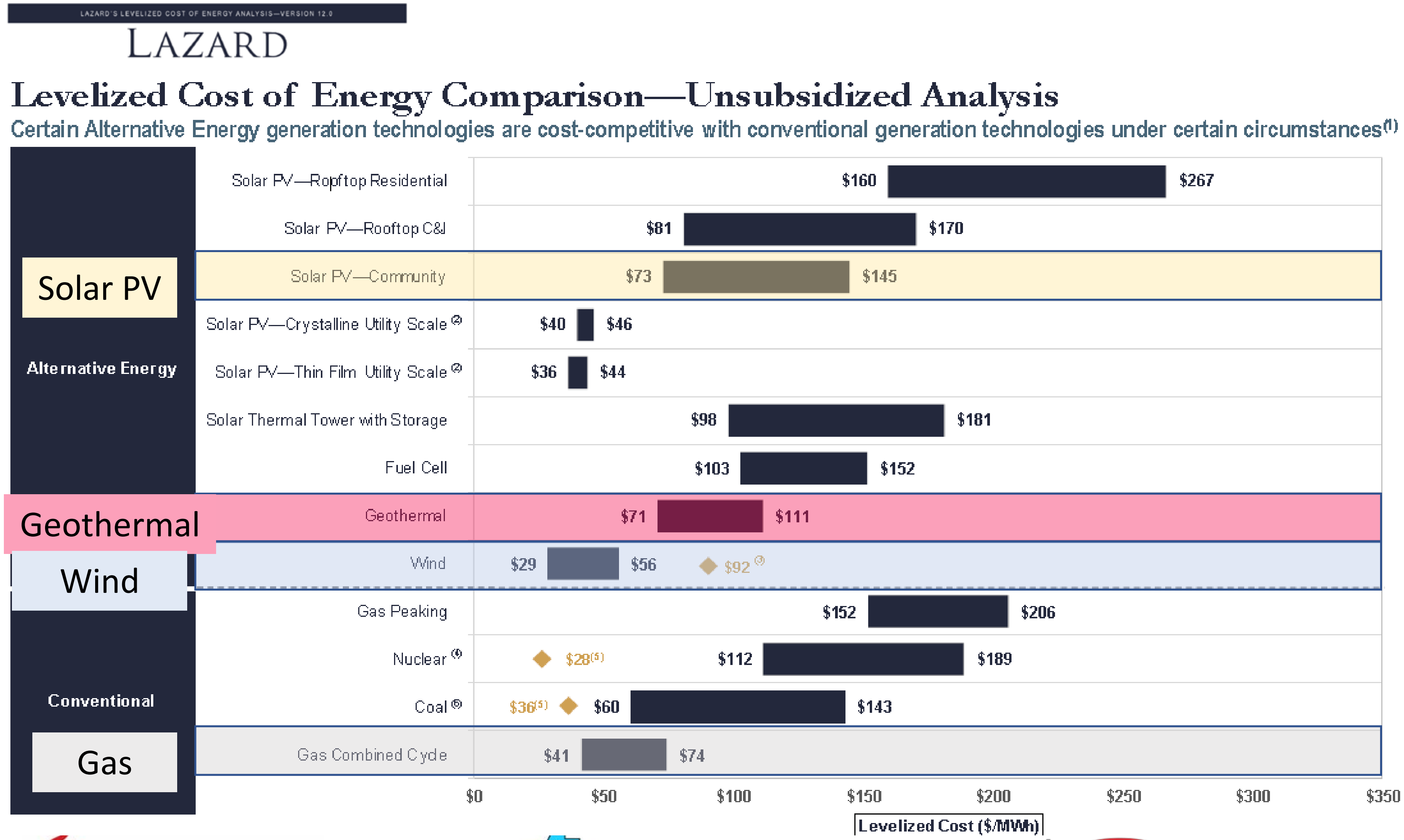
GEOTHERMAL ADVANTAGES



Lazard – US based analysis released November 2018

$USD 73 - 145	Solar PV
$USD 71 - 111	Geothermal
$USD 29 - 56	Wind
$USD 41 - 74	Gas

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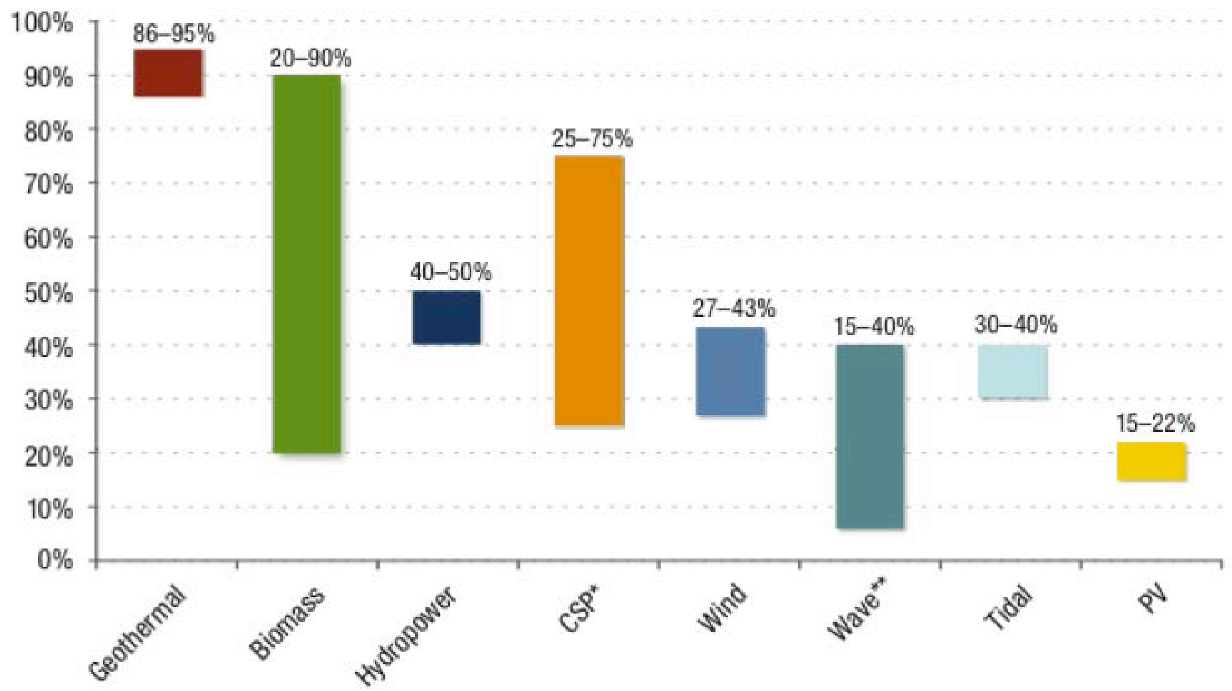
Renewable energy capacity factors in the US.



Capacity factor is what percentage of the time your facility is operating at it’s rated capacity.

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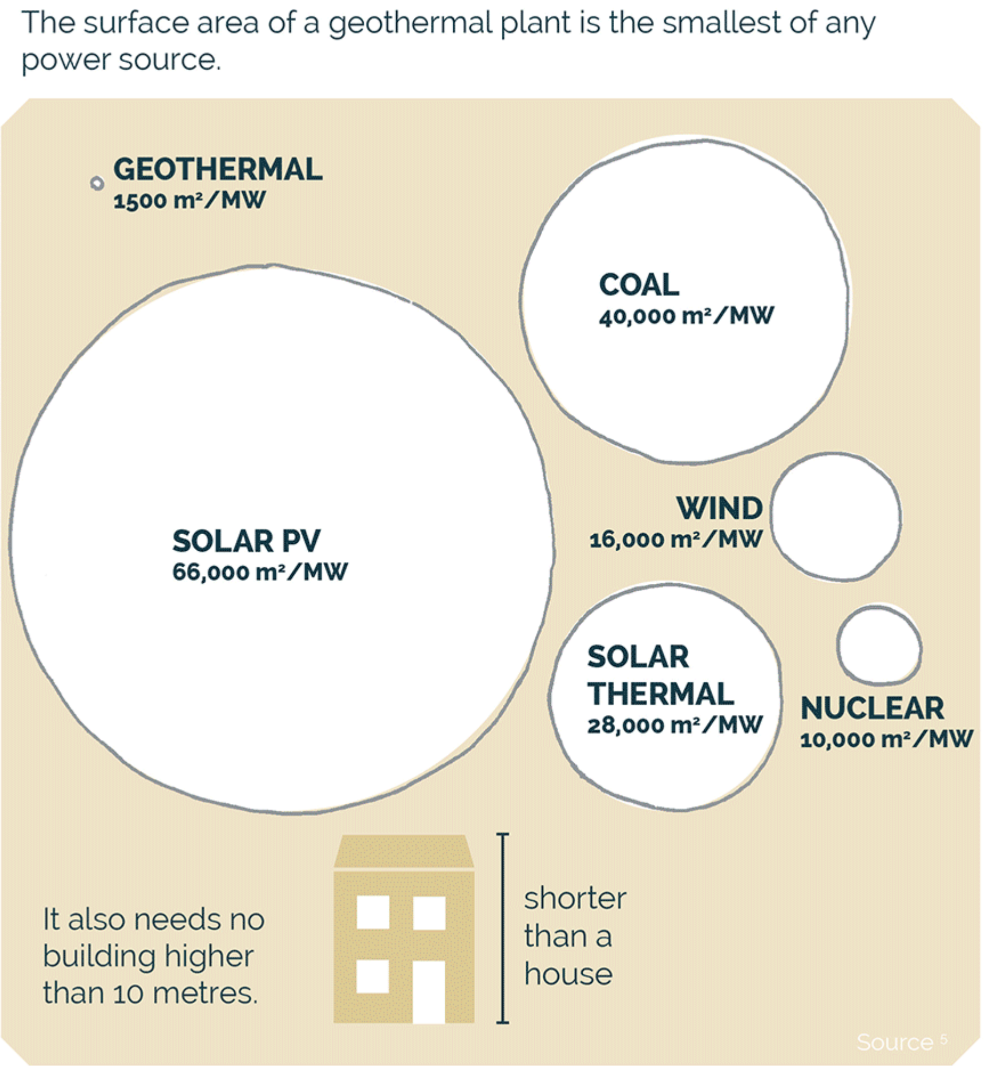
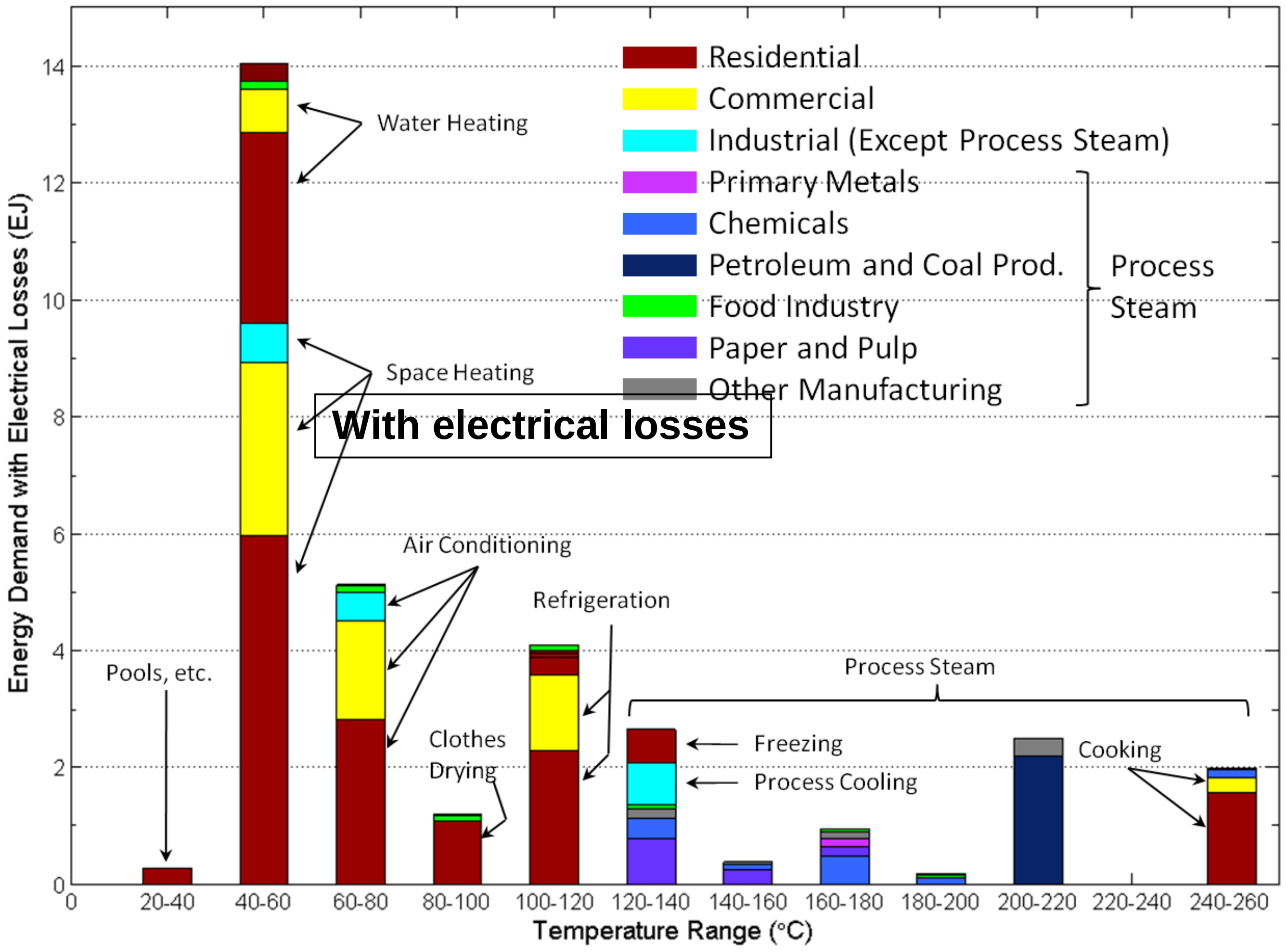


Among geothermal’ s many advantages is the small footprint relative to other renewables. In addition, in the NWT or Western Canada Sedimentary basin in general, much of the infrastructure can piggyback off of the existing oil & gas infrastructure, reducing the land impact and reducing costs.

GEOTHERMAL ADVANTAGES

THE POWER OF ΔT (TEMPERATURE DIFFERENCES)

About 25% of US energy use occurs at temperatures less than 120^{o}C and most of it comes from burning natural gas and oil



The Thermal Spectrum of U.S. Energy Use

Energy consumed as a function of utilization temperature

© by J.W. Tester, D.B. Fox and D. Sutter, Cornell University 2010

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GEOTHERMAL ADVANTAGES

THE POWER OF ΔT (TEMPERATURE DIFFERENCES)

406 / Xuebin Zhang et al.

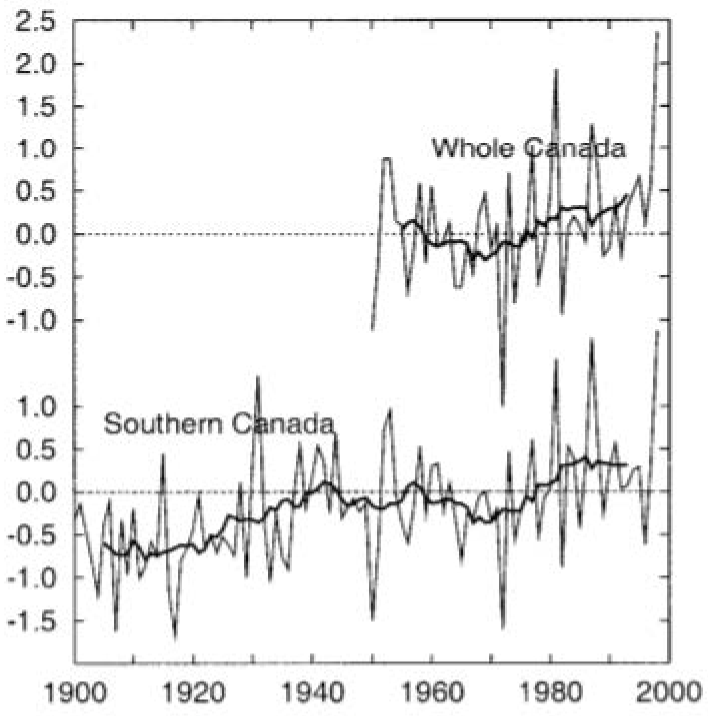

Fig. 3 Departures from the 1961–1990 mean of area average mean temperature (°C). Bold curves are 11-year moving averages.

With mean annual temperatures just above zero – even a thermal input of 20°C can have economic value for space heating or other industries that require part or all of their process to be above zero.

Xuebin Zhang , Lucie A. Vincent , W.D. Hogg & AΔn Niitsoo (2000) Temperature and precipitation trends in Canada during the 20th century, Atmosphere-Ocean, 38:3, 395-429, DOI: 10.1080/07055900.2000.9649654 To link to this article: https://doi.org/10.1080/07055900.2000.9649654

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THE POWER OF ΔT (TEMPERATURE DIFFERENCES)

	January	February	March	April	May	June	July	August	September	October	November	December
Avg. Temperature (°C)	-28.2	-25.1	-19.1	-7.3	4	11.9	15.4	13.4	6.4	-1.7	-14.2	-23.5
Min. Temperature (°C)	-32.5	-30.2	-25.3	-13.4	-1.4	6.6	10.6	9.1	3	-4.3	-17.9	-27.4
Max. Temperature (°C)	-23.9	-20	-12.8	-1.2	9.4	17.3	20.3	17.8	9.8	0.9	-10.5	-19.6
Avg. Temperature (°F)	-18.8	-13.2	-2.4	18.9	39.2	53.4	59.7	56.1	43.5	28.9	6.4	-10.3
Min. Temperature (°F)	-26.5	-22.4	-13.5	7.9	29.5	43.9	51.1	48.4	37.4	24.3	-0.2	-17.3
Max. Temperature (°F)	-11.0	-4.0	9.0	29.8	48.9	63.1	68.5	64.0	49.6	33.6	13.1	-3.3
Precipitation / Rainfall (mm)	14	13	13	11	17	23	38	41	32	34	26	18

Heating degree days (HDD) measures how cold an area is. An average house would use ½ lt of oil per HDD

- Fort Good Hope 9137 HDD
- Yellowknife 7878 HDD
- Edmonton 5025 HDD

(NWTenergy.ca)

Reference

Environment Canada. Meteorological Service of Canada. Canadian Climate Normals. 1981-2010 Climate Normals & Averages.

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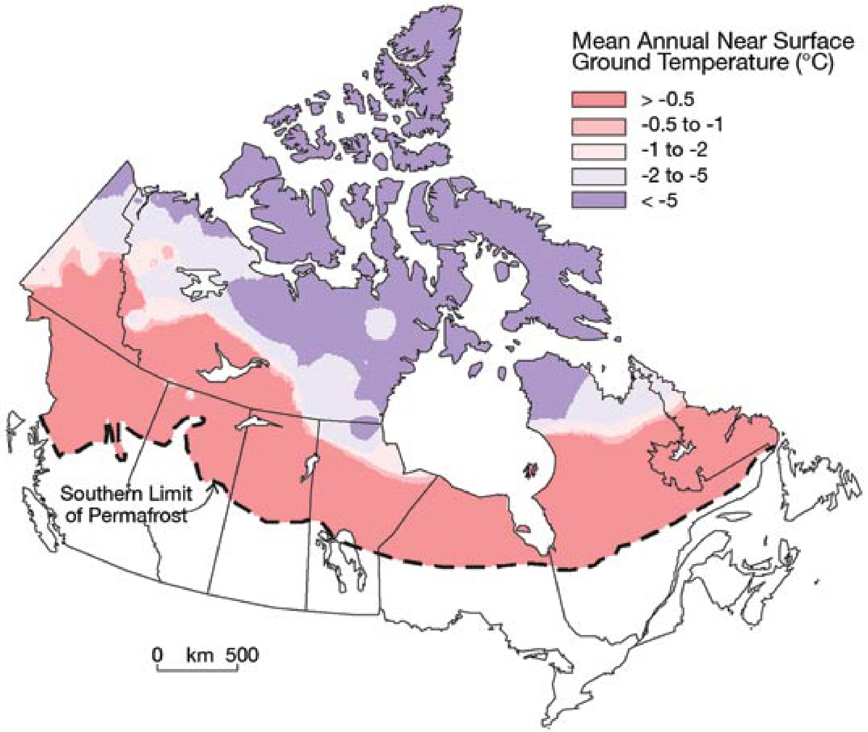
GEOTHERMAL ADVANTAGES

Arctic to subarctic climate

- Permafrost conditions
- High heating loads
  - > 7000 degree-days
- Mean annual temperatures of less than zero degrees Celsius



Smith and Burgess, 2004

Energy supplied by fossil fuels

- To generate electricity.
- To heat buildings.
- Carbon offset. potential.
- Reliable alternative to hydrocarbons.

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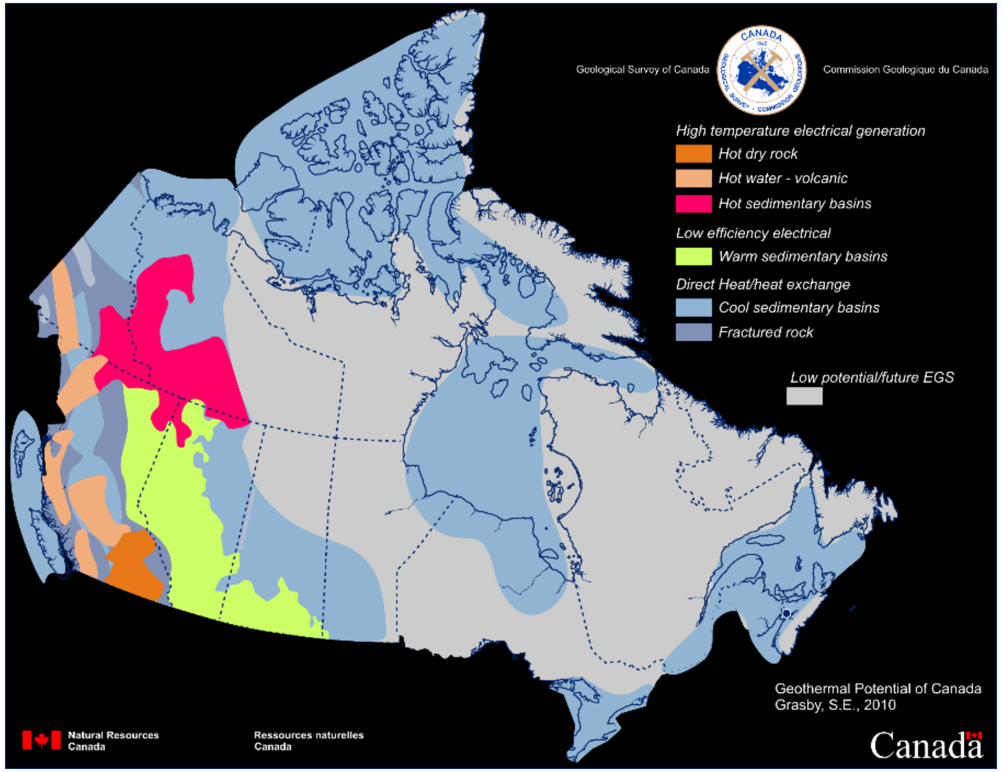
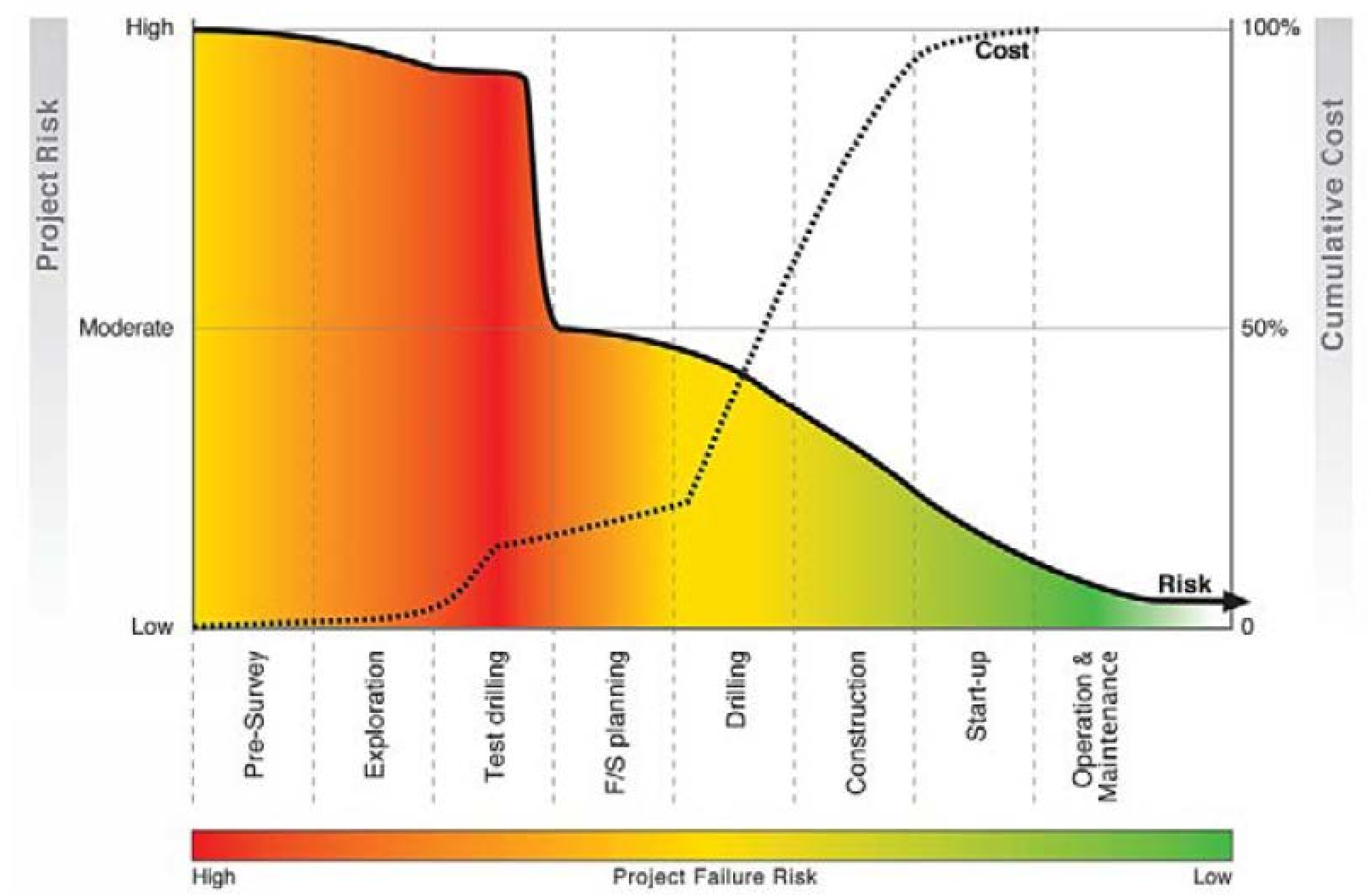
Economic factors



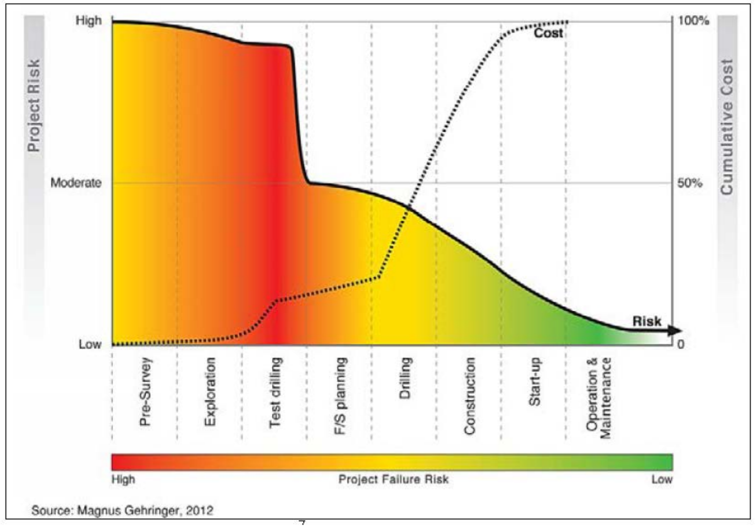
Canada's geothermal future!

Project development risk and costs



Source: Magnus Gehringer, 2012

Economic Considerations



1. Project development
   a. Exploration and evaluation of the resource
   b. Exploration drilling
   c. Production drilling
   d. Surface piping and infrastructure
   e. Plant design and construction (CAPEX)
   f. Operation (OPEX)
2. Social economic factors – local employment
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4. Direct-use income – thermal
5. Carbon Off-set income – thermal and electrical

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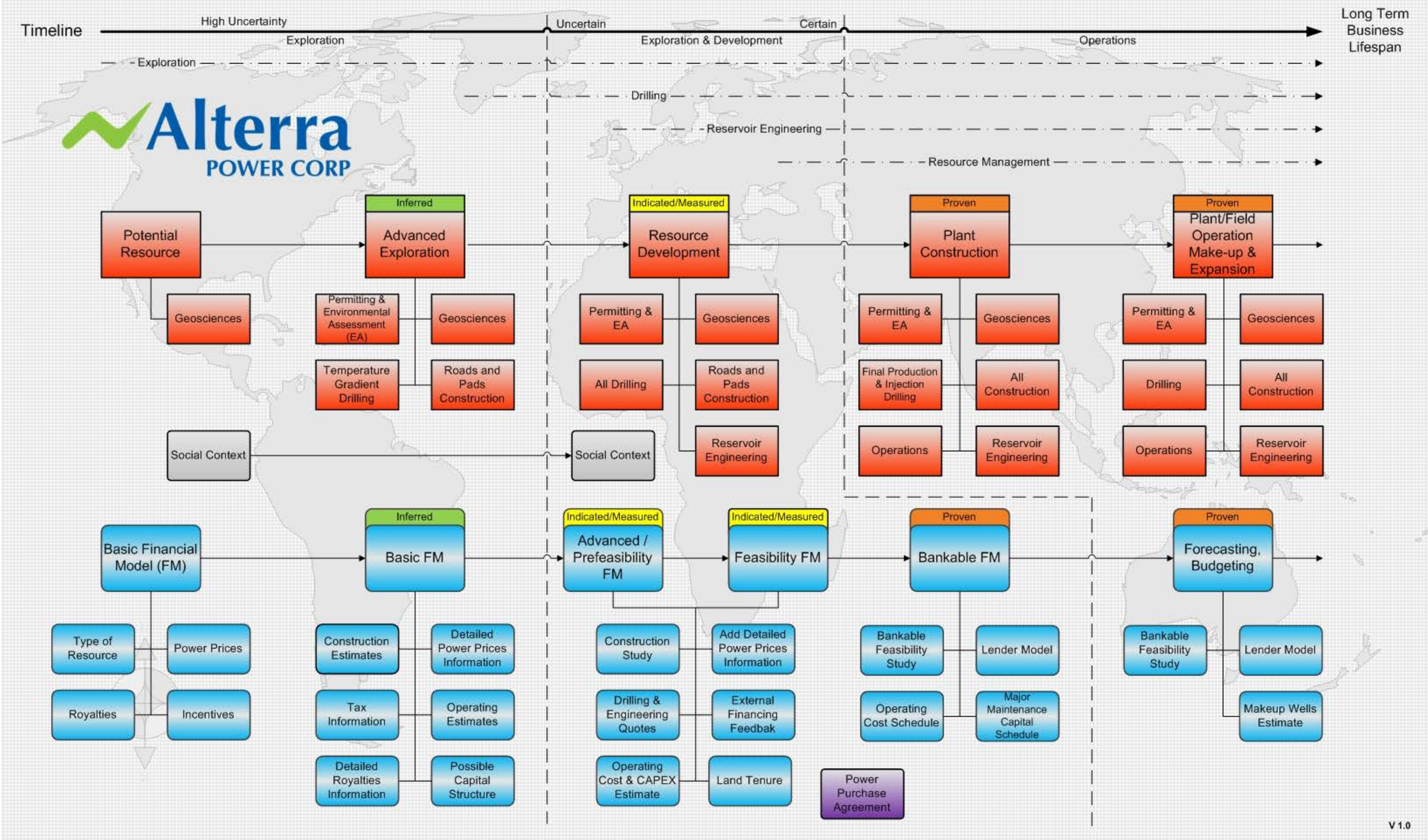
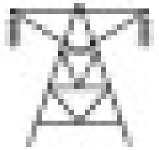
Economic considerations: development schematic





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Economic considerations: levelized cost of power calculations

British Columbia (Kerr Wood Liedel and Geothermex 2015)
Clarke Lake: 34 MW @ 29.7 $/MWh
Jedney: 15 MW @ 39.8 $/MWh

Table E1-1: Results of Volumetric Assessment and Economic (GETEM) Analysis

Geothermal Prospect Site/Area	Plant Type	Initial MW estimate (GDDM)	MW (gross) at 90% probability from Vol.Est.	MW (net) : Parasitic = 10% for Flash 25% for Binary	Levelized Cost of Electricity* (CAN¢/kWh) Discount Rate 5%
Canoe Creek – Valemount	Flash	15	14.3	12.9	26.8
Clarke Lake	Binary	34	18.4	13.8	29.7
Clarke Lake (5 MW scenario)	Binary	5	-	3.8	33.2
Jedney Area	Binary	15	12.2	9.2	39.8
Kootenay	Binary	20	19.9	14.9	22.8
Lakelse Lake	Binary	20	19.6	14.7	23.4
Lower Arrow Lake	Binary	20	19.6	14.7	23.7
Meager Creek (Pebble Creek volume assumed equivalent)**	Flash	100-200 total (50-100 ea)	198.0 combined (99.0 ea)	178.2 combined 89.1 (ea)	11.7
Mt. Cayley	Binary	50	40.7	30.5	17.3
Okanagan	Binary	20	18.3	13.7	24.1
Sloquet Creek	Binary	10	10	7.5	21.8

* These LCOEs have been revised from the previous versions of this report to correct the values used for the depreciation schedule in GETEM (Lines 32 to 37 of Table V-1)
** Pebble Creek transmission and infrastructure costs are significantly less than those at Meager Creek, resulting in a lower LCOE value for Pebble Creek (11.5 CAN¢/kWh).

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Economic considerations: levelized cost of power calculations

Northeast BC: Western Canada sedimentary basin calculations 2018 (Palmer-Wilson et al. 2018)

Simple economic models were developed for each of the four proxy power plants, using capital costs (cost to build the plant and drill the necessary number of wells) and specific measures of financial viability (see below), to find the levelized cost of producing electricity in dollars per mega-watt hour (MWh) of energy produced.

Horn River: 3.7 MW @ 162 $/MWh
Clarke Lake: 44.5 MW @ 166 $/MWh
Prophet River: 22.0 MW @ 144 $/MWh
Jedney: 7.8 MW @ 156 $/MWh

Calculations used to compare financial viability of the four projects include:

- Levelized Cost of Energy (LCOE): the cost at which electricity is produced throughout the lifetime of the project. Any power plant technology can be compared via LCOE.
- Net Present Value (NPV): the difference between all discounted costs and revenues. Comparing the NPV of different projects helps establish which has greater financial returns.
- Internal Rate of Return (IRR): equal to the discount rate at which the NPV becomes zero.

Economic considerations: financial model MD Greenview

Key factors affecting project costs:

- Drilling costs (depth and size)
- Plant development cost (reservoir size and type – flash vs binary)

Economic viability:

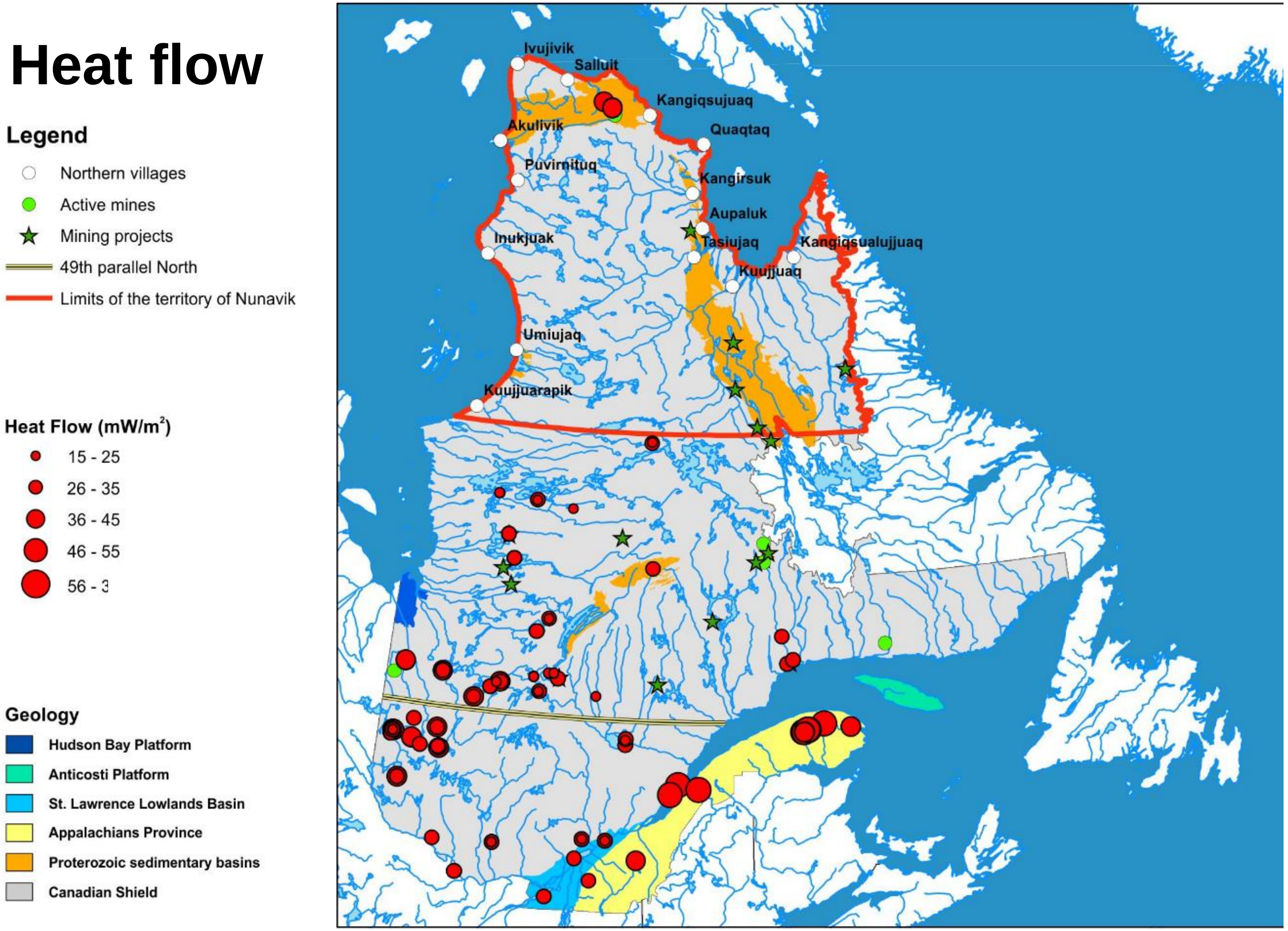
- Price of electricity – how much is someone willing to pay?
- Price of thermal energy – what is the load and how much is it worth?
- Carbon offset credits
- Cost of money

Palmer-Wilson et al. 2018 stated the three key factors needing more work are:

- Reduce uncertainty regarding size of geothermal reservoir
- Estimate achievable brine flow rates
- Determine the commercial value of heat

Economic considerations: Technological advancement & new innovations

Heat flow



Northern Geothermal Potential Research Chair

- Resource assessment of northern mines and communities
- Adapt technologies to deal with arctic to subarctic climate

Institut nordique du Québec

KATIVIK

Centre d'études nordiques

INRS

UNIVERSITÉ DE RECHERCHE

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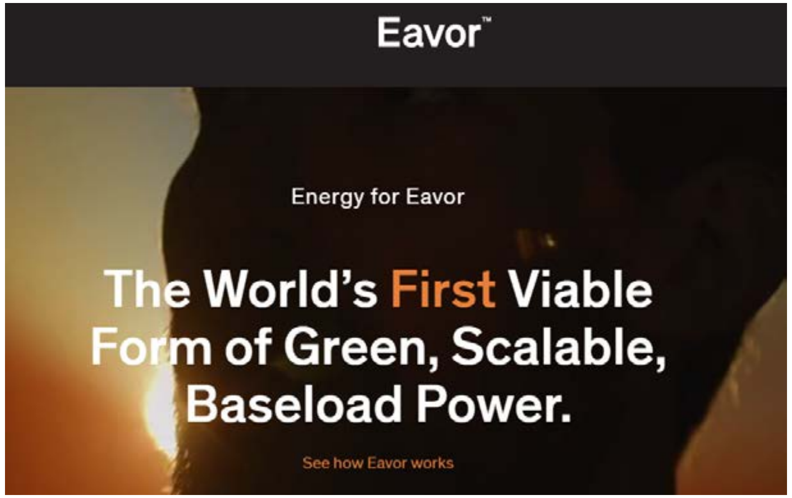
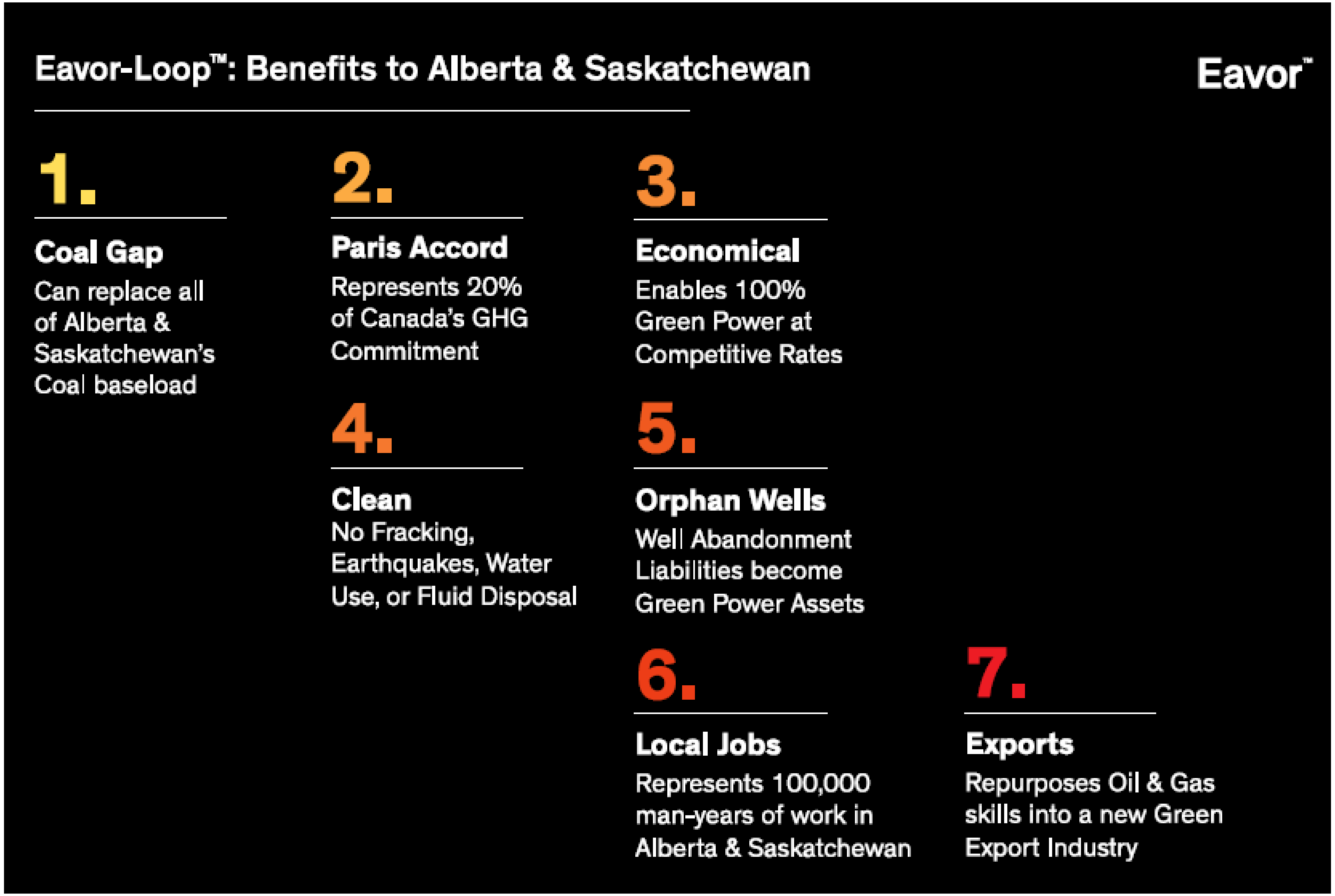
Economic considerations: Technological advancement & new innovations



Calgary based Eavor, partnered with Sweden's Climeon technology company hope to be able to provide power from 70°C and above waters in a sustainable and cost effective way.



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The role of Government

What is needed for geothermal development?

- Government recognition that geothermal resources will fill the basic infrastructure needs of the north and support continued development and occupation of the land (sovereignty).
- Like bridges, roads and highways, geothermal energy must be considered "infrastructure" and the costs born across the tax payer base of Canada. "What is good for the north is good for the rest of Canada."
- Projects in Finland, Sweden, Denmark and elsewhere are proving EGS technology; Canada needs to get on-board and support geothermal.

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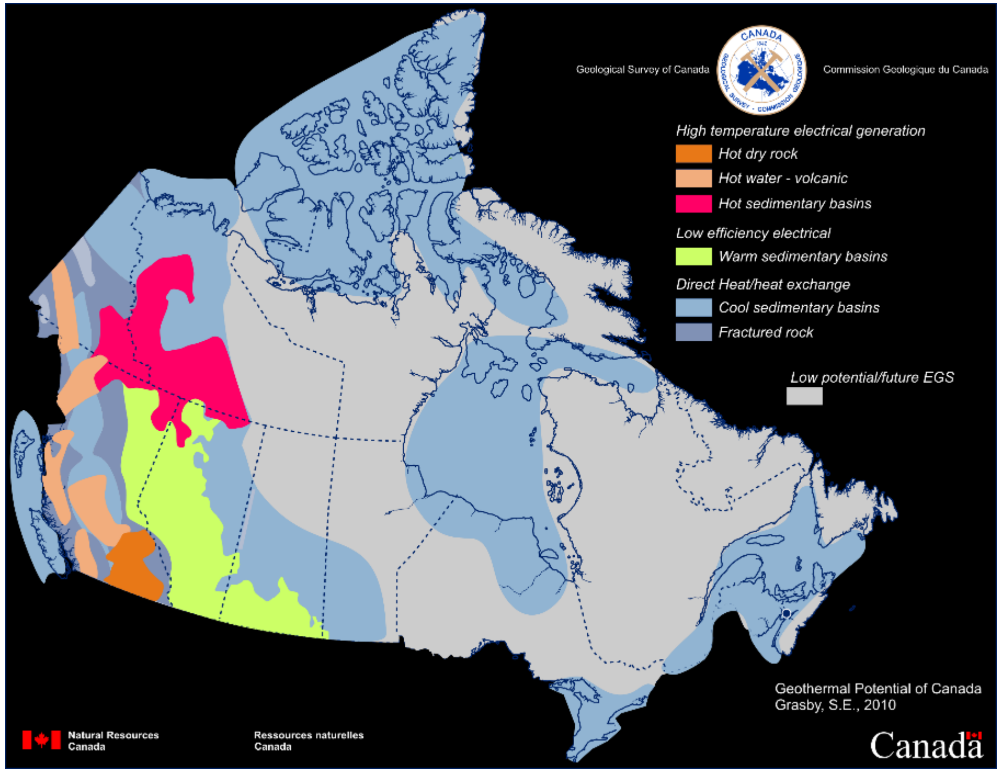
Economic factors: Project development



Canada's geothermal future!

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Economic Considerations

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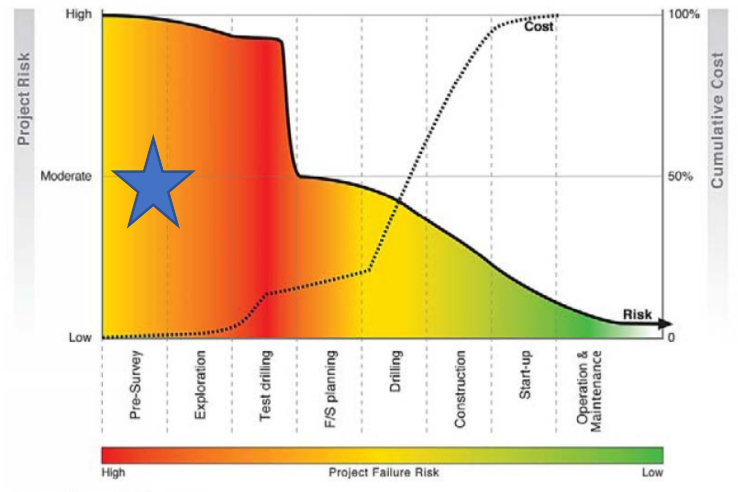


Source: Magnus Gehringer, 2012

Geothermal development costs: pre-feasibility study costs NWT

TABLE 5: GENERIC COST ESTIMATE FOR GEOTHERMAL PRE-FEASIBILITY STUDY			
Task	**Estimated Cost Range**		
Existing information review	$20,000	–	$30,000
Detailed field geology	$30,000	–	$40,000
Geophysical surveys	$40,000	–	$60,000
Thermal gradient holes	$200,000	–	$250,000
Borehole geophysics and well temperature survey	$20,000	–	$30,000
Core logging and core sample analyses	$20,000	–	$30,000
Hydrogeology and hydrogeochemistry	$20,000	–	$30,000
Conceptual geothermal model	$20,000	–	$30,000
Preliminary economical evaluation	$10,000	–	$20,000
Preliminary environmental assessment and permitting	$20,000	–	$30000
TOTAL	$400,000	–	$550,000

NWT Geothermal Feasibility Map Northwest Territories Y22101146 April 2010

Geothermal development methodology: exploration

COST

TIME

Geological data

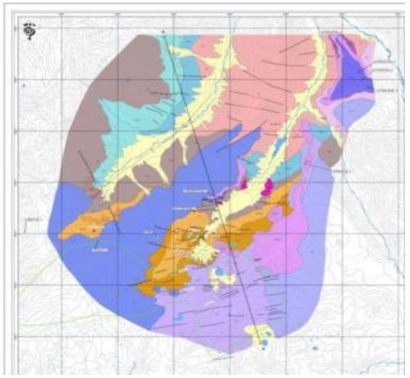
Geochemical data

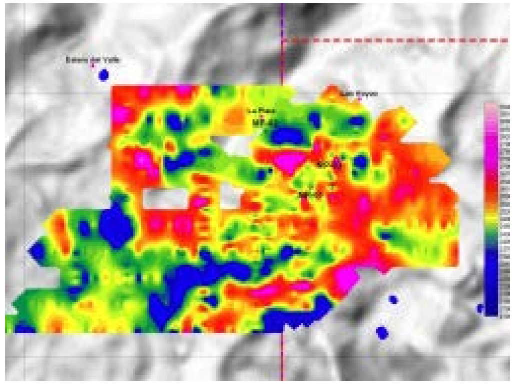
Geophysical data

Conceptual model
Size, depth, type of fluids and temperature

Resource estimation

Exploration drilling



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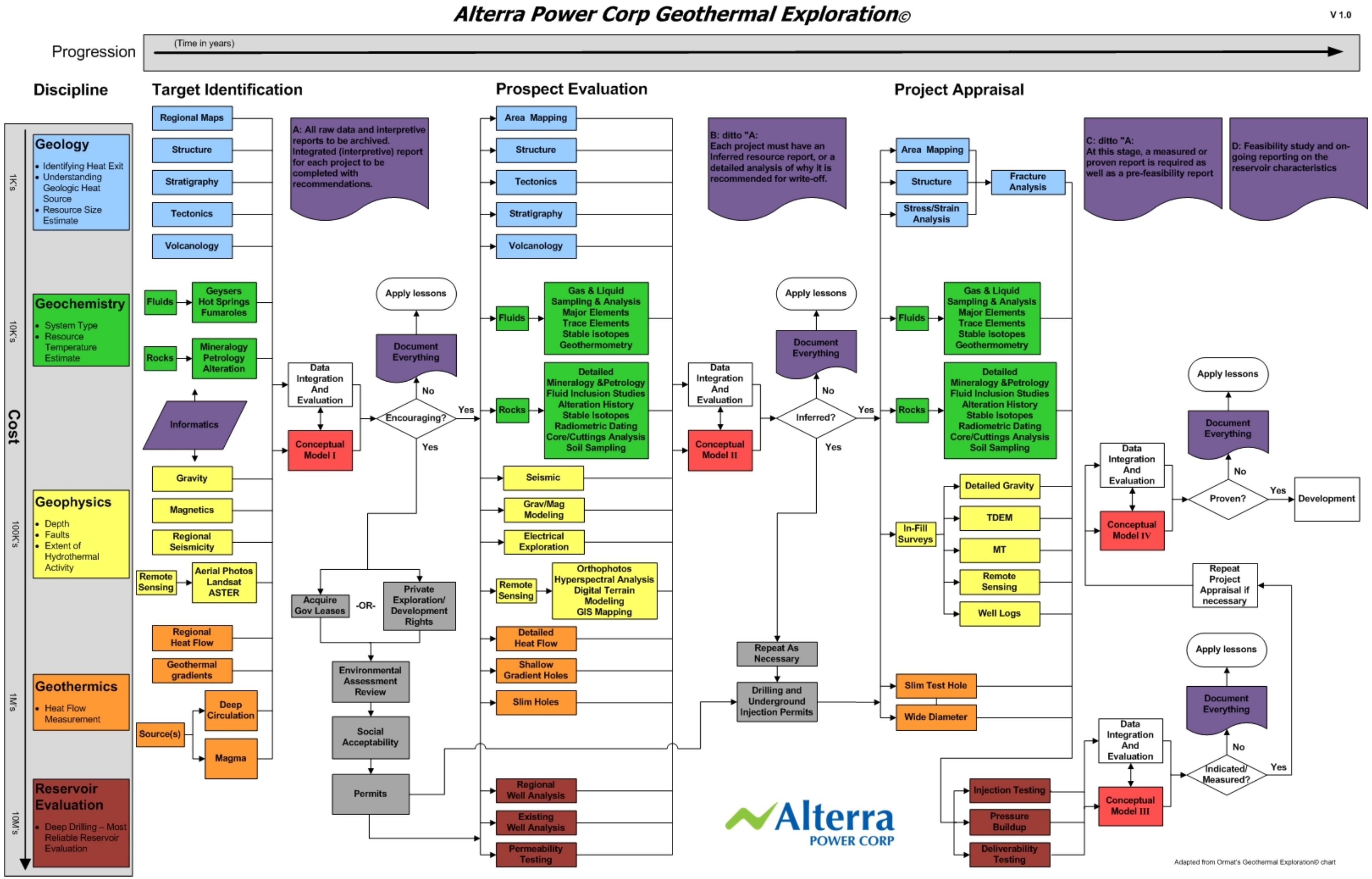
Geothermal development methodology: exploration



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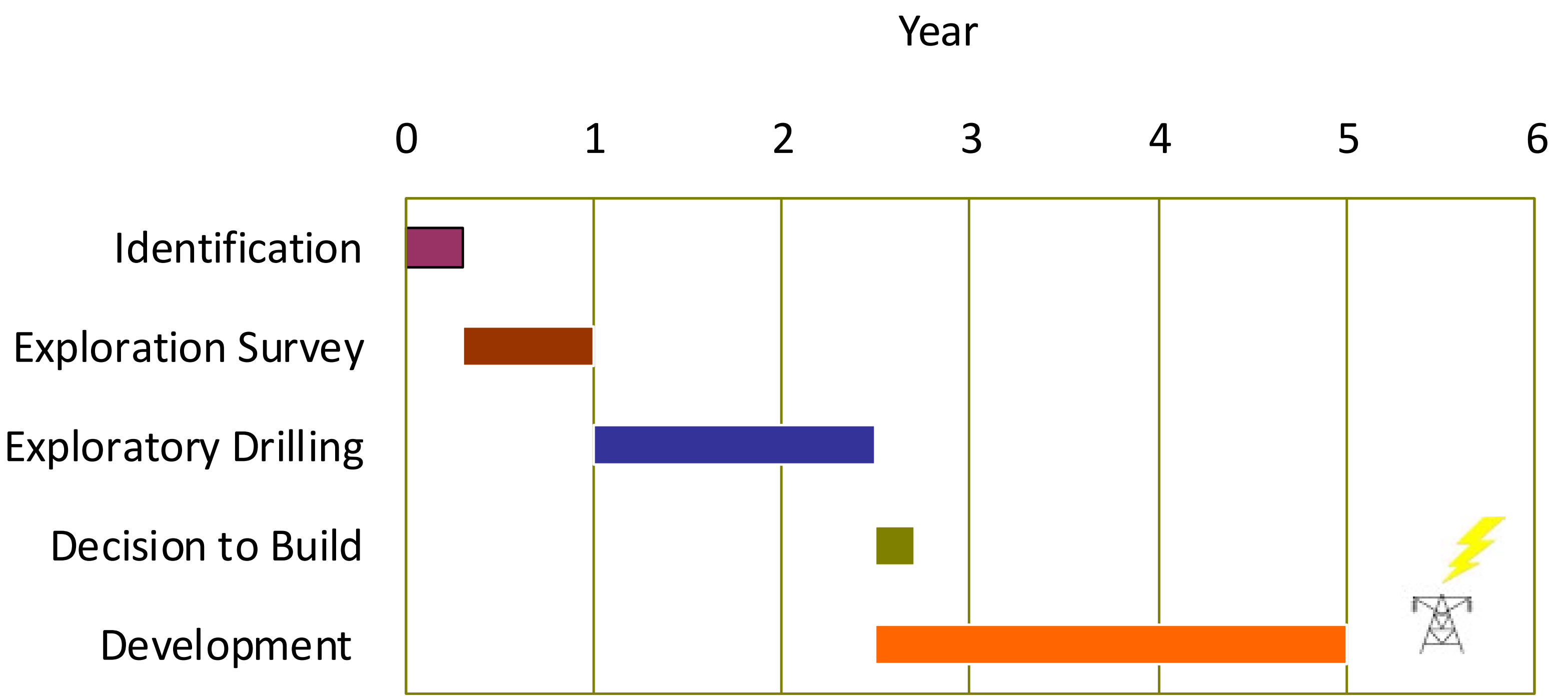
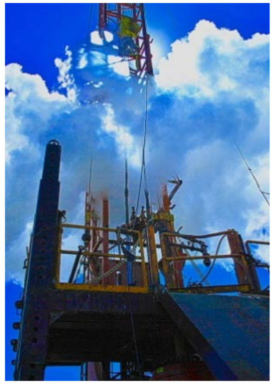
Timeline of a geothermal power development

Time = Money





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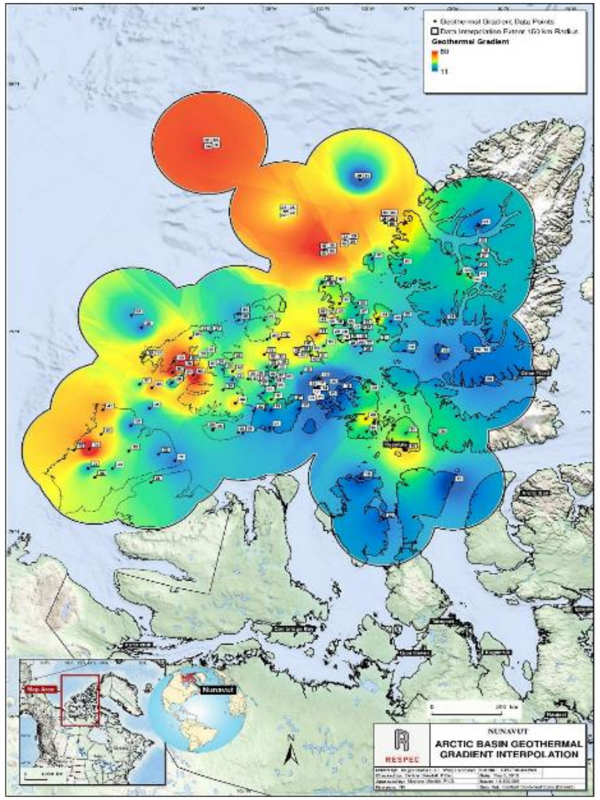
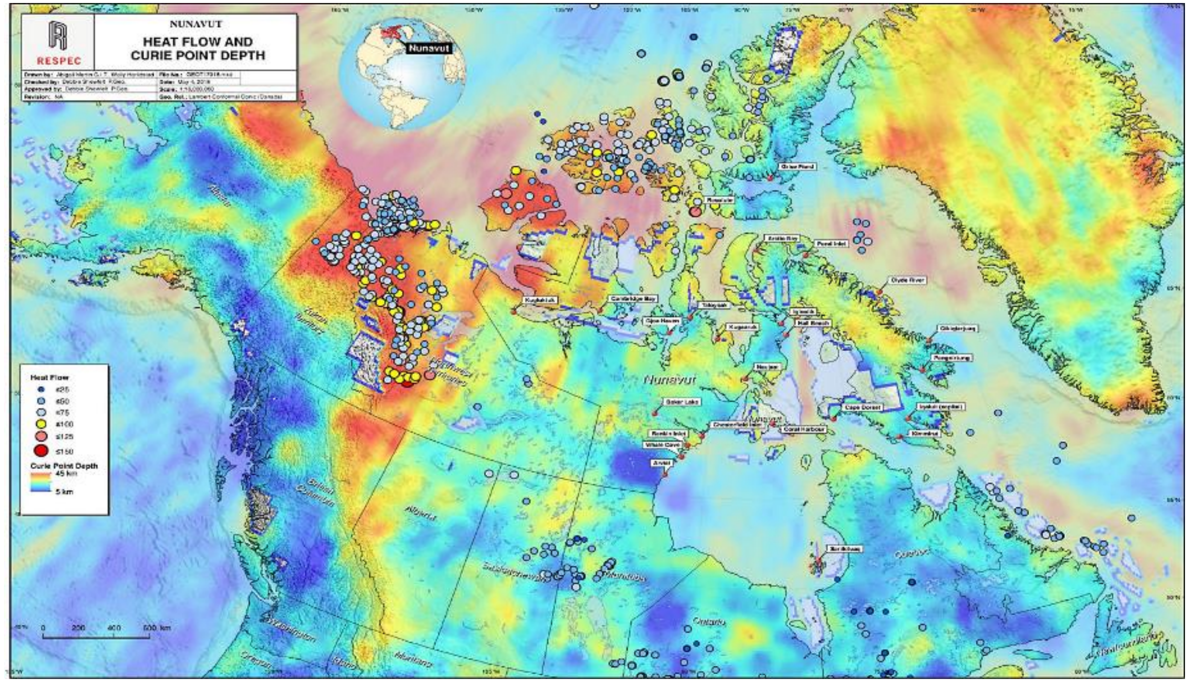
Nunavut Geothermal Resource Assessment



Heat flow



Curie point depth

- Depth to reach Curie temperature ~580 ºC
- Potential for direct-use applications

RESPEC

Qulliq Energy Corporation
Société d'énergie Qulliq
Qulliq Aluryaktuqtunik Ikumatjutiit

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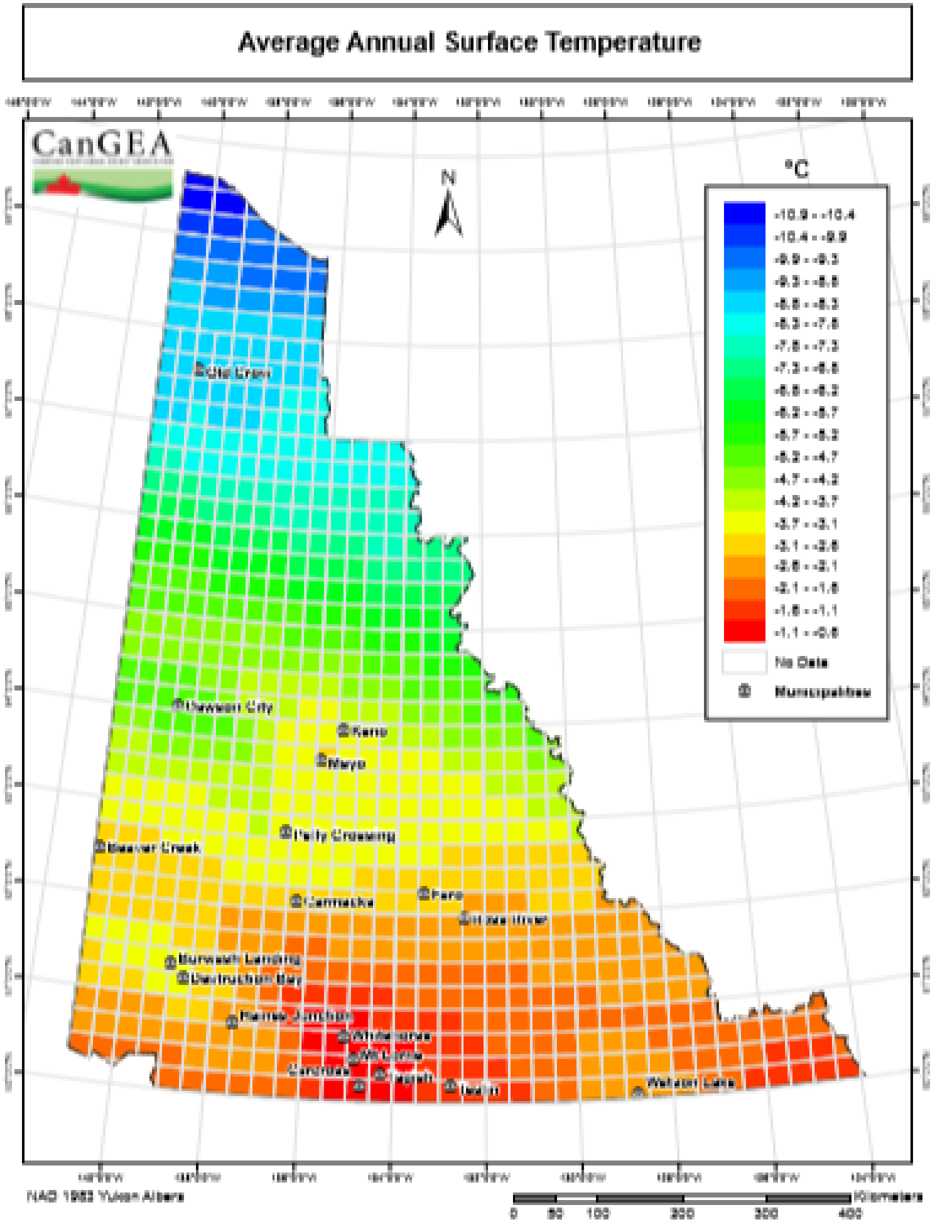
QIKIQTAALUK CORPORATION

Yukon Government Initiatives

Yukon Geological Survey

Yukon's geothermal potential could be more than 1,700 MW of energy (Calculated as "heat in place"). This is equivalent to 18 times the current energy supplied by Yukon's renewable electrical system (90 MW). The Yukon government has just drilled two temperature gradient wells.



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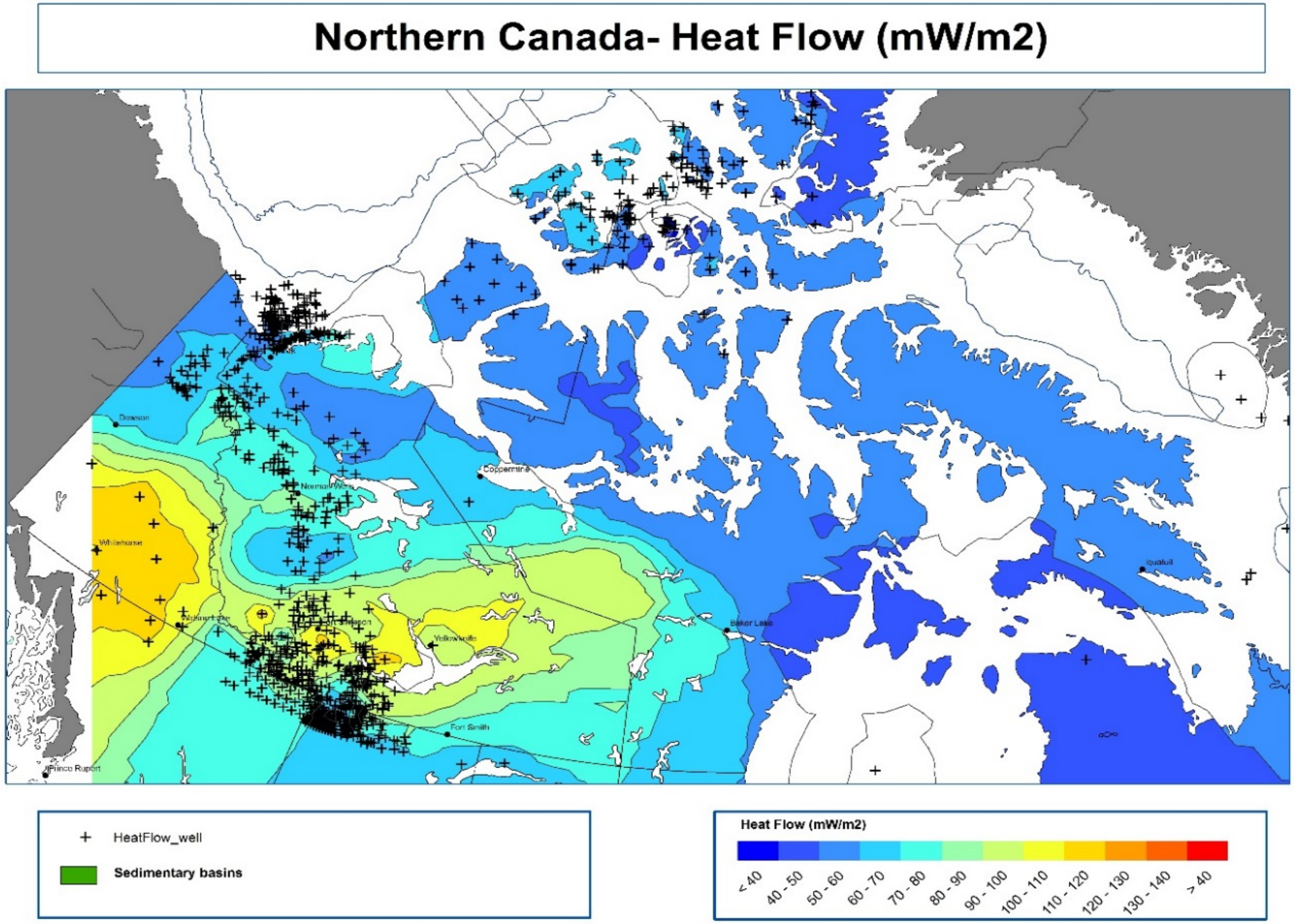
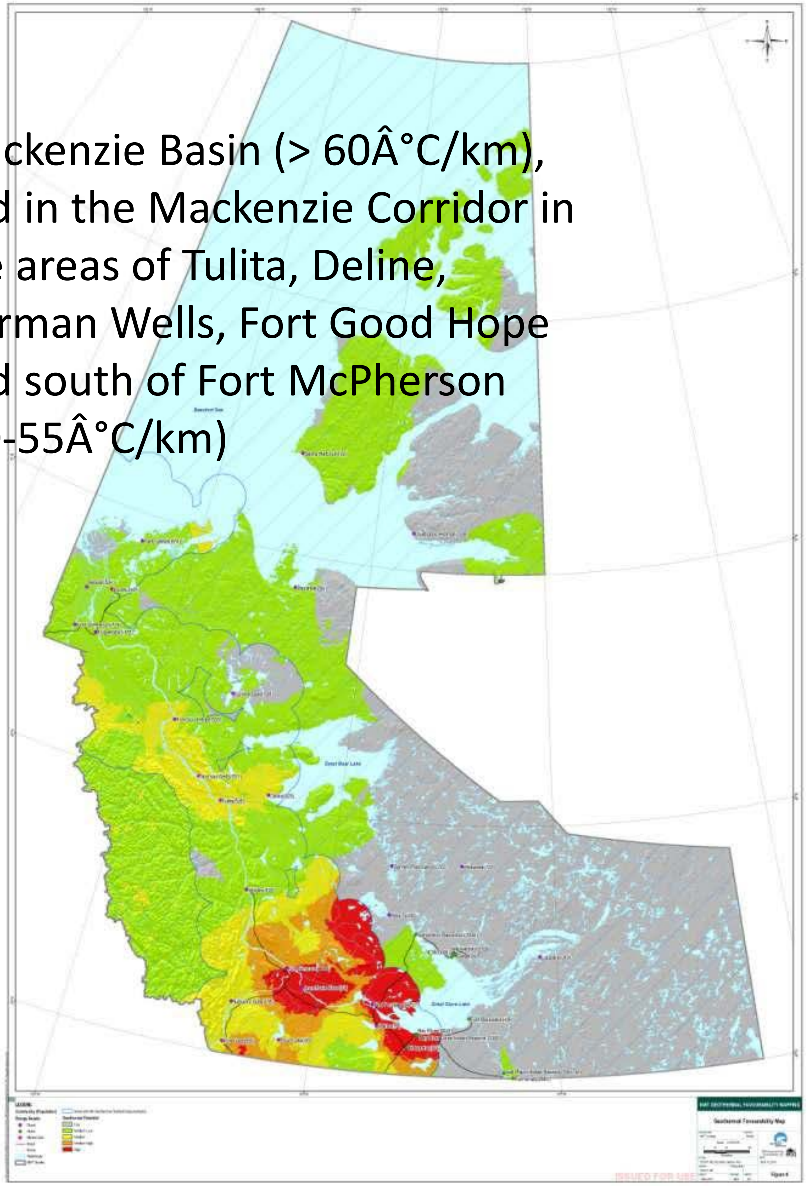
North West Territories heat flow map



Heat-Flow Contour Map From Dr. Jacek Majorowicz (University of Alberta - Unpublished; Used With Permission).



Mackenzie Basin (> 60Â°C/km), and in the Mackenzie Corridor in the areas of Tulita, Deline, Norman Wells, Fort Good Hope and south of Fort McPherson (40-55Â°C/km)

NWT Geothermal Favourability Map 2010

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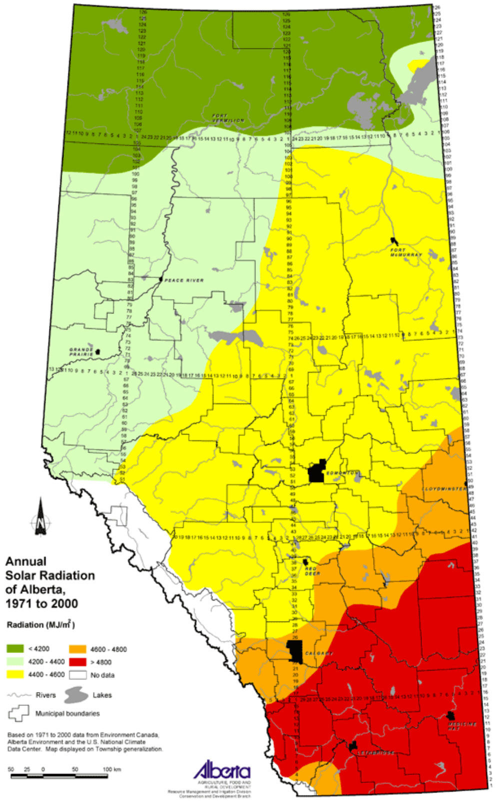
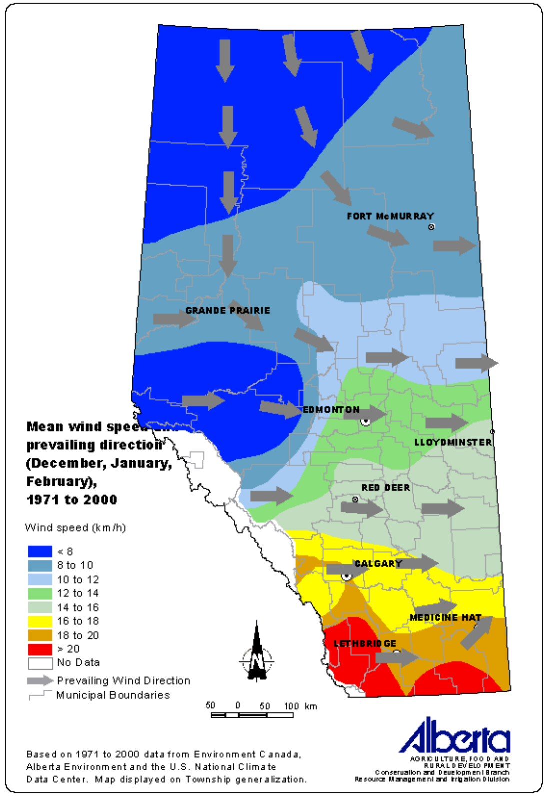
Renewable energy options for Alberta

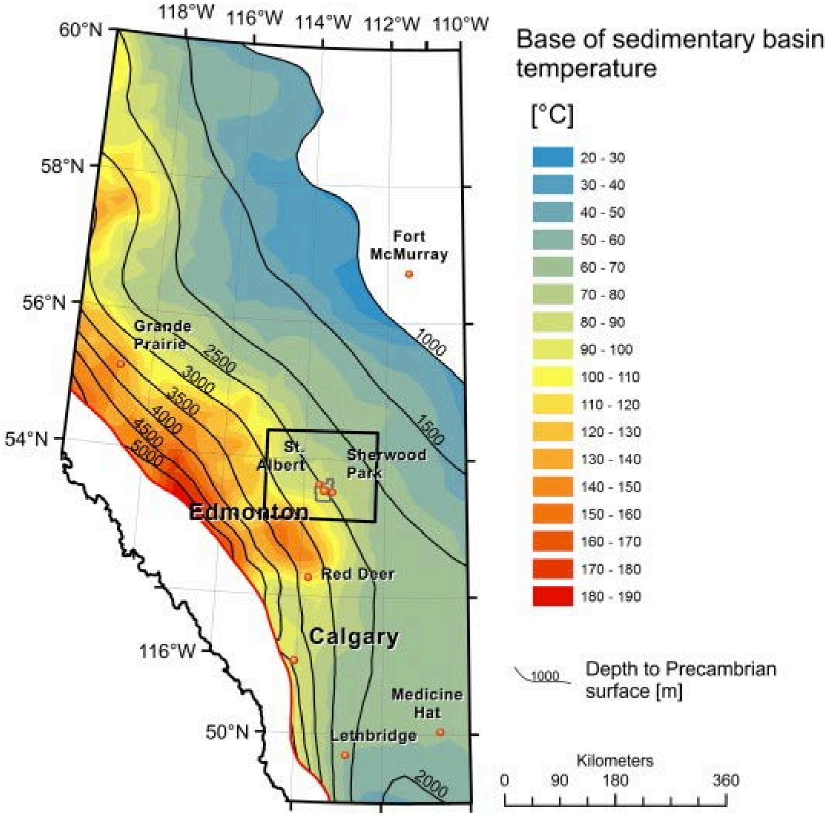
Solar Resource



Wind Resource



Geothermal Resource



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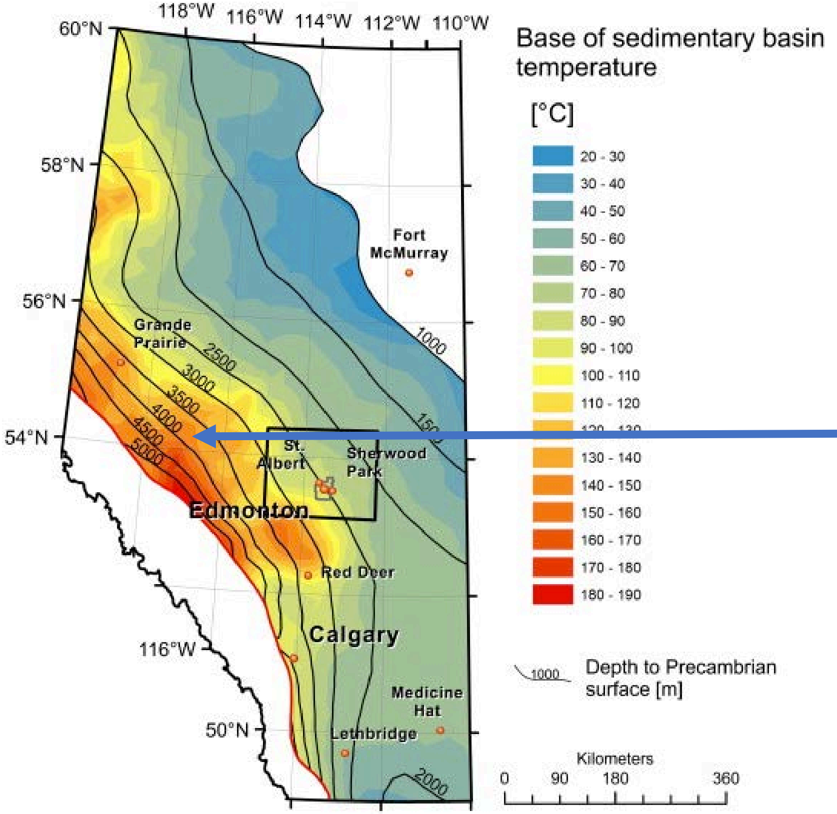
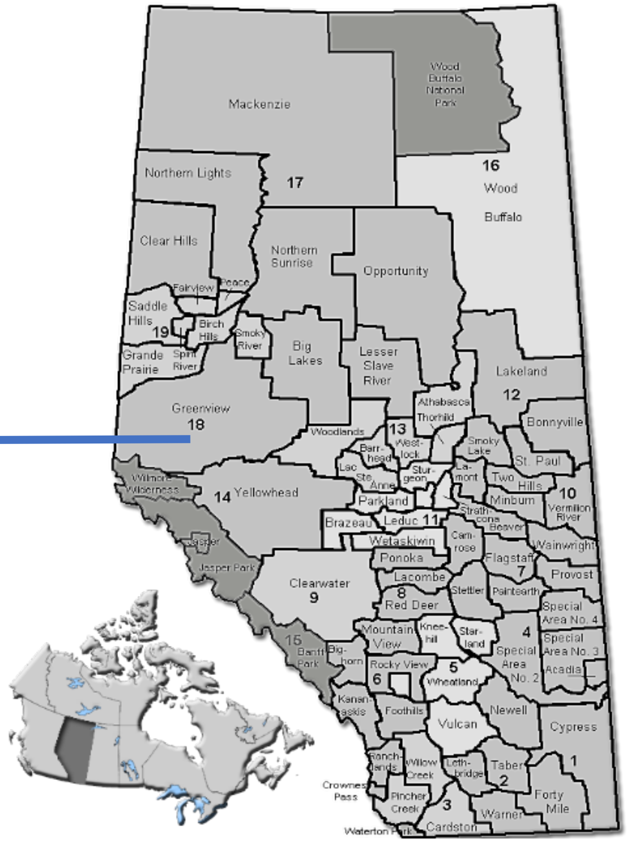
Municipality of Greenview, Alberta





MUNICIPAL DISTRICT OF GREENVIEW No. 16

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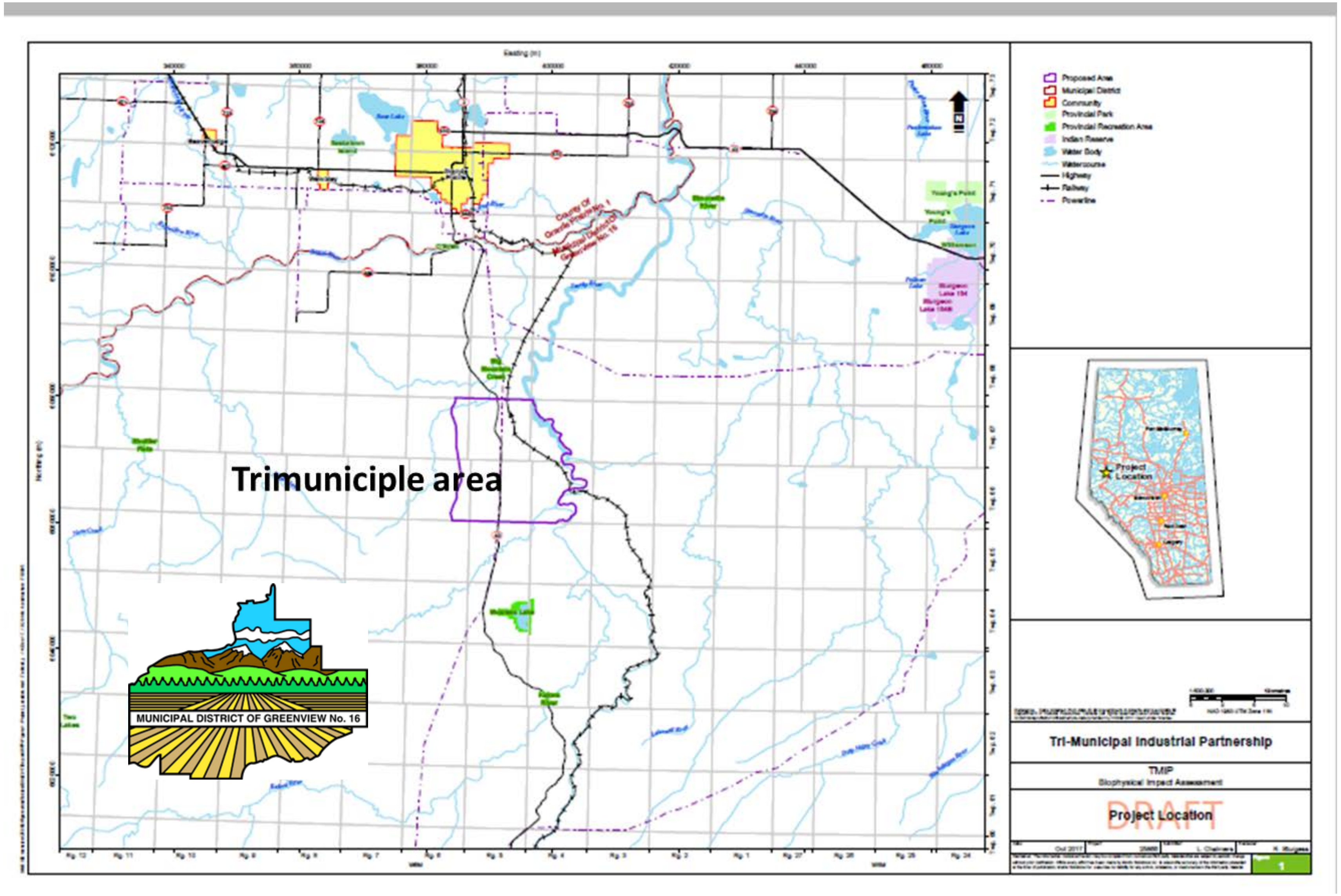
Municipality of Greenview, Alberta, Industrial Park

Partnership between the MD of Greenview, and the County and City of Grande Prairie for a heavy industry industrial park.

- Rail road
- Power line
- Highway
- ~60,000 drilled wells within the MD
- Use of existing wells, geophysical and geological data for exploration



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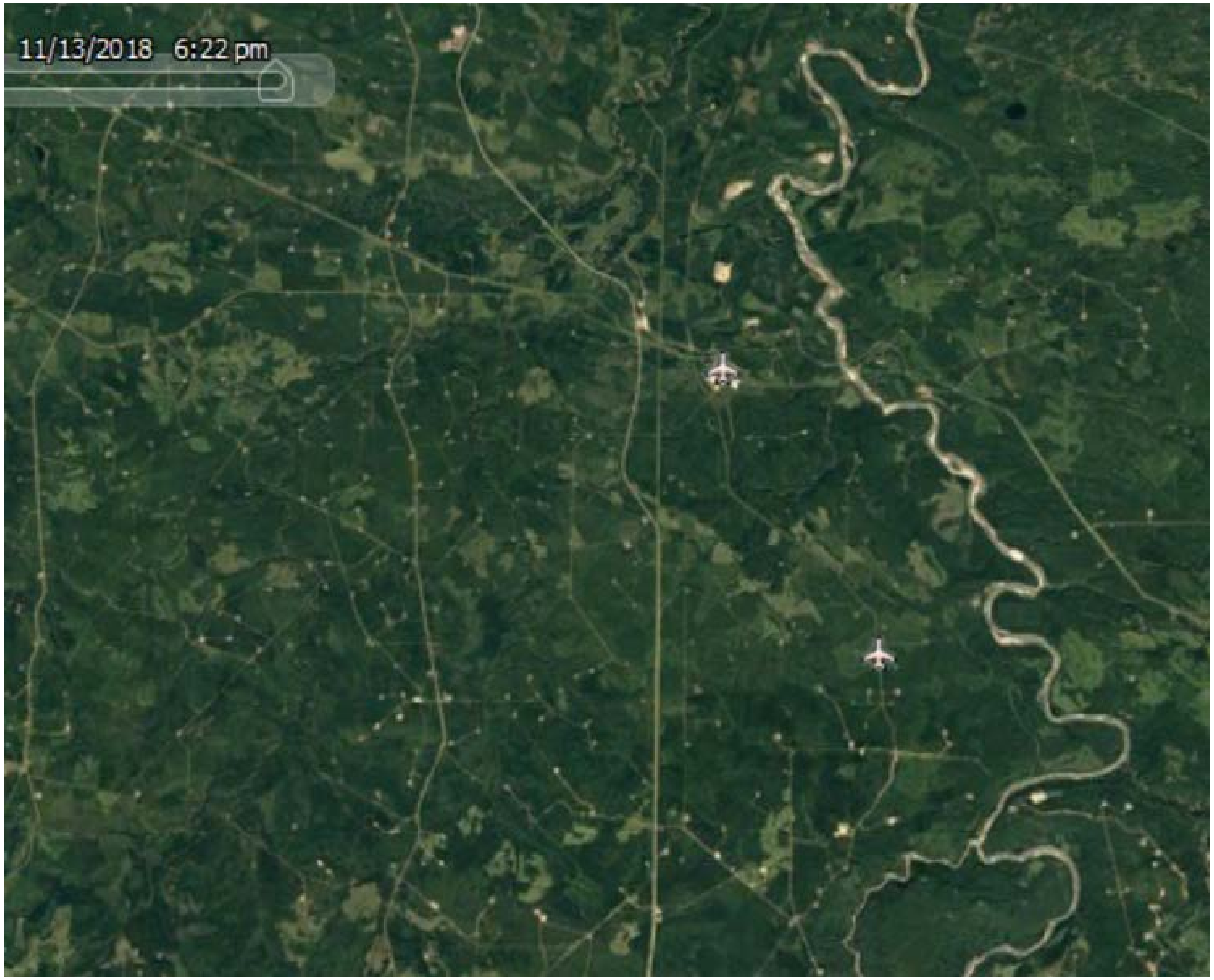
Municipality of Greenview, Alberta, Industrial Park

Partnership between the MD of Greenview, and the County and City of Grande Prairie for a heavy industry industrial park.

- Significant existing infrastructure: roads and pads
- Surface rights now owned by the MD Greenview
- Economic driver is the ability for the MD to supply “green power” to industry both as electrical and thermal energy.



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Municipality of Greenview, Alberta (MDGV)

- Geothermal power generation facility and associated well field in the M.D. of Greenview.
- 5MWe (net), 8MWe (gross) closed loop, distribution connected, air-cooled, power generation facility.
- Initial phases of the facility will require 6 wide-bore production wells to be purpose drilled based on 172 kg/s of flow of 200°C water.
- Initial phases of the facility will require a number of re-injection wells (may be purpose drilled, may be previously drilled wells).
- Power facility is to be built and commissioned in a modular fashion that can scale to load developed in the area.
- Potential funding from Alberta and Federal governments

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Technical considerations: Study methodology

Study was commissioned by the MD Greenview and piggybacked on an earlier study of the Fox Creek area. The result was the ERPP application.

Main factors studied:

- Bottom hole temperatures
- Porosity, permeability, and pressure
- Water recovery in hydrocarbon drilling
- Water production in hydrocarbon production
- Well history
- Drilling problems
- Well condition and status
- Location and proximity to electricity grid and land development area
- Size and volume of the targeted reservoirs
- Potential energy production
- Review case studies of existing pilot projects

Technical considerations: Regulatory and other

1. Who owns the heat/energy?
2. Water trespass regulations.
3. What to do about residual hydrocarbons?
4. Well history and repurposed wells, liability and asset calculations?
5. Drilling problems faced by developers? (these are deep, wide wells)
6. Well condition and status of abandoned wells.
7. Location and proximity to electricity grid and land development area.
8. Size and volume of the targeted reservoirs.
9. Discrepency between timing of heat and electricity offtakes
10. Review case studies of existing pilot projects.
11. Dealing with sour wells.

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Technical considerations: Challenges

1. The BHT and flow rates within the target formations (sub-Duvernay and basement) are not well characterized (they are not hydrocarbon targets).
2. Economics of the project will be dependent on the outcome of the testing.
3. Final decisions on the number of production wells will be dependent on the bottom hole conditions (Temperature and flow rate).
4. Oil and gas wells are not necessarily suitable for production for electrical generation.
5. Oil and gas wells may make suitable injectors and there is some possibility that flows could be high enough for limited direct-use applications under specific circumstances.
6. May need to drill water injection wells in addition to production wells.
7. Sour wells will be a factor in the development process and have potential impact on economics.
8. ERPP approval was placed on hold due to a lack of clarity surrounding regulations and permitting.

Project development: financial model MD Greenview

Expected Capital Expenditures & Key Financial Details	
Nameplate Capacity (kw)	8,000
Parasitic Load estimate (%)	38%
Project net output kw	5,000
Number of Wells Drilled	6
Drilling Depth (mVd)	3,000
Drilling cost ($/mVd)	$1,250
Total drilling cost	$22,500,000
Drilling cost per kw	$2,813
Power Plant Cost - Turboden ($/kw) ($1000 EUR Quote)	$1,500
Supplementary Construction Cost - ONEC ($/kw)	$1,500
Total installed cost ($/kw)	$ 5,813
Hours in a Year	8,760
Capacity Factor Estimate	80%
Total net kWh Produced Annually	35,040,000
Estimated PPA Value ($/kwh)	$0.100
Carbon Price ($/tonne)	$50
Annual Maintenance ($/kW)	$110
Fluid and Field Testing	$650,000
Geoscience	$ 1,350,000
Total Testing & Geoscience	$ 2,000,000
Total Capital Budget	$ 48,500,000
Other	$ 2,425,000
Total Project Budget	$ 50,925,000

Expected Capital Expenditures & Key Financial Details	
Finance	
Down Payment (%)	80%
Down Payment	$ 40,740,000.00
Amount to Finance	$ 10,185,000.00
Interest Rate	4.000%
Years of Loan	15
Monthly Interest Rate	0.333%
Number of Payment Periods	180
Monthly Debt Servicing Payment	$75,337.22
Annual Debt Servicing for loan term	$ 904,046.58
Yearly Electricity Losses (%)	0.00%
Annual Electricity Price Escalator	0.50%
Weighted Average Cost of Capital	6.0%
IRR	7.38%
Net Present Value	$ 7,305,786.12

CDN $6 Million / Megawatt installed.

8 MWe gross (5 MWe Net) @ 100 $CDN/MWh

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Project development: financial model MD Greenview

Economic Value of Waste Heat and Offsets		
Waste Heat for Utilization	143.95	GJ/hour
Hours / Annually	8760	
Plant Capacity Factor	80%	
Hours of heat production	7008	
Annual Heat Production	1,008,801.60	GJ
Price of Natural Gas	$ 2.25	GJ
Annual Heat Sale Revenue	$ 2,269,803.60	
Carbon Intensity of Natural Gas	56	kg CO2/GJ
GHG offset from geothermal heat	56,492,889.60	kg
	56,492.89	tonne
Carbon Tax Rate	$30	tonne
Sale of offset (discounted)	90%	
Value of Offset Sale Annually	$1,525,308.02	
Economic Value of Waste Heat & Offsets	$3,795,111.62	Annually

Green house gas avoidance

Annual Electricity Production: Net (AP_{net})
$Ap_{net}=(Capacity_{net} * Hr_{annual})*C_{apacity}F_{actor}$
$Ap_{net} = (5\text{ MW} * 8760\text{hr})*0.8$ $= 35{,}040\text{ MWh/yr}$ $= 35.04\text{ GWh/yr}$

Grid Displacement Factor for 2022 and 2031
$G_{rid}\,D_{isplacement}\,F_{actor}\,(tCO_2e/MWh)_{2022} = GDF_{2018} - 5\%$ $= 0.59tCO_2e - 0.0295$ $= 0.56tCO_2e$
$GDF_{2031} = GDF_{2022} - 20\%$ $= 0.56tCO_2e - 0.112$ $= 0.45tCO_2e$

Annual GHG Reduction
$GHG_{reduction} = AP_{net} * G_{rid}D_{isplacement}F_{actor}(tCO_2e/MWh)_{2022}$
$GHG_{reduction} = 35{,}040\text{ MWh} * 0.56tCO_2e$ $= 19{,}622.4\ tCO_2e$ $= 0.0196\ MtCO_2e$

Facility Lifespan (35 Years) GHG Reductions	
$GHG_{reduction(2022\text{-}2030)} = (AP_{net} * 9_{yr}) * GDF_{2022}$	$= (35{,}040*9)*0.56tCO_2e$ $= 176{,}601.6\ tCO_2e$ $= 0.1766\ MtCO_2e$
$GHG_{reduction(2031\text{-}2057)} = (AP_{net} * 26_{yr}) * GDF_{2030}$	$= (35{,}040*26)*0.45tCO_2e$ $= 409{,}968\ tCO_2e$ $= 0.4100\ MtCO_2e$
$GHG_{reductions(total)} = GHG_{reduction(2023\text{-}2030)} + GHG_{reduction\,(2031\text{-}2057)}$	$= 176{,}601.6\ tCO_2e + 409{,}968\ tCO_2e$ $= 586{,}569.6\ tCO_2e$ $= 0.5866\ MtCO_2e$

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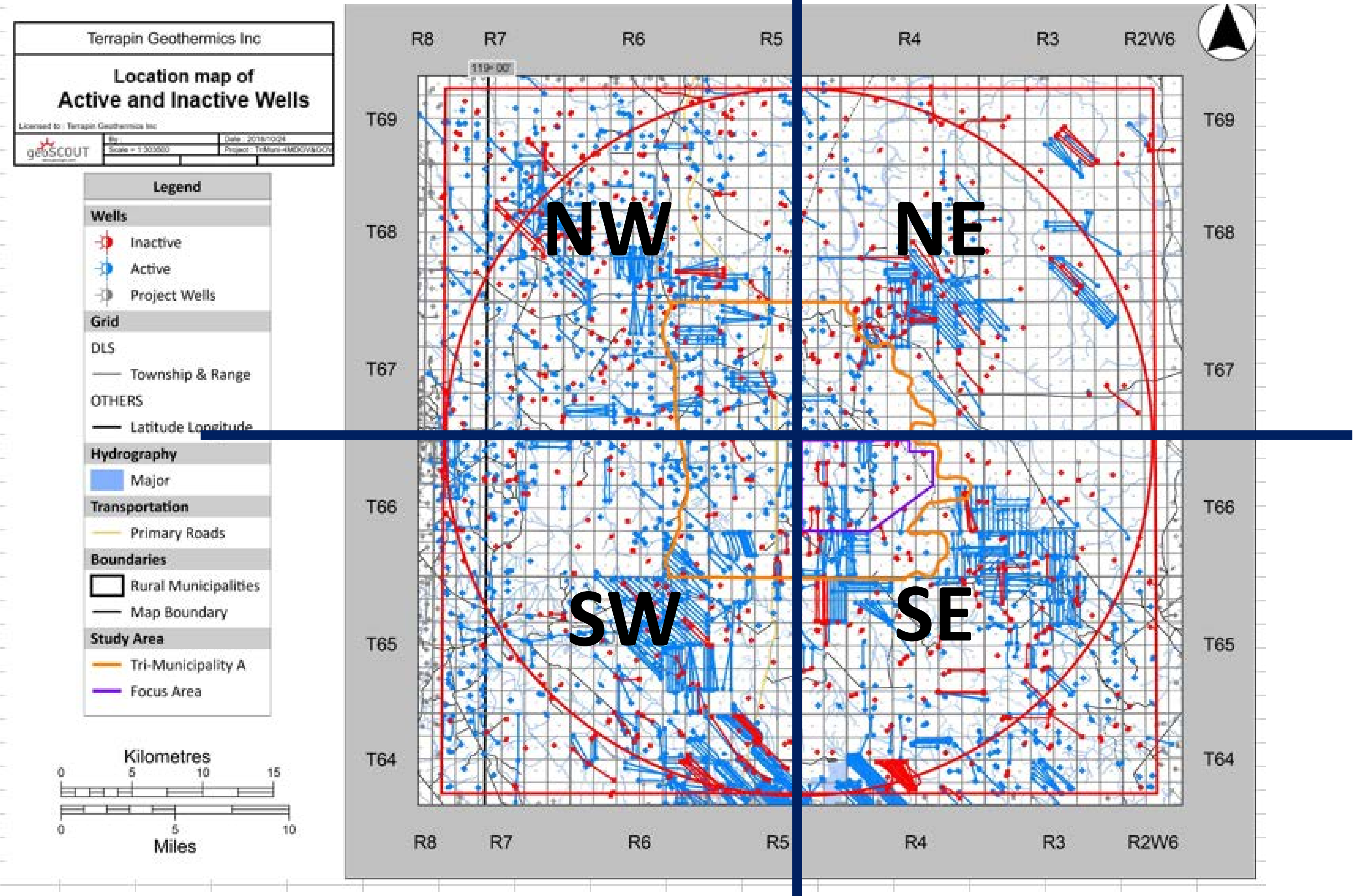
Existing infrastructure and data

Trimuniciple (TMIP) area divided into four quadrants. Well heads and tracks are shown for the 1538 active wells (Blue) and the 603 inactive wells (red) within the mapped area.

Area is roughly

12 X 12 miles 144 mi^2

19 X 19 km 361 km^2



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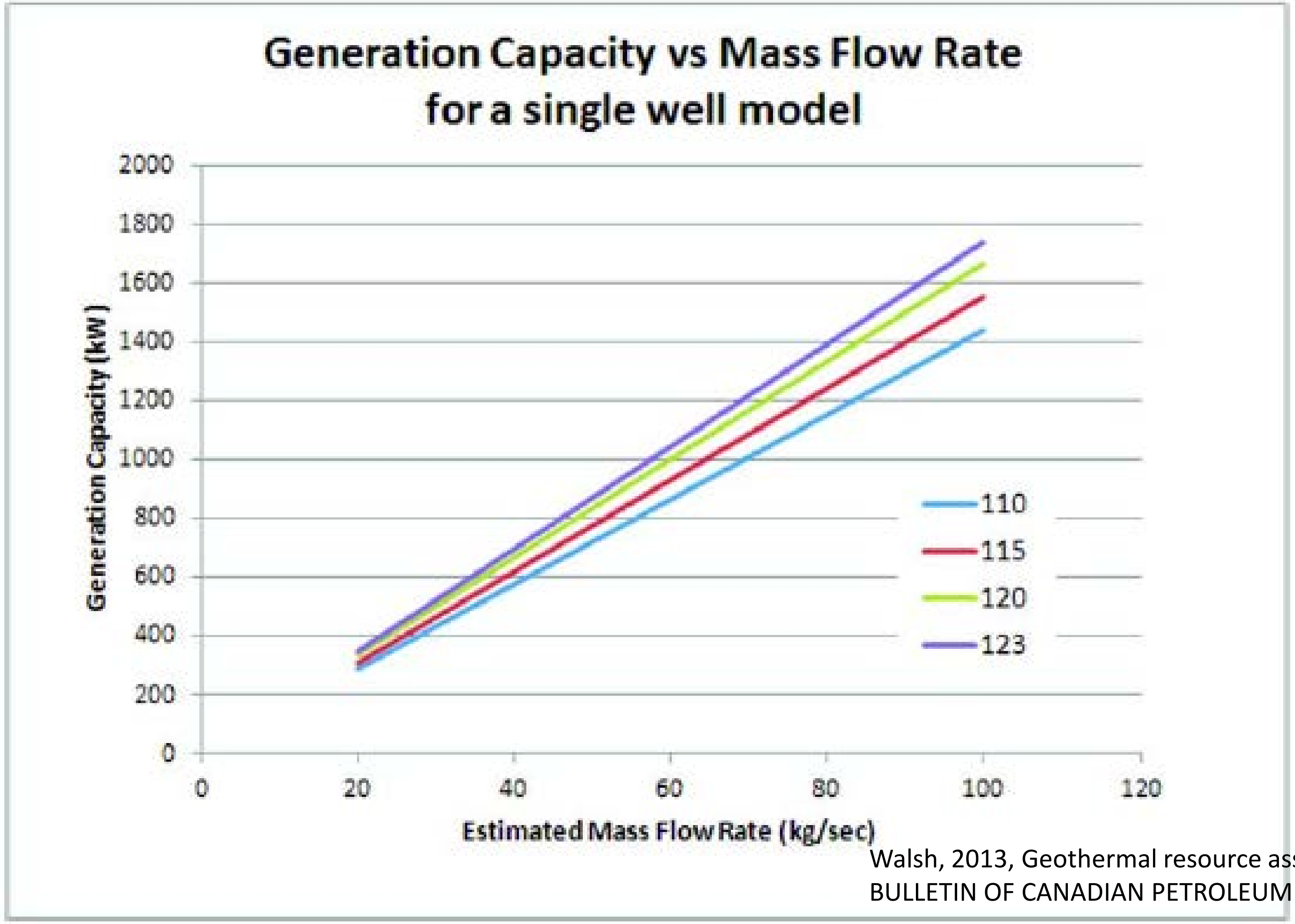
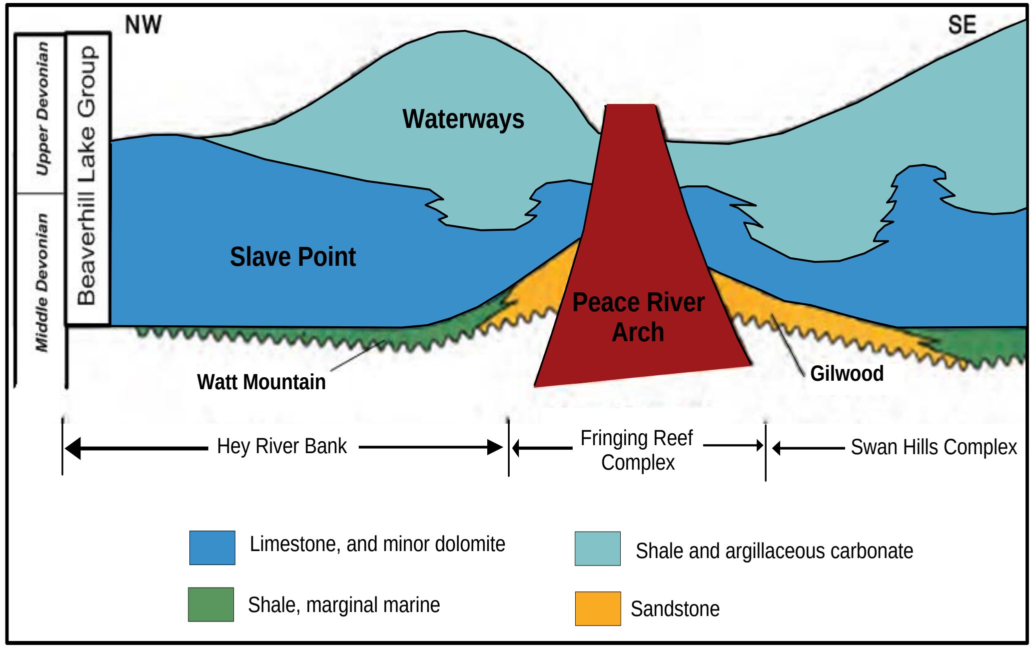
What heat and flow rates are needed?

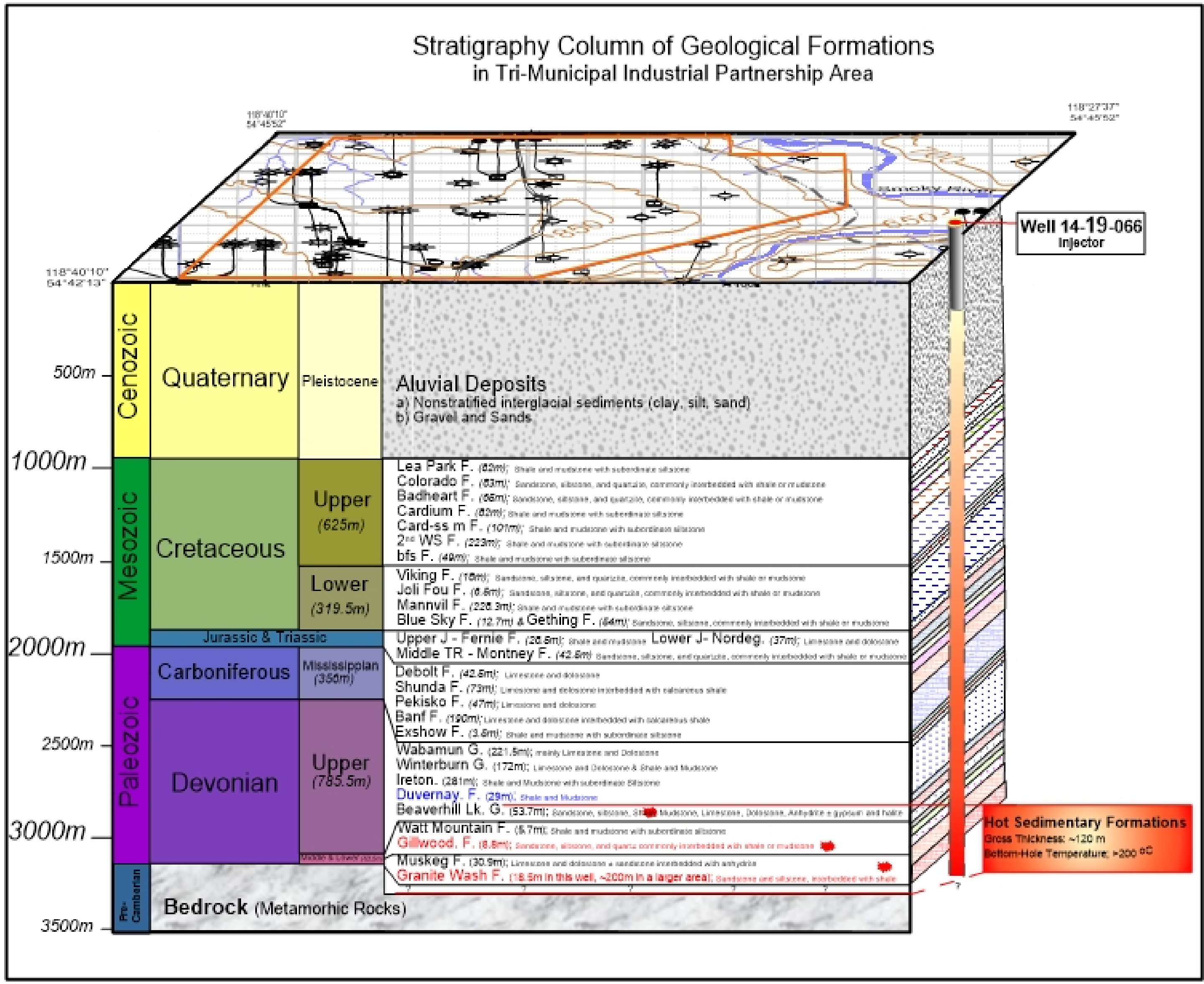


Data suggests there are "oceans" of water, but data was collected for oil and gas purposes. Actual sustained flow from wide diameter wells over decades is not known. Pump tests and other down hole measurement will be needed in order to understand how much water is flowing.

Walsh, 2013, Geothermal resource assessment of the Clarke Lake Gas Field, Fort Nelson, British Columbia, BULLETIN OF CANADIAN PETROLEUM GEOLOGY, Volume 61, Number 3, September 2013, Pages 241–251

Defining the target formation





Key for geothermal energy is access to <u>significant</u> quantities of water. Formations of interest are below the Duvernay. Of greatest interest are the carbonates (especially dolomites) and sandstones and the basement.

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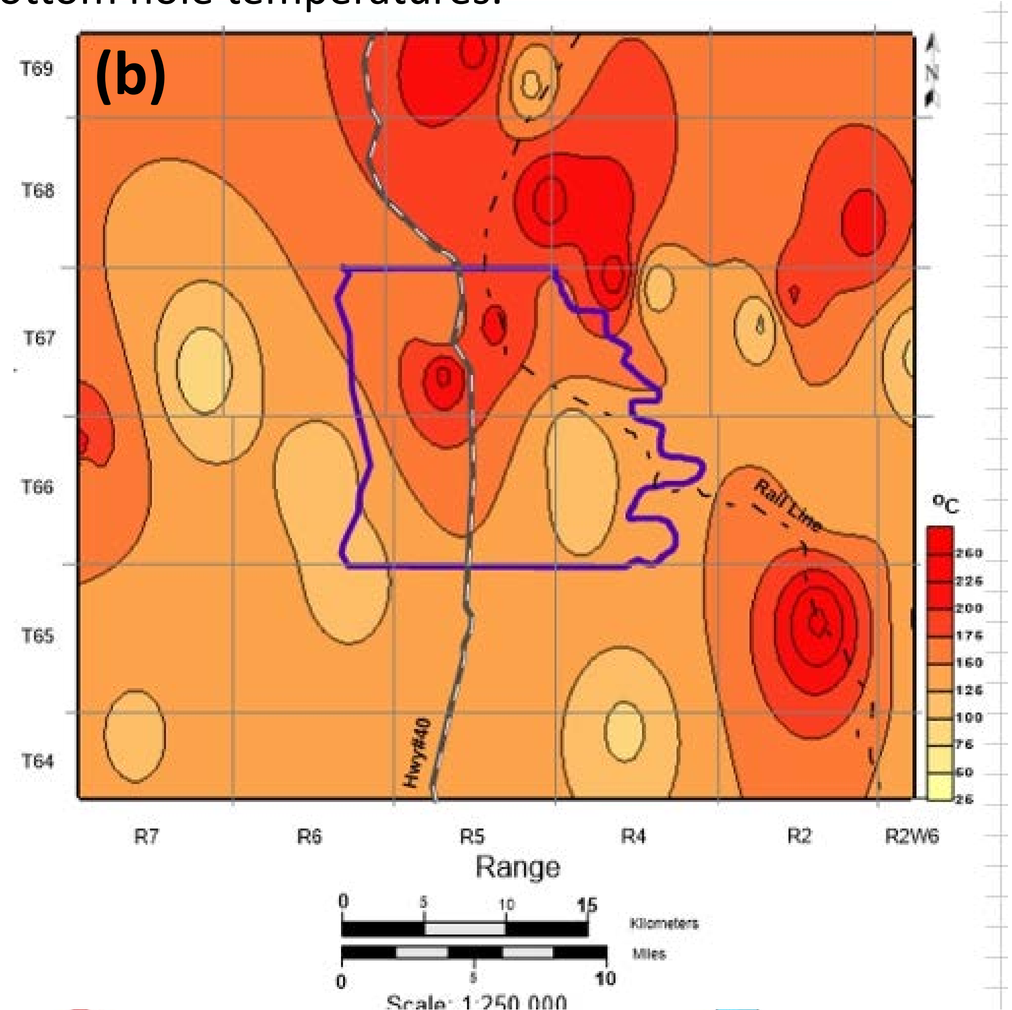
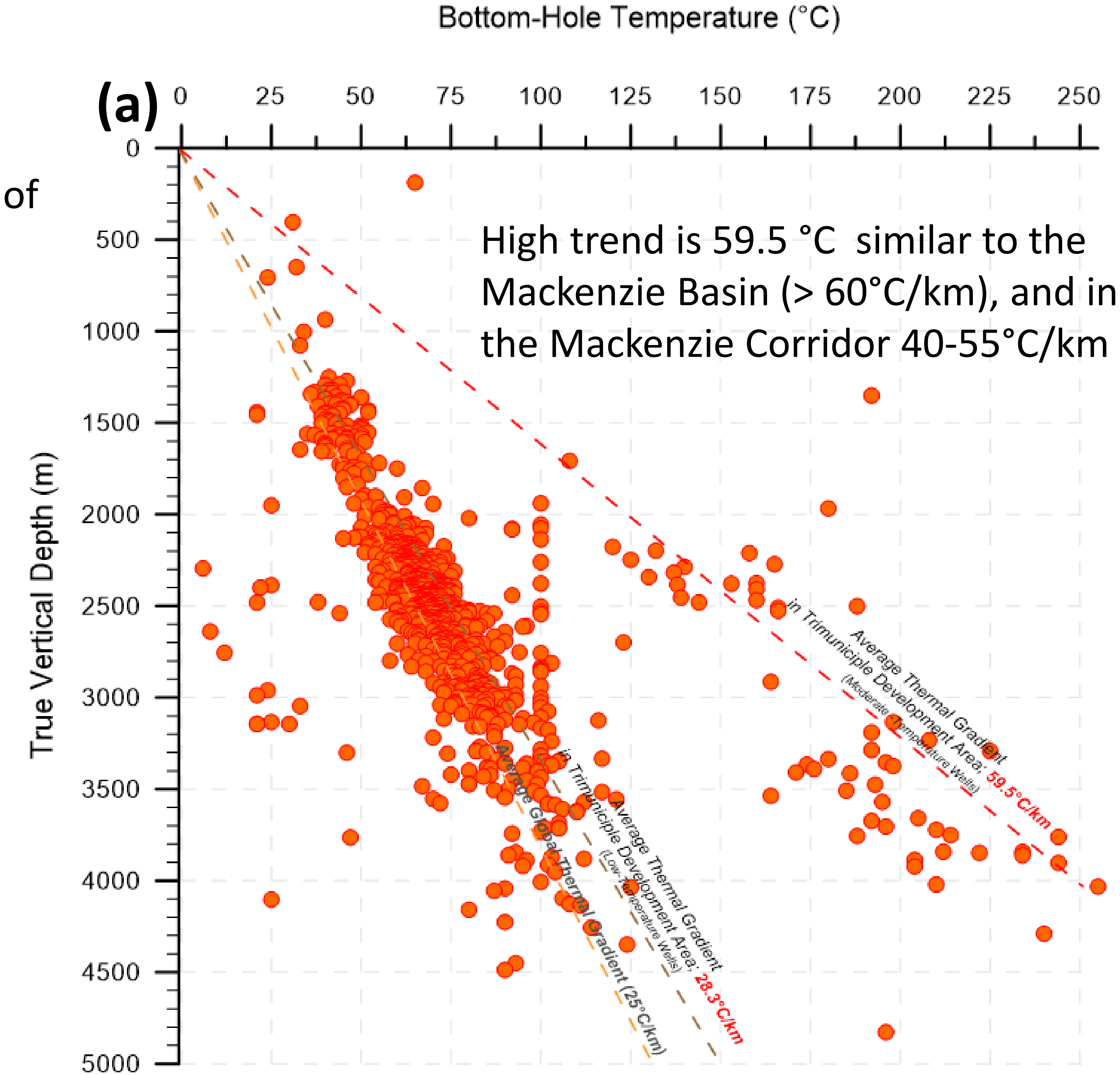
Existing infrastructure and data

(a) Temperature gradients calculated from corrected BHT (Deming 1989) for wells in the Trimuni area. (b) isopach map of bottom hole temperatures.





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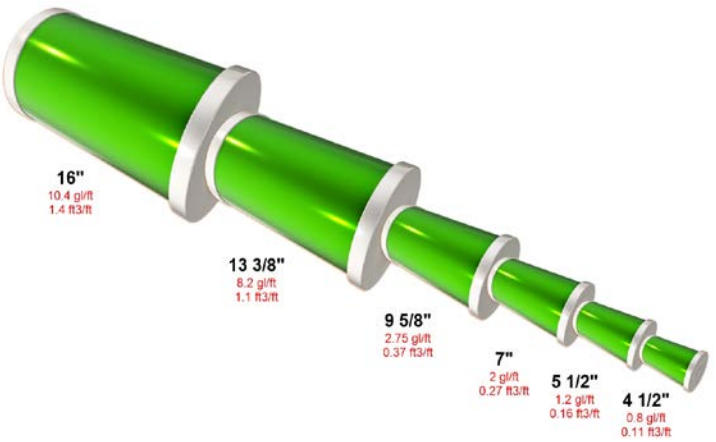
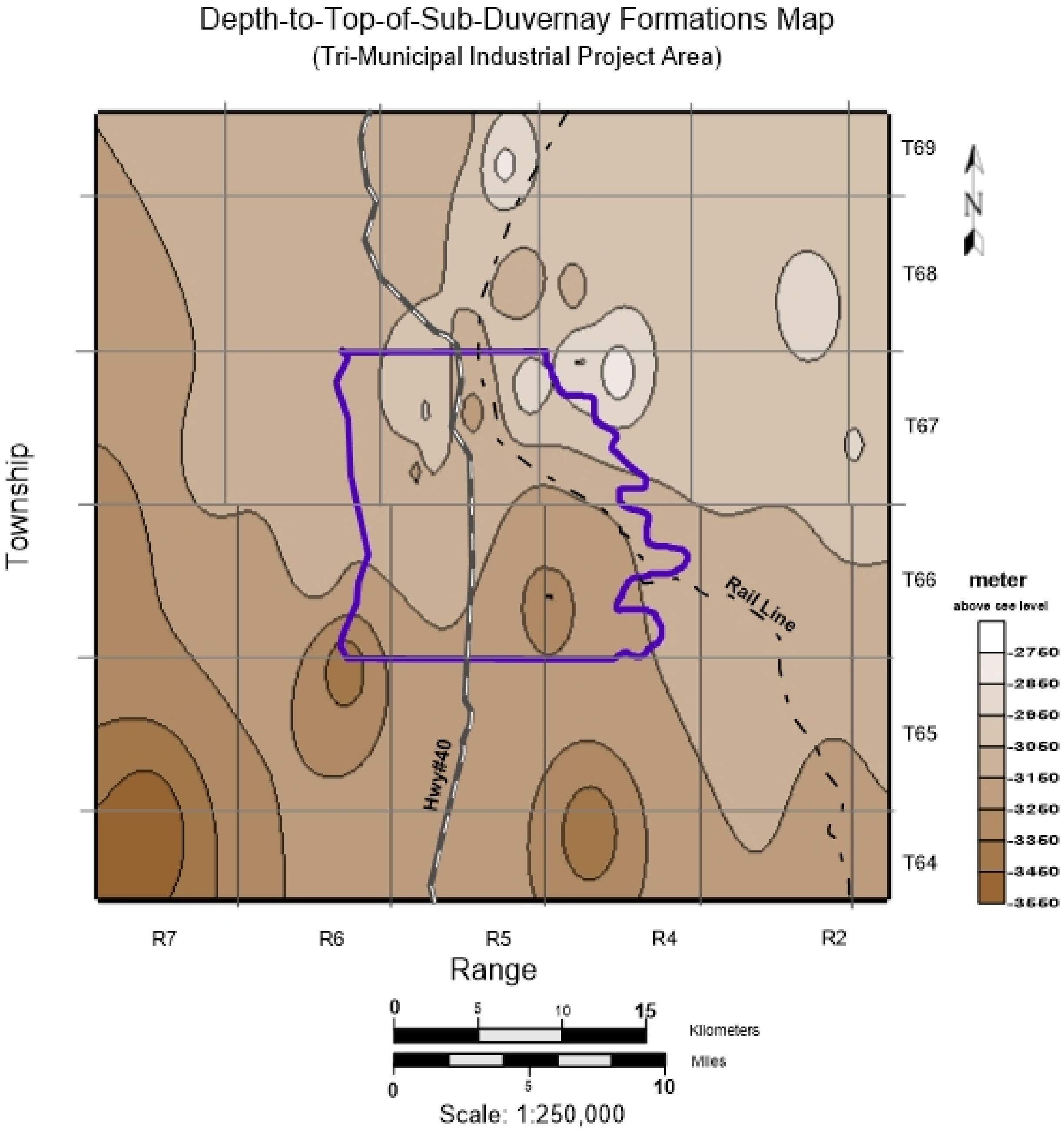
Existing infrastructure and data

Isopach map showing depth to the target formation (Lower Devonian: sub-Duvernay Formation).

- Temperatures are predicted to be ~200°C @ 3.5 km.
- Assumed flow rates are 25 – 35 kg/s per wide diameter well (9 5/8” – 13 3/8”).
- Total mass production 172 kg/s





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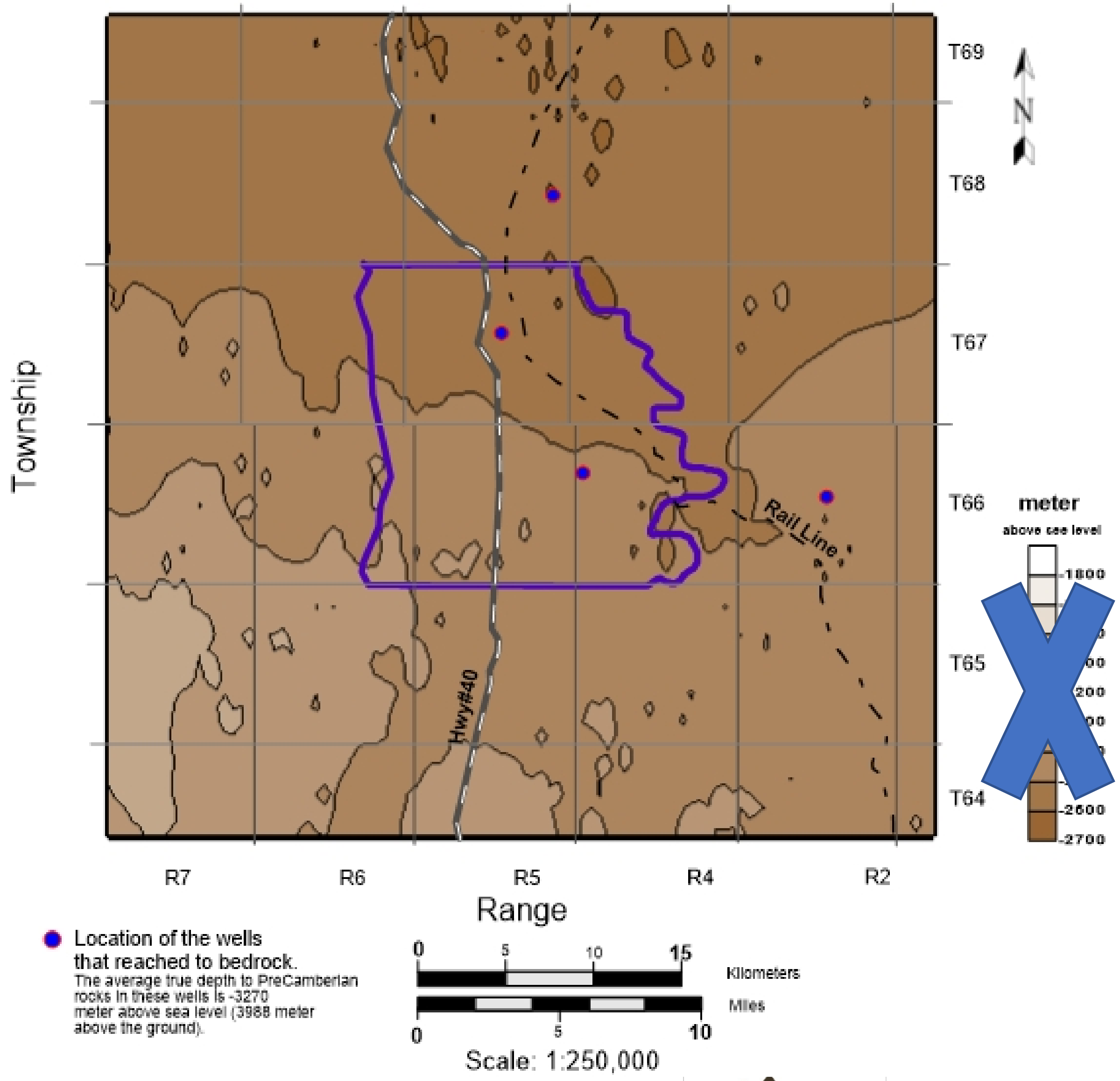
Existing infrastructure and data

The basement rocks are potentially altered and fractured as they were emergent prior to subsidence, transgression and burial by marine sediments. Only two wells in the TMIP area penetrate to basement.

Depth-to-Bedrock Map
(Tri-Municipal Industrial Project Area)



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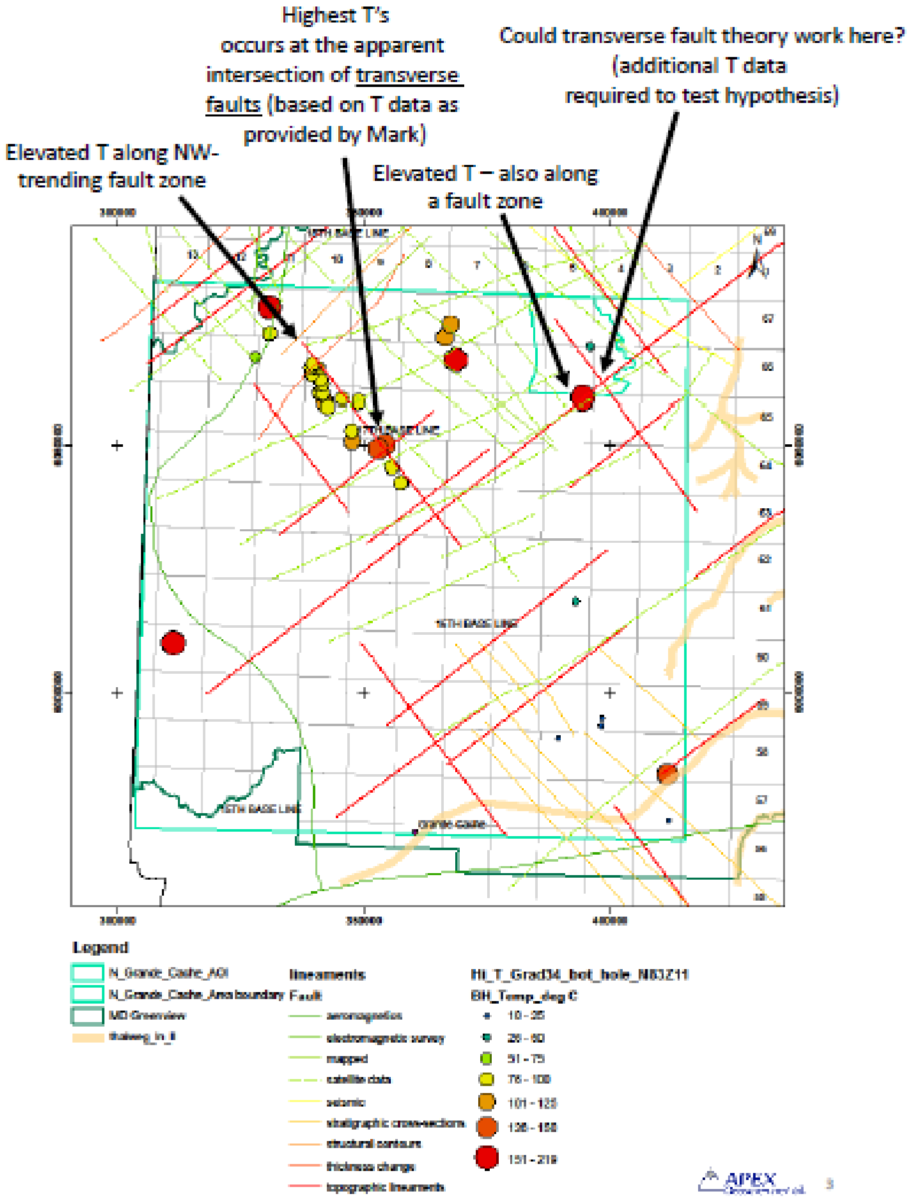
Existing infrastructure and data

Subsurface structural pattern suggests that some of the hottest BHTs are coincident with lineaments in the subsurface. These fracture zones may be bringing hot brines from the basement into the overlying aquifers. The Duvernay formation (a tight shale formation) may act as a thermal barrier, trapping heat in the deep subsurface.

Exploration results suggest that flow rates are 172 liters/second (from multiple production wells) and the temperature could be as high as 200°C.



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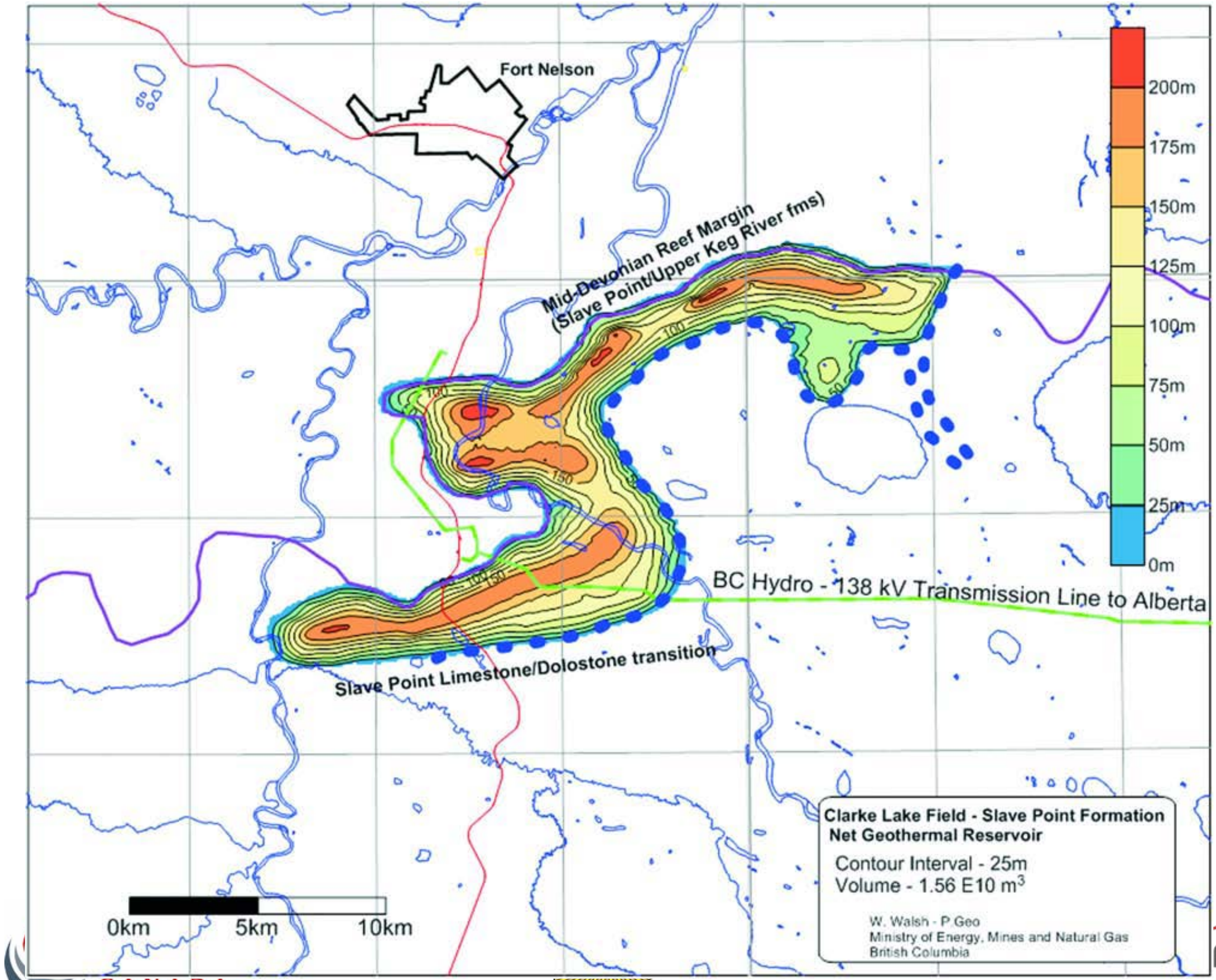
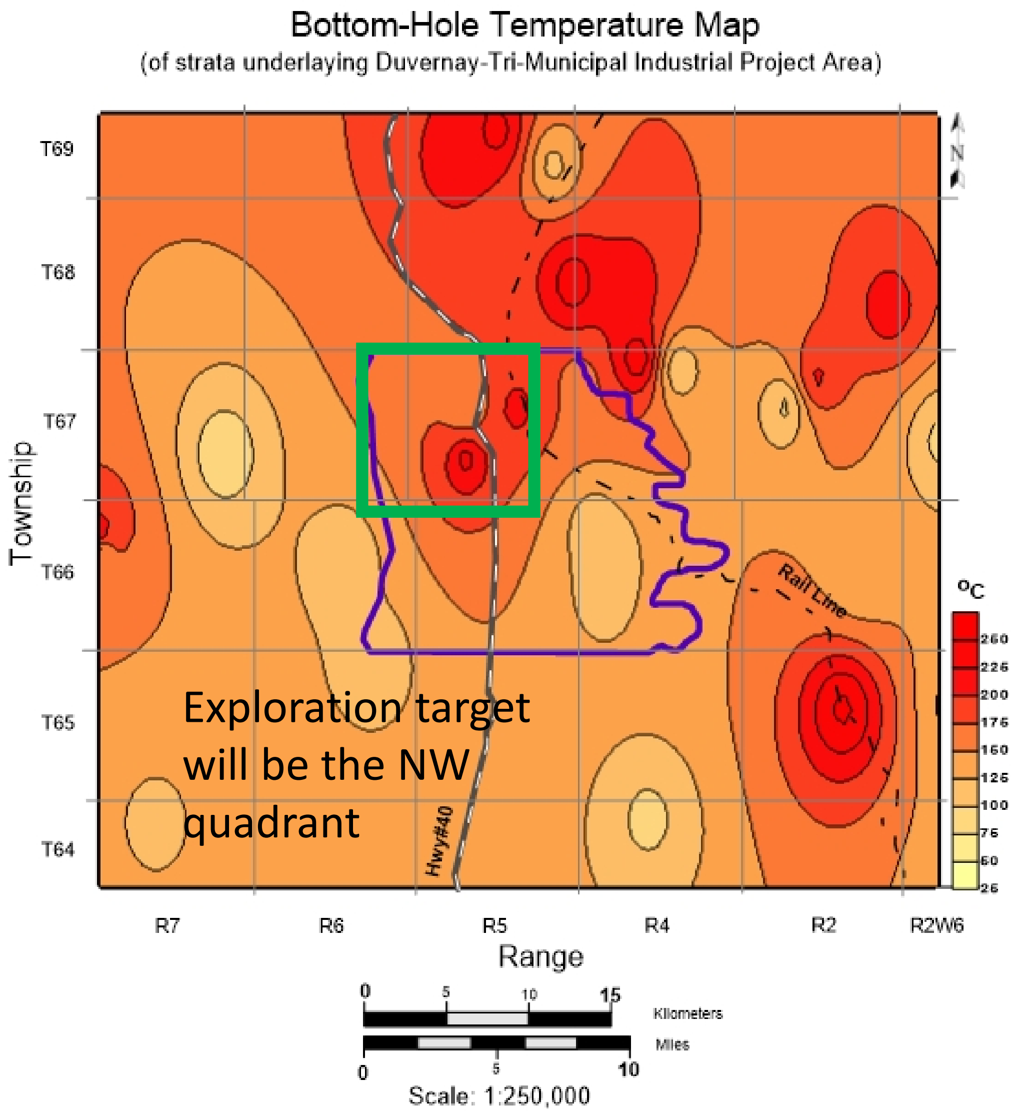
How much water really flows?

For this project's economic calculations we assumed 172 kg/s of flow of 200°C water.



The Middle Devonian Slave Point Formation in the Clark Lake field of British Columbia has dolomitized zones that show high permeability. Two gas wells were flow tested by Petro-Canada for approximately a year: 2800 m^3/day (33kg/s) with a deliverability of 0.75 (m^3/d)/kPa

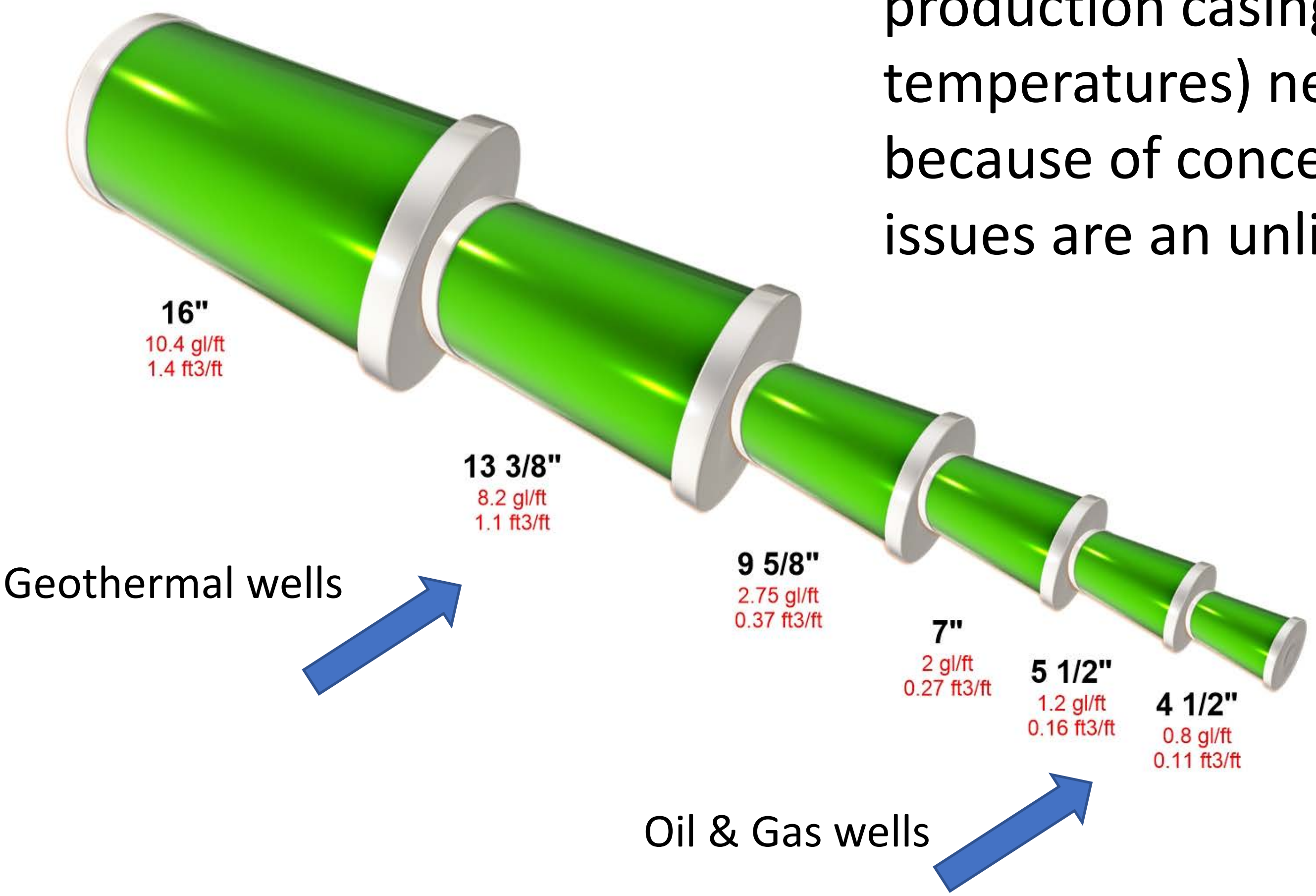
Summary of exploration target information

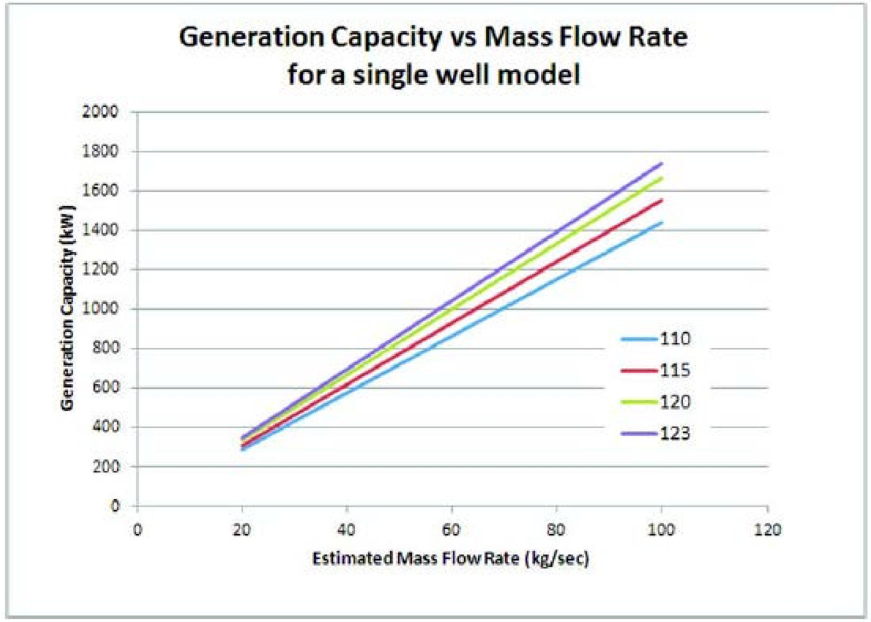


- Hydrocarbon extraction in the region is focused on the Duvernay, Montney and related Late Devonian and Triassic aged formations
- Production formation, Gilwood, is within the early Devonian strata (Elk Point Group)
- Maximum assumed fluid temperature is expected to be 200°C based on BHT
- Combined fluid flow from six wells is expected to be 172 kg/s
- Fluid composition of the geofluids is alkali bicarbonate water with a pH of 7.8
- There is limited potential to encounter hydrocarbons within the target formations
- All produced fluid is expected to be reinjected. The Leduc formation is the likely injection target and at least one injection well will need to be drilled. Chemical mixing issues (different formational waters) have not yet been assessed.

Geothermal production wells: existing wells

Typical gas well production casing 5 ½” and oil well production casing 4 ½”. Geothermal (Alberta reservoir temperatures) needs very large volume flows. Old wells, because of concerns about casing integrity or other issues are an unlikely options for electrical production.





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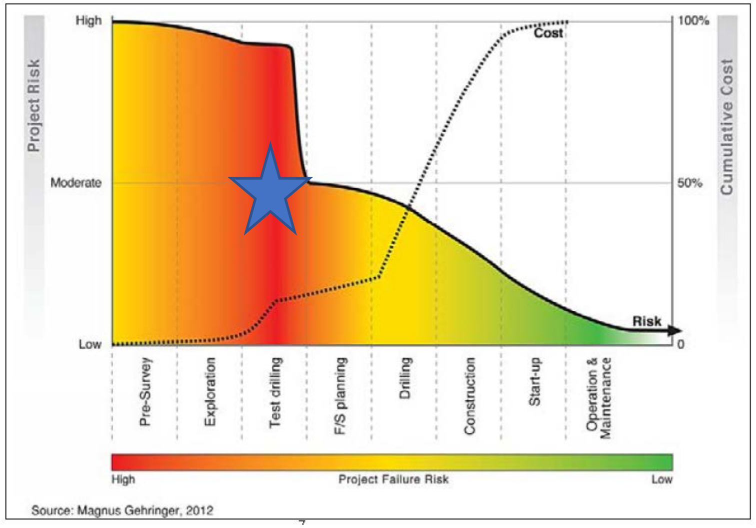
Economic Considerations

1. Project development
   a. Exploration and evaluation of the resource
   b. Exploration drilling
   c. Production drilling
   d. Surface piping and infrastructure
   e. Plant design and construction (CAPEX)
   f. Operation (OPEX)
2. Social economic factors – local employment
3. Electrical Generation income - PPA
4. Direct-use income – thermal
5. Carbon Off-set income – thermal and electrical



Slim hole drilling: core to narrow diameter “slim” holes

Alterra power, Mariposa geothermal project, diamond drilling 3 well campaign.

If the resource has never been drilled before, then “slim” hole drilling may save significant funds if the resources turns out to be not as hot or as voluminous as anticipated and does not warrant further development. However, in remote locations, without existing infrastructure, slim hole drilling may cost nearly as much as wide diameter drilling.

Typically at least 3 wells are drilled into a greenfield project.

Slim hole drilling: core to narrow diameter “slim” holes

Alterra power, Mariposa geothermal project, diamond drilling 3 well campaign.

- In some areas, winter weather must combated to keep the project going.
- In steep terrain avalanches can sometimes be a hazard.
- Heavy snow fall requires some protection for the rig and crew.

Exploration drilling: wide diameter


HS Orka, Reykjanes, Iceland 2014


Alterra, Soda Lake drilling, 2009

- Once the infrastructure has been built and results from the pervious phases are favourable, wide diameter drilling starts.
- If successful, wells can be used for production.
- If less than successful, they can be used for monitoring wells.

Exploration drilling: well testing

Wireline surveys can measure resistivity, conductivity, downhole temperatures, formation pressures, as well as sonic properties, and wellbore dimensions. Well bore integrity and cement bonding. Logging is typically done after formation changes, loss of circulation, or other changes in the well and at the end drilling. Pump testing follows the end of drilling. Wells are then allowed to heat up for days to weeks to months.

Exploration drilling: well testing (the old fashioned way)

Dixie Queen, Nevada, 2010

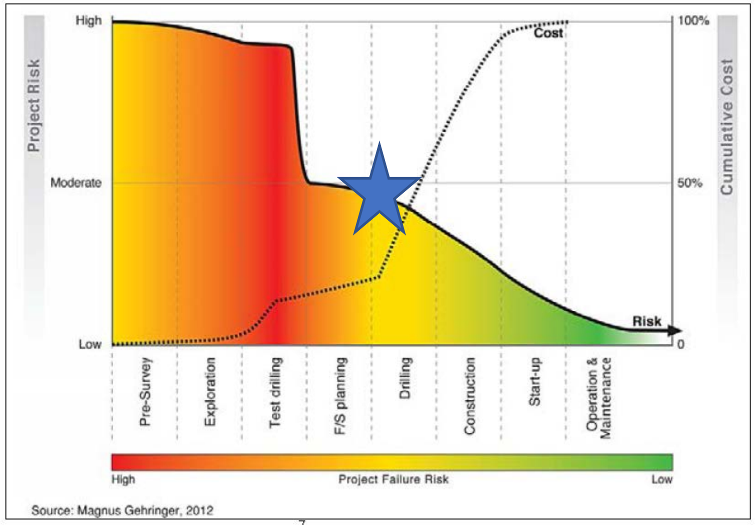
Wireline surveys can measure resistivity, conductivity, downhole temperatures, formation pressures, as well as sonic properties, and wellbore dimensions. Well bore integrity and cement bonding. Logging is typically done after formation changes, loss of circulation, or other changes in the well and at the end drilling. Pump testing follows the end of drilling. Wells are then allowed to heat up for days to weeks to months.

Exploration drilling: flow testing

Alterra Power, Soda Lake, Nevada

Wells are allowed to heat up for days to weeks to months, depending on projected bottom hole temperatures and expected well performance (based on pump tests). Following heat up, the wells are then flowed. If flash they are run through a separated and vented to atmosphere (depending on gas composition), brines are either flowed to a sump or injected depending on local environmental regulations and fluid chemistry.

Economic Considerations



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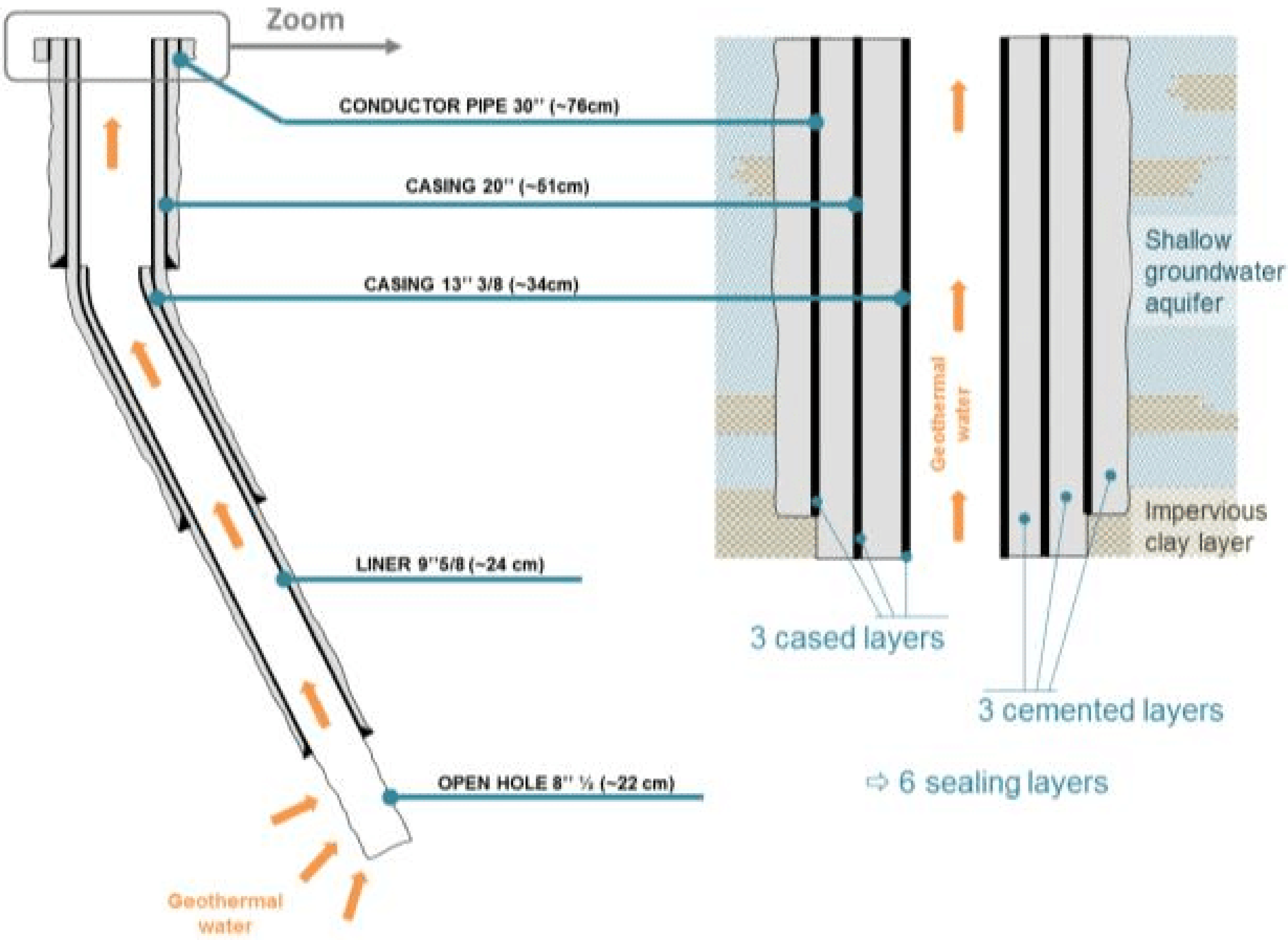
Geothermal production wells

Iceland 2008

HS Orka, Reykjanes, Iceland 2014

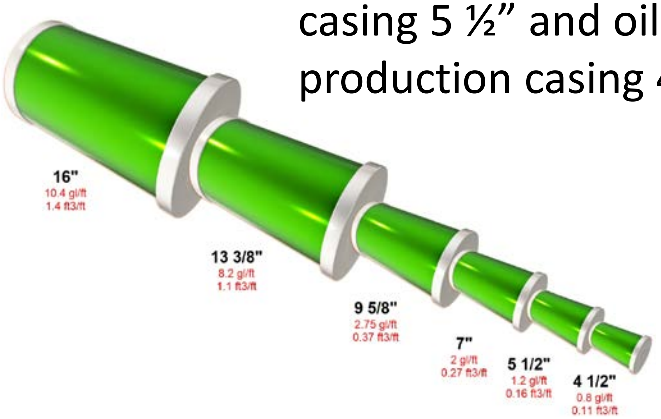
Rigs used for oil and gas drilling are used with some differences with mud handling and "loss of circulation" is celebrated. High temperature wells have additional nuances, such as double ram BOP due to temperature limitations of rubber BOPs

Geothermal production wells



High temperature cements are used for wells over 170°C; lost circulation is only treated if it is above the production zone. Open holes are not common; most have perforated liners.

Typical gas well production casing 5 ½" and oil well production casing 4 ½" .



Economic Considerations

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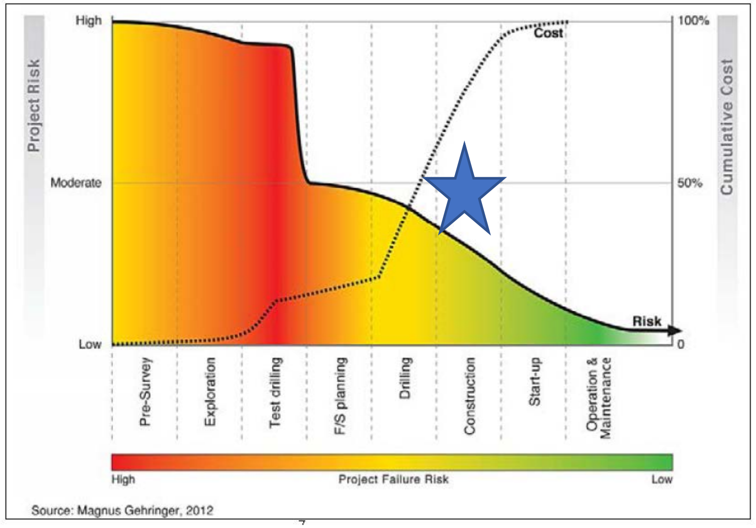

Surface infrastructure - pipes

Piping can have a significant cost – especially important for Direct-use.

HS Orka, RN 33, Reykjanes, Iceland 2014

Geysers, California 2009

HS Orka, Svartsengi, Iceland 2016

HS Orka, RN 33, Reykjanes, Iceland 2014

Alterra Power, Soda Lake, Nevada 2009

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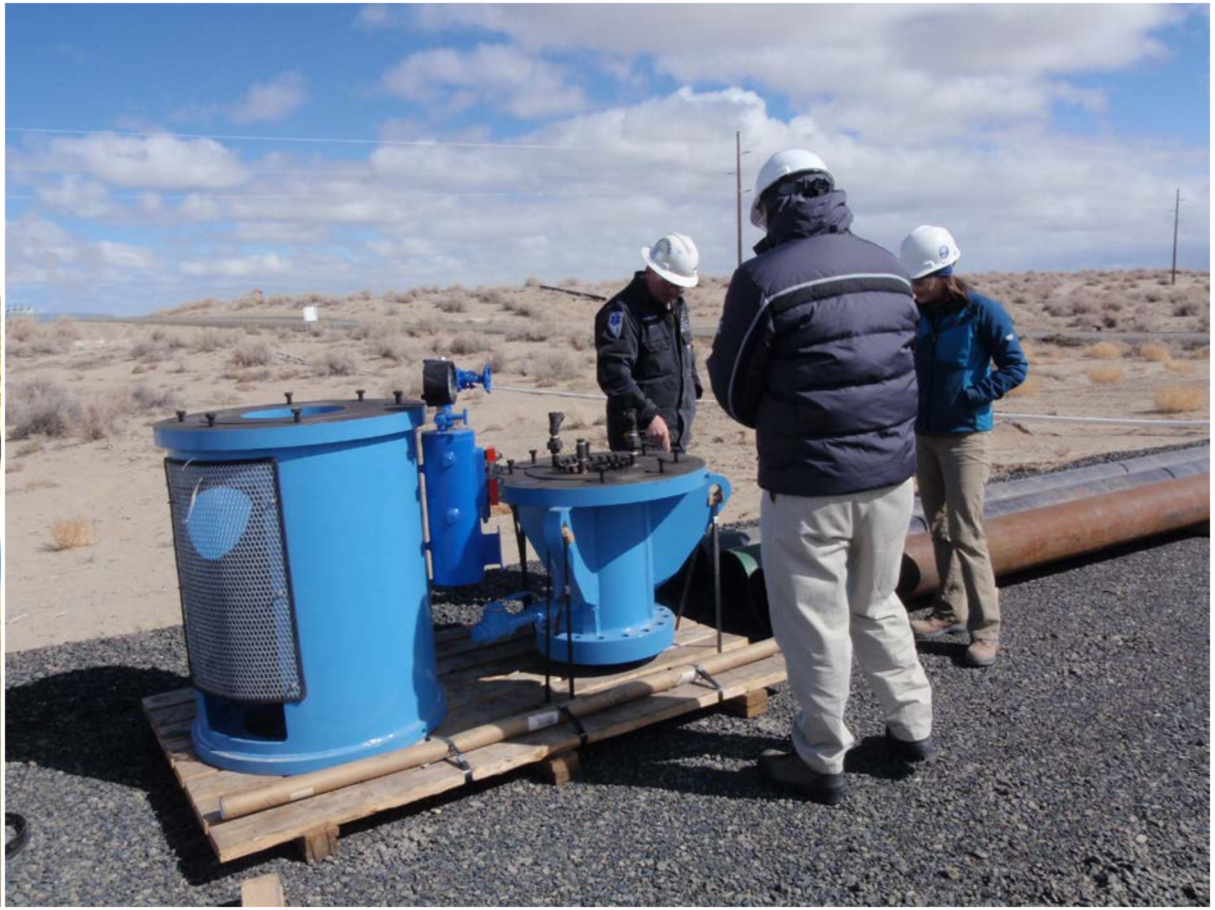
Surface infrastructure – pumps



Cost of pumps and impact on parasitic load for TMIP area will be characterized after drilling and well testing.

Surface infrastructure – well heads


HS Orka, RN 33, Reykjanes, Iceland 2014


Dixie Valley, Nevada, 2014

Arctic weather conditions demand protected well heads which adds extra cost to projects.

Economic Considerations

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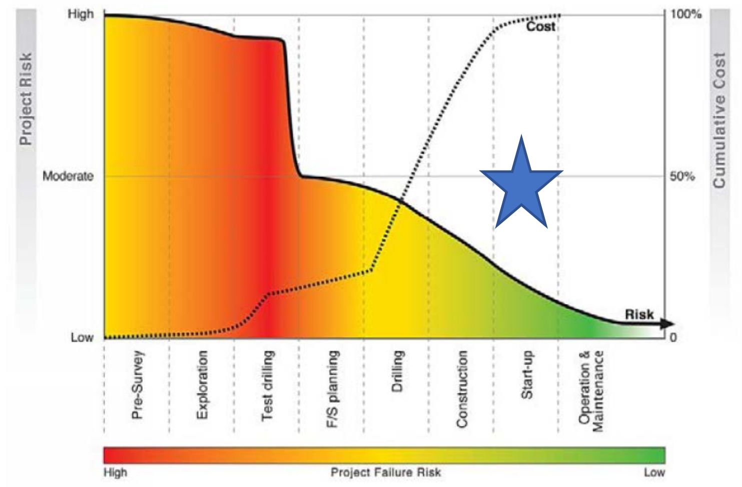

Source: Magnus Gehringer, 2012

Lazard Geothermal Result
USD $46 - 76/MWh Capital costs
USD $25-35/MWh Fixed O&M
No Fuel costs, no variable O&M
USD $71 – 111 /MWh Total

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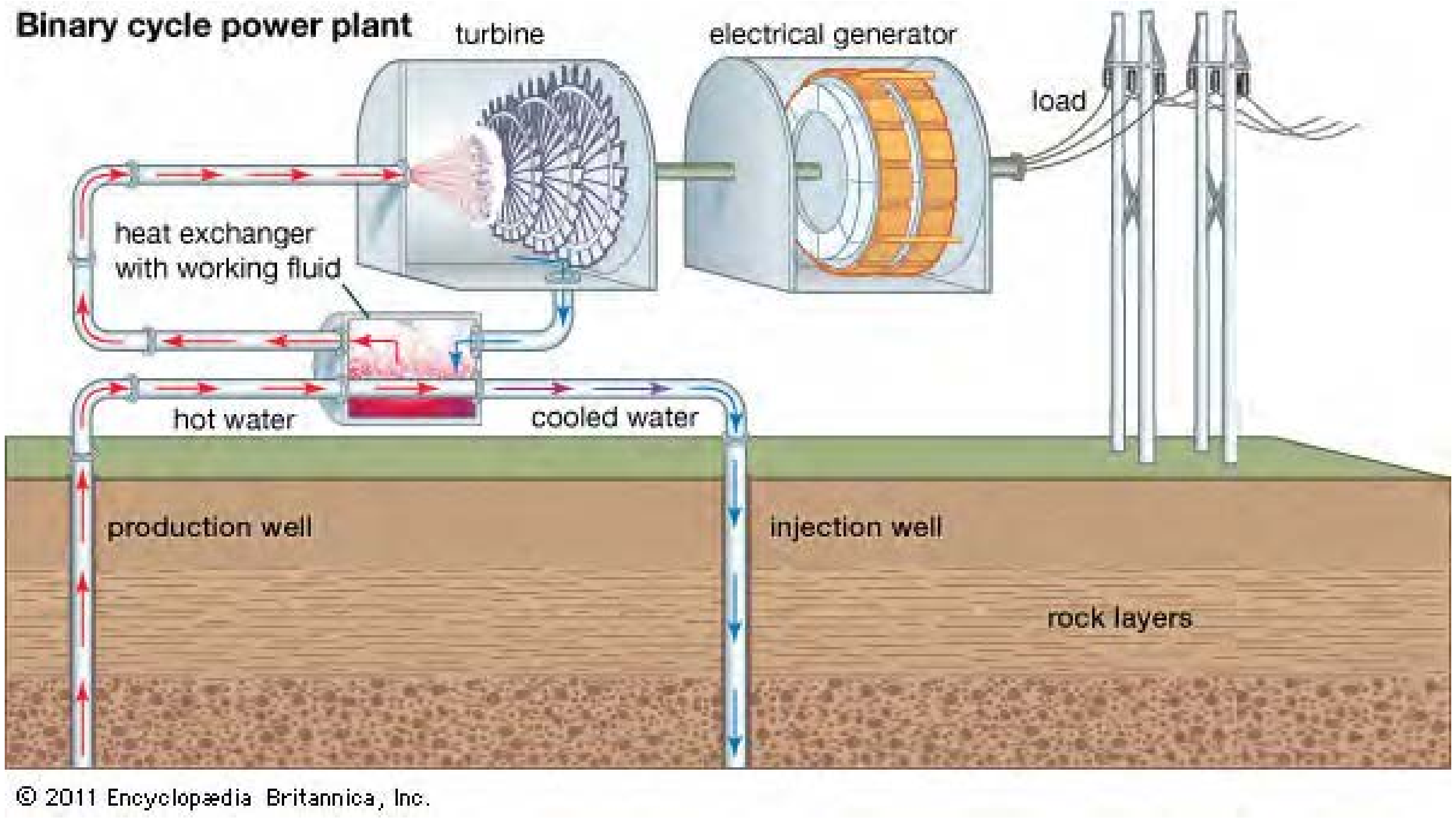
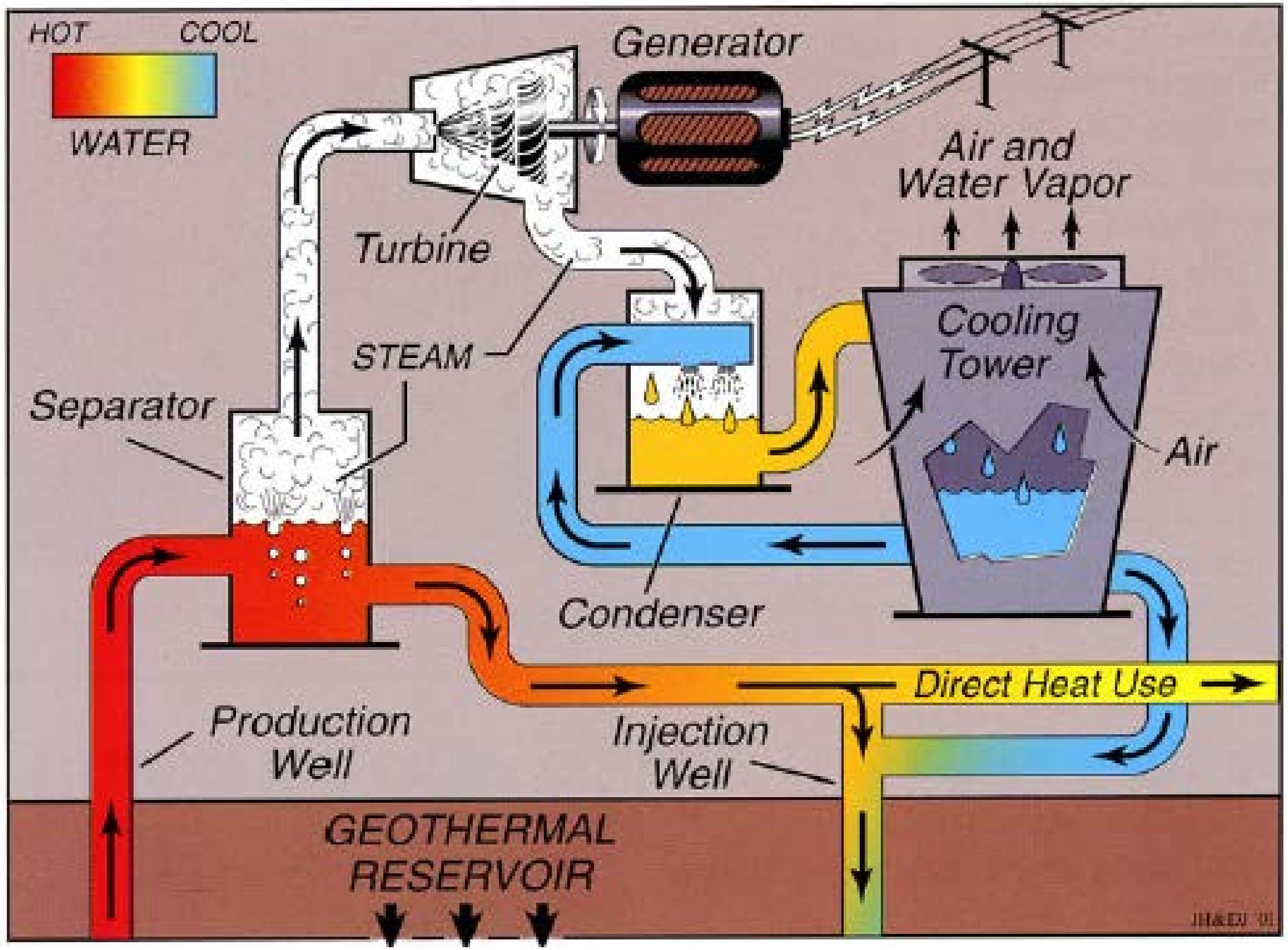
Plant design and construction (CAPEX) – ORC (Binary)



Organic Rankine Cycle (ORC) system. The geothermal water heats another liquid which boils at a lower temperature than water. The two liquids are kept completely separate through the use of a heat exchanger, which transfers the heat energy from the geothermal water to the working fluid. The secondary fluid expands into gaseous vapour. The force of the expanding vapor, like steam, turns the turbines that power the generators. All of the produced geothermal water is injected back into the reservoir.

Assumed 25% patristic load, but may be higher depending on reservoir conditions. (Options for direct use of fluids.)

Plant design and construction (CAPEX) - Flash



Assumed 10% parasitic load, but may be higher depending on reservoir conditions. Options for direct use of relatively high temperature fluids.

Flash systems use produced steam to directly run turbines. Depending on local conditions, the produced geothermal water is injected back into the reservoir.

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Plant design and construction (CAPEX)

Geothermal brine in temperature	200	[°C]
Geothermal brine mass flow rate	170	[kg/s]
Gross electric ORC power output *(a)*	8,000 [(1)]	[kW]
ORC and ACC parasitic consumptions *(b)*	700	[kW]
Net electric ORC power output *(a) – (b)*	7,300 [(2)]	[kW]

Economic Considerations

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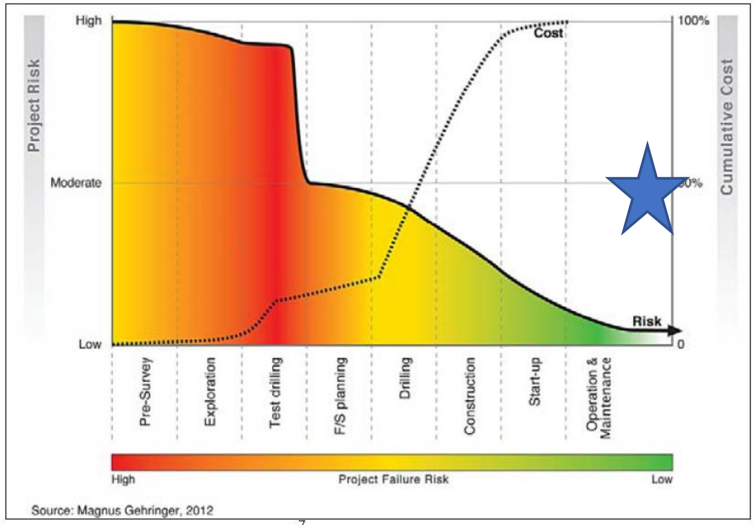

Lazard Geothermal Result
USD $46 - 76/MWh Capital costs
USD $25-35/MWh Fixed O&M
No Fuel costs, no variable O&M
USD $71 – 111 /MWh Total

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Geothermal plant operation (OPEX)

HS Orka, Svartsengi, Iceland 75 MWe geothermal power plant

Turboden, *5.6 MWe geothermal ORC Turboden plant for Hochtief Energy Management Kirchstockach – Munich, Germany*

Geothermal plants and well fields, *well managed* will last for decades. Pitfalls include chemical issues (scaling and corrosion), reservoir pressure, falling reservoir temperatures, injection, turbine issues and plant wear and tear (extreme weather). You must keep the reservoir healthy!

Plant operations – A binary, water cooled power plant

Soda Lake 1

- Built 1987
- Consists of four (4) Binary Ormat Energy Converters (OEC's)
  - Three (3) parallel Level 1 units, 1.2MWgross/each
  - One (1) Level 2 unit, 1.5MWgroww
  - Water Cooled condensing system
  - Isopentane working fluid
  - Nameplate capacity 5.1MWgross, current output 2.5MWnet
  - Average flow rate/temperature 1150gpm @340F
  - Design flow rate/temperature 900gpm@360F

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Geothermal Energy – A binary, air cooled plant

Soda Lake 2

- Built 1990
- Consists of six (6) Binary Ormat Energy Converters (OEC's)
  - HP and LP Level 1&2 units, 3MWgross/each
  - Air Cooled condensing system
  - Pentane working fluid
  - Nameplate capacity 18MWgross, current output 5.5MWnet
  - Average flow rate/temperature 3,600gpm @330F
  - Design flow rate/temperature 5,000gpm@380F

Geothermal plant operation (OPEX)

When things go wrong. Promising sites are not developed or stalled somewhere along the development pathway. Usually it is because of insufficient funding for the long term development. Typically 70% “steam-behind-pipe” is needed before debt financing.

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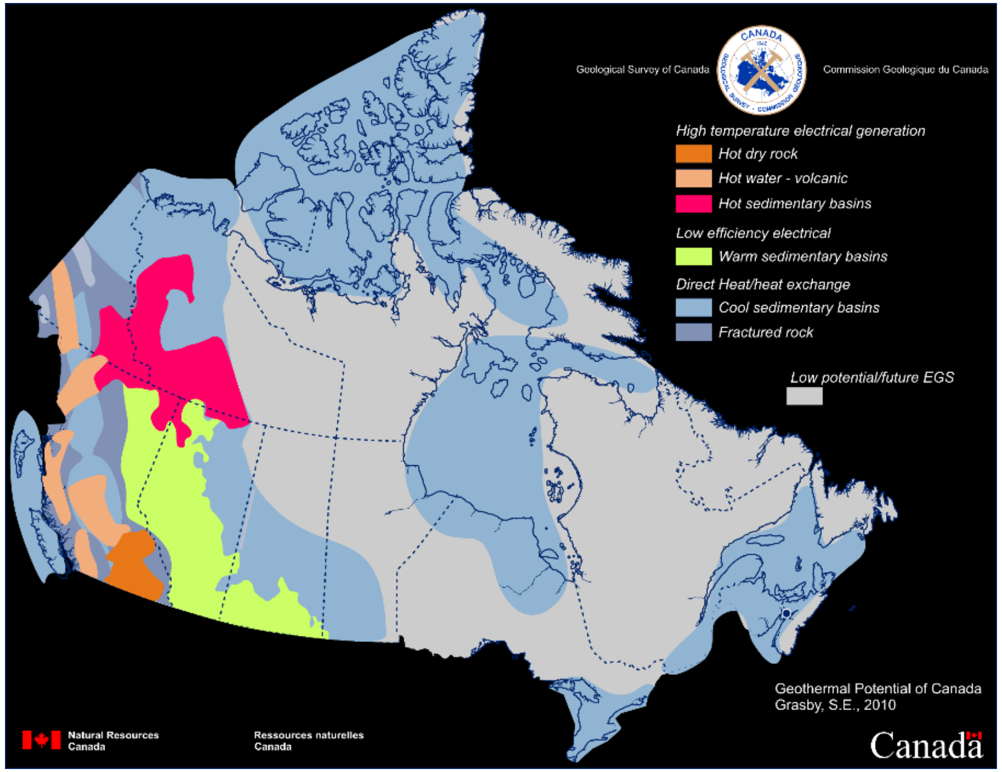
Economic factors: financial models



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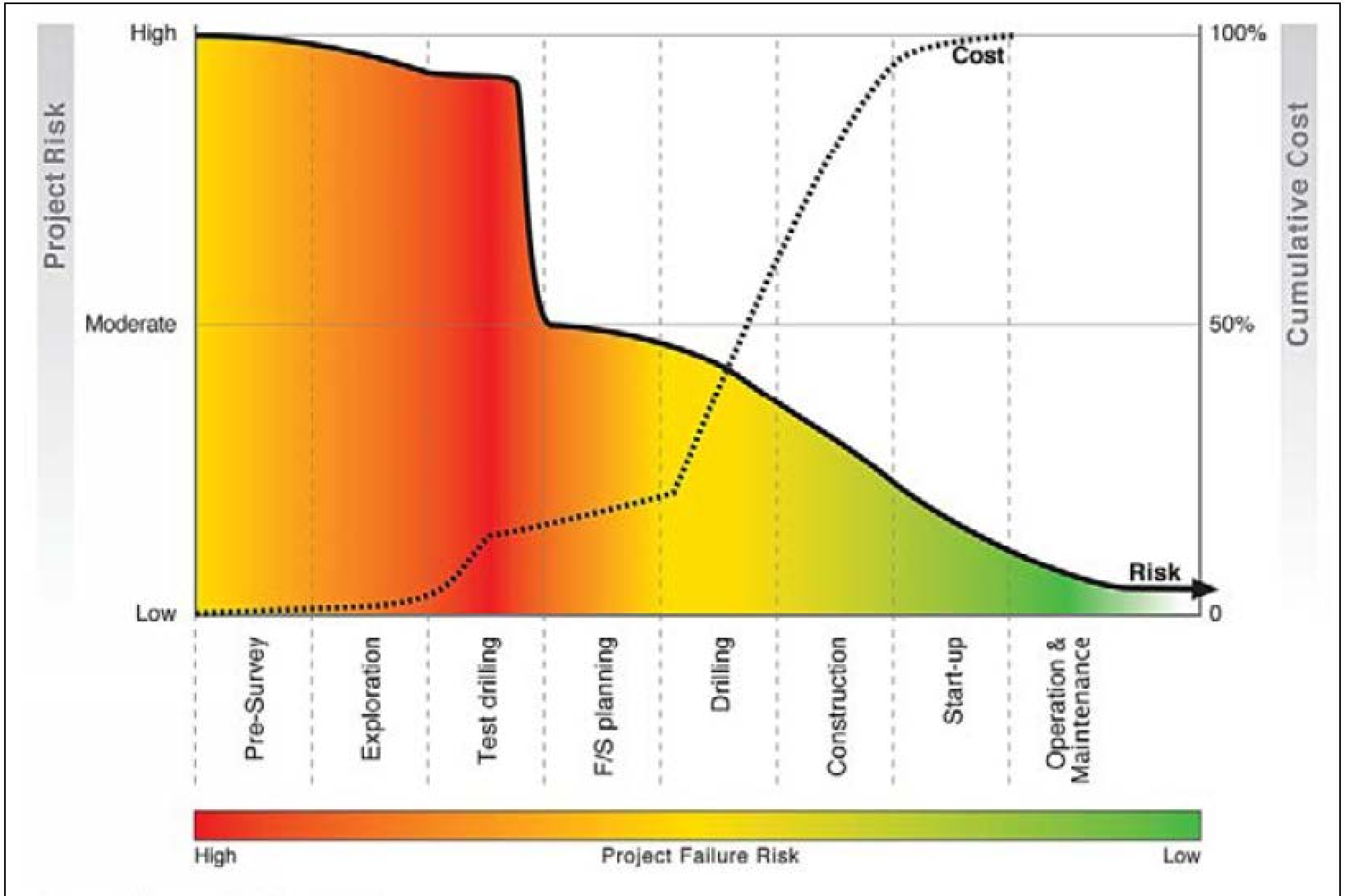
Project development risk and costs



Source: Magnus Gehringer, 2012

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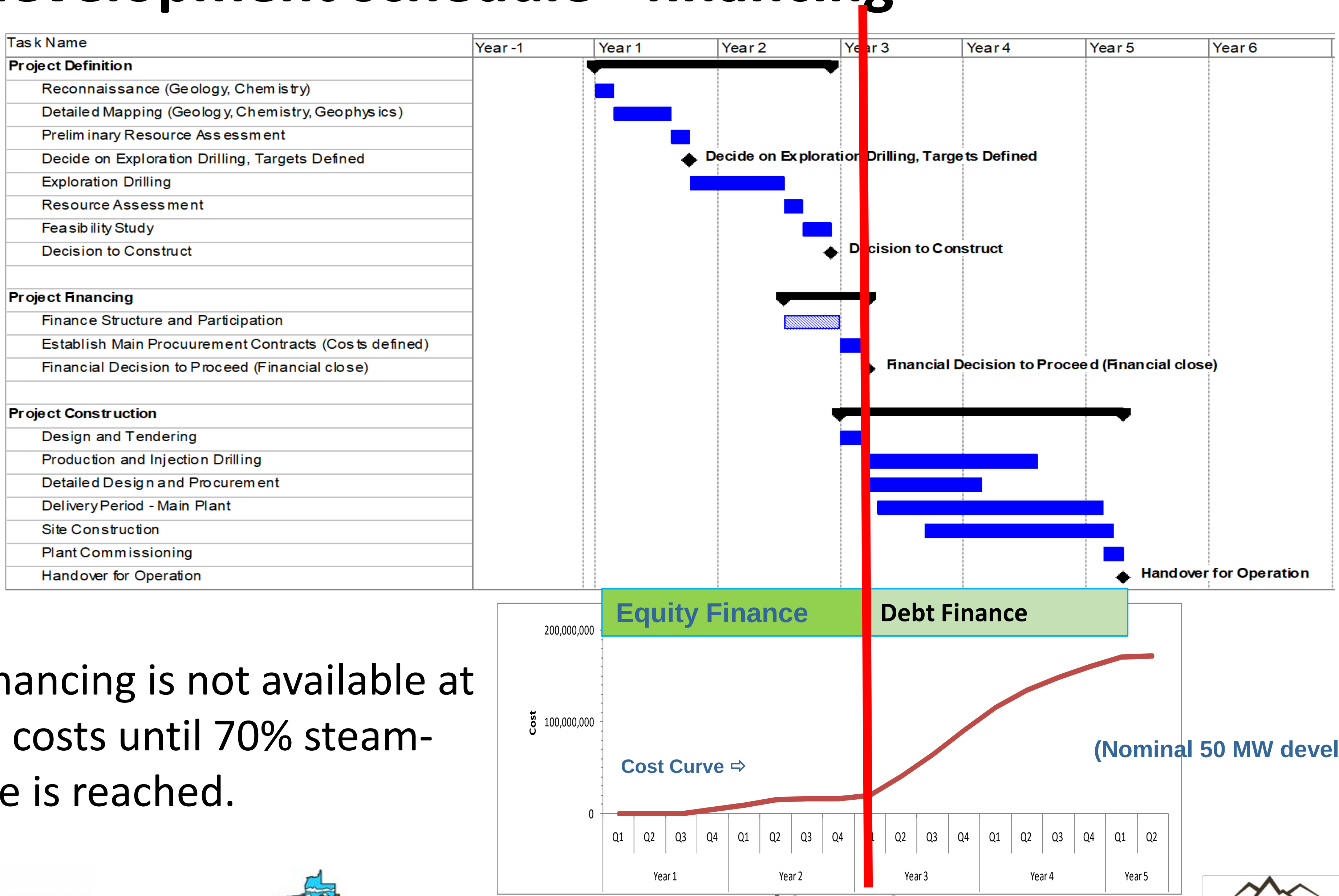
Project development schedule - financing



Typically financing is not available at reasonable costs until 70% steam-behind-pipe is reached.

(Nominal 50 MW development)

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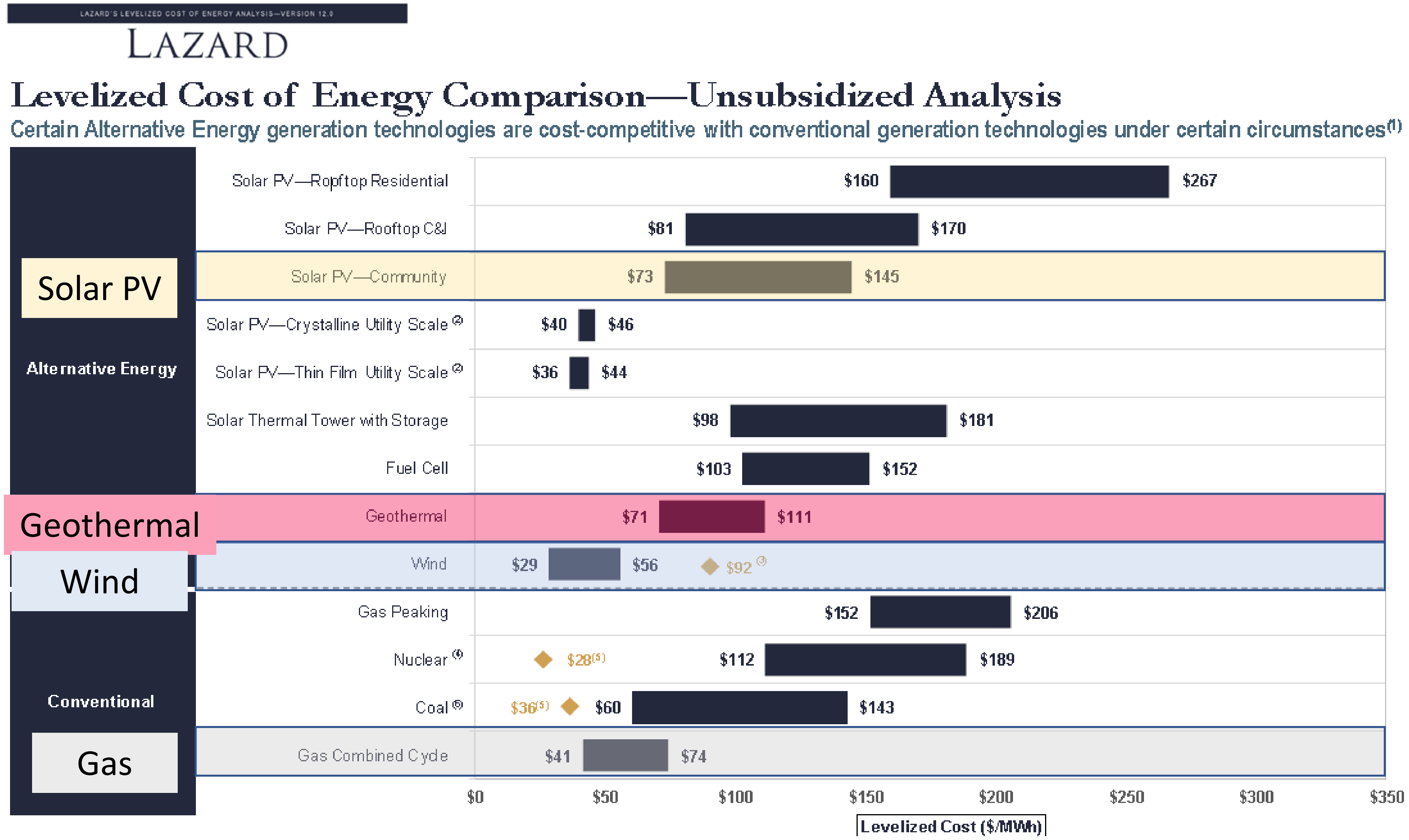
Levelized cost of electricity



Lazard – US based analysis released November 2018

$USD 73 - 145 Solar PV

$USD 71 - 111 Geothermal

$USD 29 - 56 Wind

$USD 41 - 74 Gas

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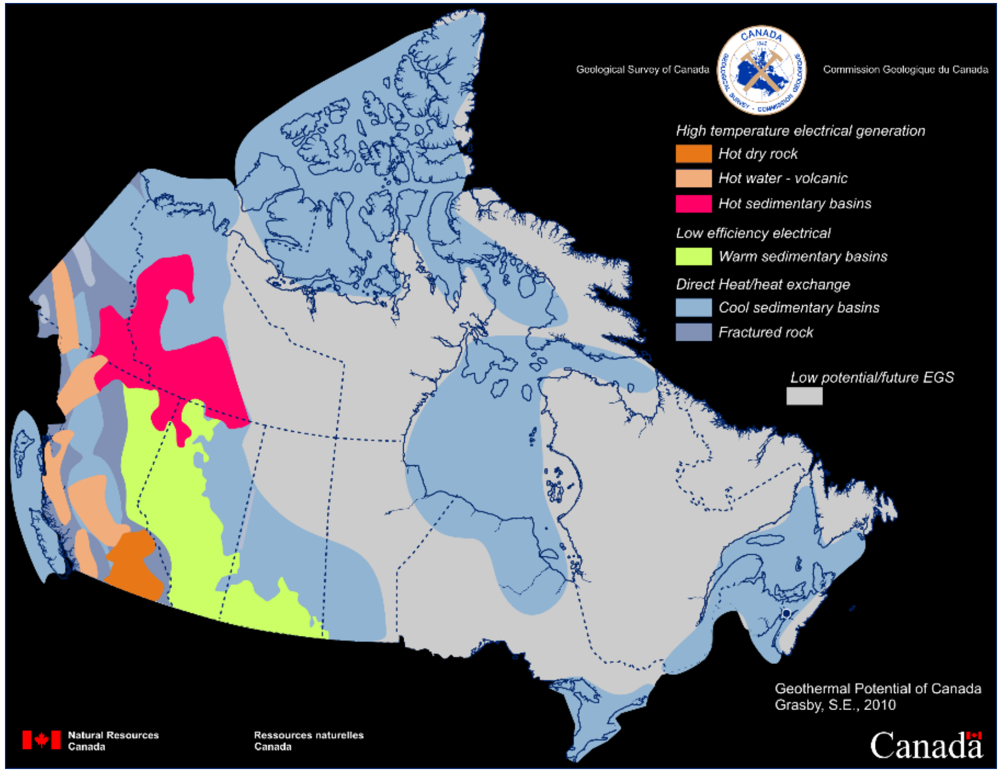
Economic factors: Social economic



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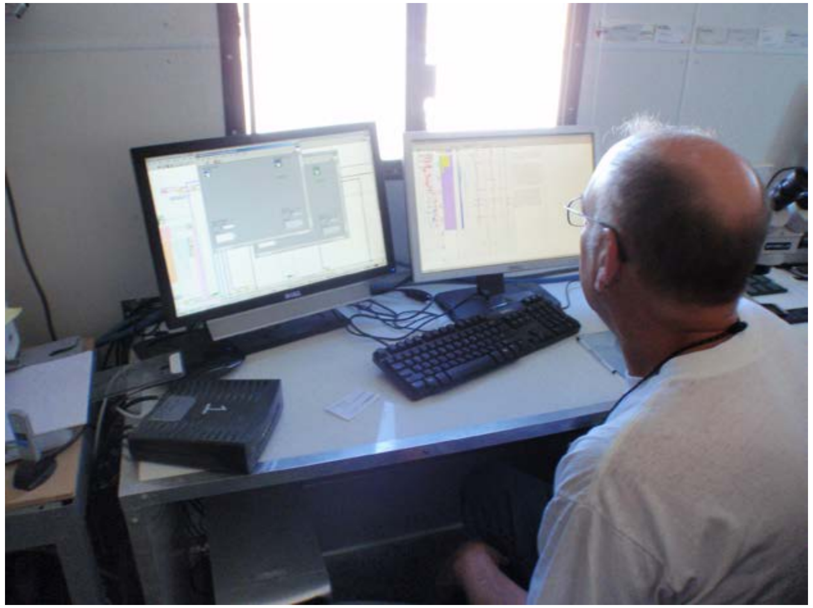
Economic Considerations

1. Project development
   a. Exploration and evaluation of the resource
   b. Exploration drilling
   c. Production drilling
   d. Surface piping and infrastructure
   e. Plant design and construction (CAPEX)
   f. Operation (OPEX)
2. **Social economic factors – local employment**
3. Electrical Generation income - PPA
4. Direct-use income – thermal
5. Carbon Off-set income – thermal and electrical

Economic factors – social economic

University of California, Berkeley in 2016 The construction of this 8 M W gross capacity facility should create 35.2 job-years of direct construction positions (or 1.01 FTE if spread over a 35C year facility lifespan), 3.2 full-time O&M positions, 9.36 full-time industry positions, 31.40 indirect and/or induced full-time positions, and 88 indirect and or induced job years for construction (or 2.51 FTE if spread over a 35 year facility lifespan). This provides us with a 47.48 total FTE positions created by the MD Greenview project.



Direct-use development (greenhouse, aquiculture, etc.) has not been factored into the calculation. Direct use typically provides more employment than electrical power generation.

Taxes or other royalty payments.

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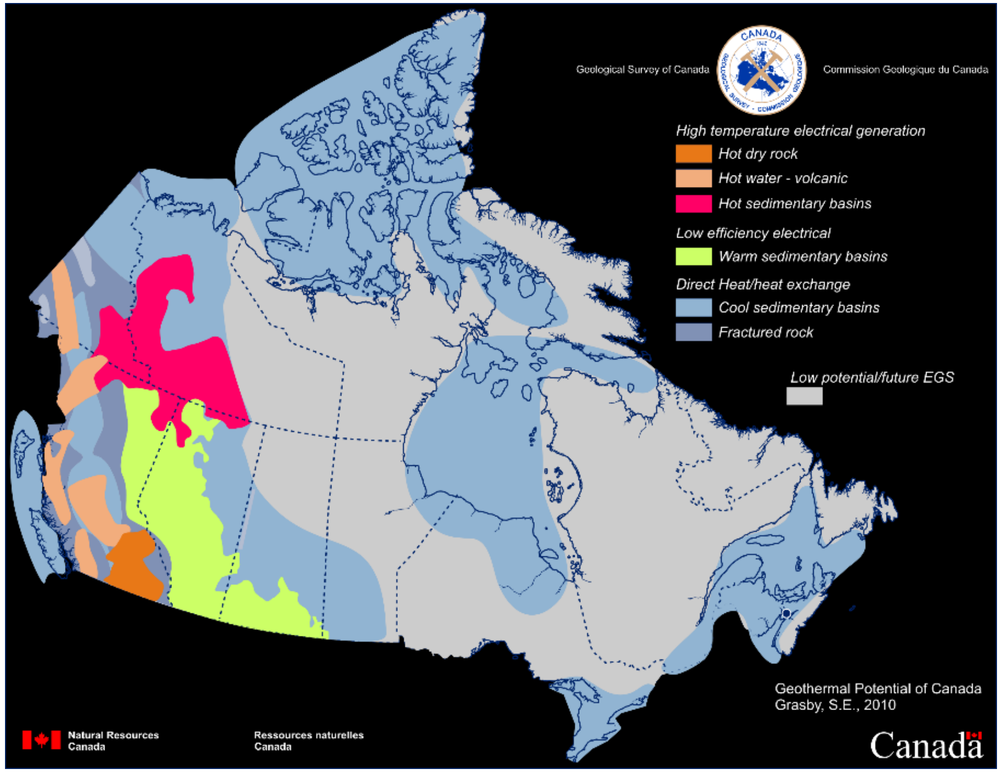
Economic factors: Electrical generation



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From exploration to power production

Mariposa geothermal project, Maule, Chile

Svartsengi 75 MWe geothermal power plant

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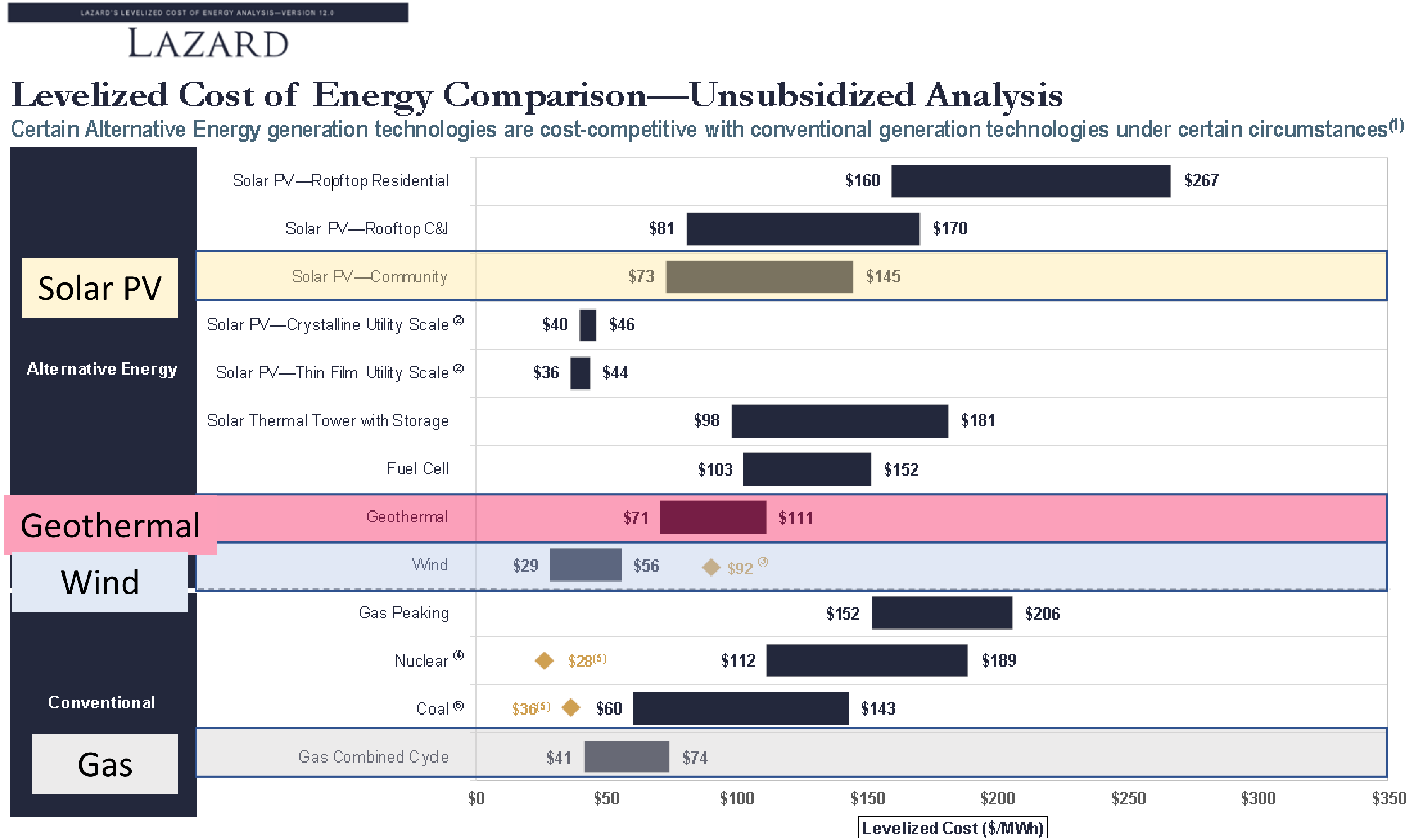
Levelized cost of electricity



Lazard – US based analysis released November 2018

$USD 73 - 145	Solar PV
$USD 71 - 111	Geothermal
$USD 29 - 56	Wind
$USD 41 - 74	Gas

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Levelized cost of electricity

LAZARD'S LEVELIZED COST OF ENERGY ANALYSIS—VERSION 12.0

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Geothermal result: $USD 71 - 111

US based analysis that does not include the following factors that could have a significant effect on the results, but have not been examined in the scope of this analysis. These additional factors, among others, could include: import tariffs; capacity value vs. energy value; stranded costs related to distributed generation or otherwise; network upgrade, transmission, congestion or other integration-related costs; significant permitting or other development costs, unless otherwise noted; and costs of complying with various environmental regulations (e.g., carbon emissions offsets or emissions control systems). This analysis also does not address potential social and environmental externalities, including, for example, the social costs and rate consequences for those who cannot afford distributed generation solutions, as well as the long-term residual and societal consequences of various conventional generation technologies that are difficult to measure (e.g., nuclear waste disposal, airborne pollutants, greenhouse gases, etc.)

Lazard – Levelized cost of energy analysis, version 12.0 2018

Levelized cost of electricity - Geoscience BC 2015-11 report

Lazard: Geothermal result: $USD 71 - 111

2. Levelized Cost of Electricity

   a. This revised report corrects the values in the depreciation schedule which is an input to GETEM. The resulting LCOEs for the favourable sites are materially different from the LCOEs previously presented;

   b. Based on the GETEM analysis, the LCOE from Table 6-1 for the favourable sites at a 5% discount rate ranges from 11.5 CAD¢/kWh for Pebble Creek to 29.7 CAD¢/kWh for Clarke Lake. The LCOE for the Jedney Area and for Clarke Lake at 5 MW (both added at the direction of Geoscience BC) are 39.8 CAD¢/kWh and 33.2 CAD¢/kWh respectively. A geothermal supply curve reflecting these results for the favourable sites is shown in Figure 7-1;

   c. Although GETEM is a complex tool and US-focused, it has the capability to permit the input of specific values reflecting British Columbia conditions. Where sufficient information was available to estimate specific parameters (such as costs for power lines and roads), these parameters were included as input to GETEM. Otherwise, default parameters, internal to the GETEM program, were used; and

   d. The cost of drilling wells during the various phases of a geothermal project has a significant impact on the LCOE, as demonstrated by sensitivity analysis of drilling costs for Pebble Creek and Sloquet Creek (Table 6-4). The LCOEs for Pebble Creek (with a base LCOE of 11.5 CAD ¢/kWh) are 7.8 and 15.2 CAD ¢/kWh, reflecting drilling costs of 50% and 150% of base case, respectively. Similarly, the LCOEs for Sloquet Creek (with a base LCOE of 21.8 CAD ¢/kWh) are 15.7 and 27.7 CAD ¢/kWh, reflecting drilling costs of 50% and 150% of base case, respectively.

Levelized cost of electricity- Geoscience BC 2015-11 report

Lazard: Geothermal result: $USD 71 – 111
2015-11 $CDN 29.7 – 39.8

Table E1-1: Results of Volumetric Assessment and Economic (GETEM) Analysis

Geothermal Prospect Site/Area	Plant Type	Initial MW estimate (GDDM)	MW (gross) at 90% probability from Vol.Est.	MW (net) : Parasitic = 10% for Flash 25% for Binary	Levelized Cost of Electricity* (CAN¢/kWh) Discount Rate 5%
Canoe Creek – Valemount	Flash	15	14.3	12.9	26.8
Clarke Lake	Binary	34	18.4	13.8	29.7
Clarke Lake (5 MW scenario)	Binary	5	-	3.8	33.2
Jedney Area	Binary	15	12.2	9.2	39.8
Kootenay	Binary	20	19.9	14.9	22.8
Lakelse Lake	Binary	20	19.6	14.7	23.4
Lower Arrow Lake	Binary	20	19.6	14.7	23.7
Meager Creek (Pebble Creek volume assumed equivalent)**	Flash	100-200 total (50-100 ea)	198.0 combined (99.0 ea)	178.2 combined 89.1 (ea)	11.7
Mt. Cayley	Binary	50	40.7	30.5	17.3
Okanagan	Binary	20	18.3	13.7	24.1
Sloquet Creek	Binary	10	10	7.5	21.8

* These LCOEs have been revised from the previous versions of this report to correct the values used for the depreciation schedule in GETEM (Lines 32 to 37 of Table V-1)
** Pebble Creek transmission and infrastructure costs are significantly less than those at Meager Creek, resulting in a lower LCOE value for Pebble Creek (11.5 CAN¢/kWh).

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Levelized cost of electricity: Geoscience BC 2015-11 report

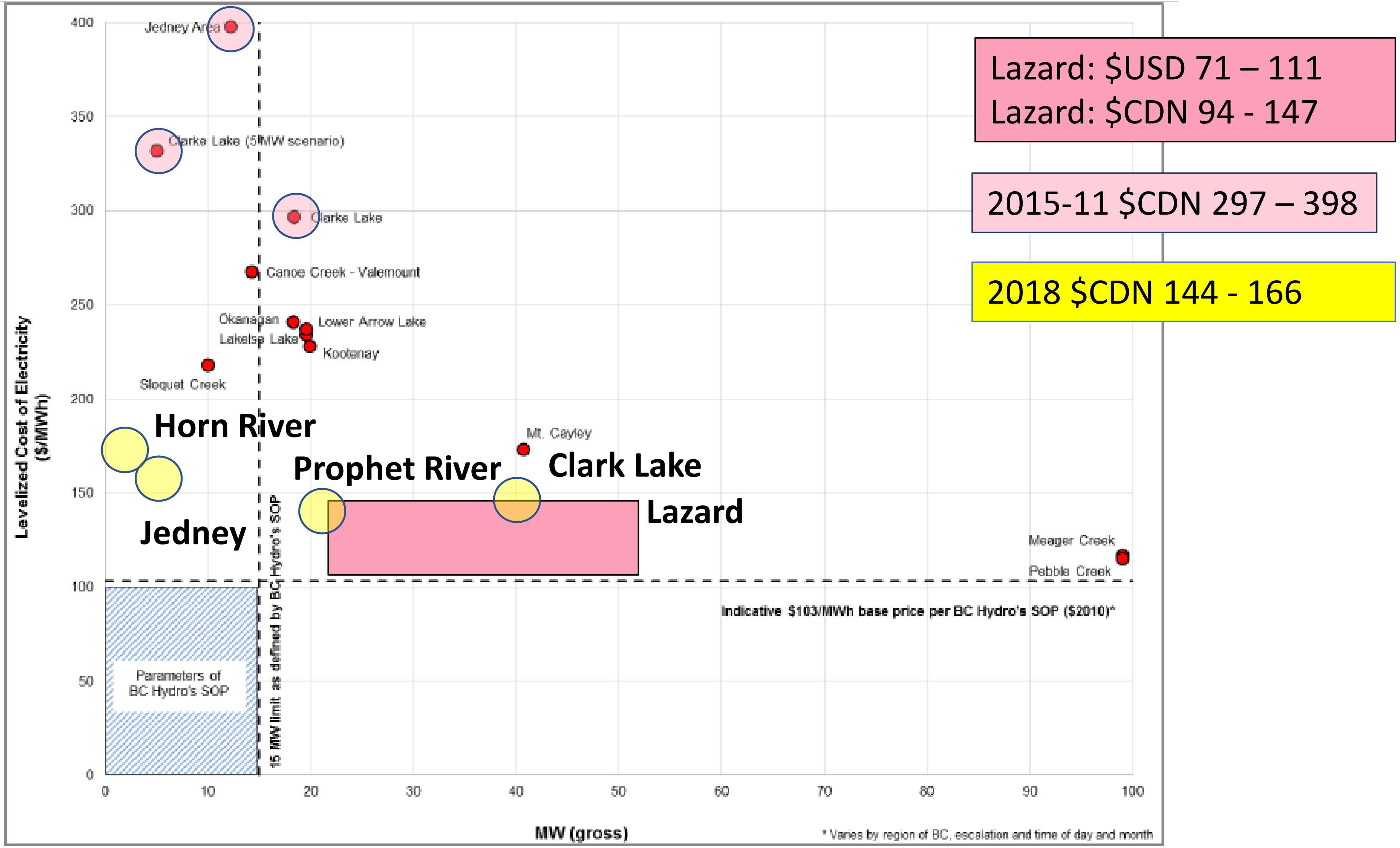

Figure E1-3: Geothermal Sites – LCOE vs Capacity

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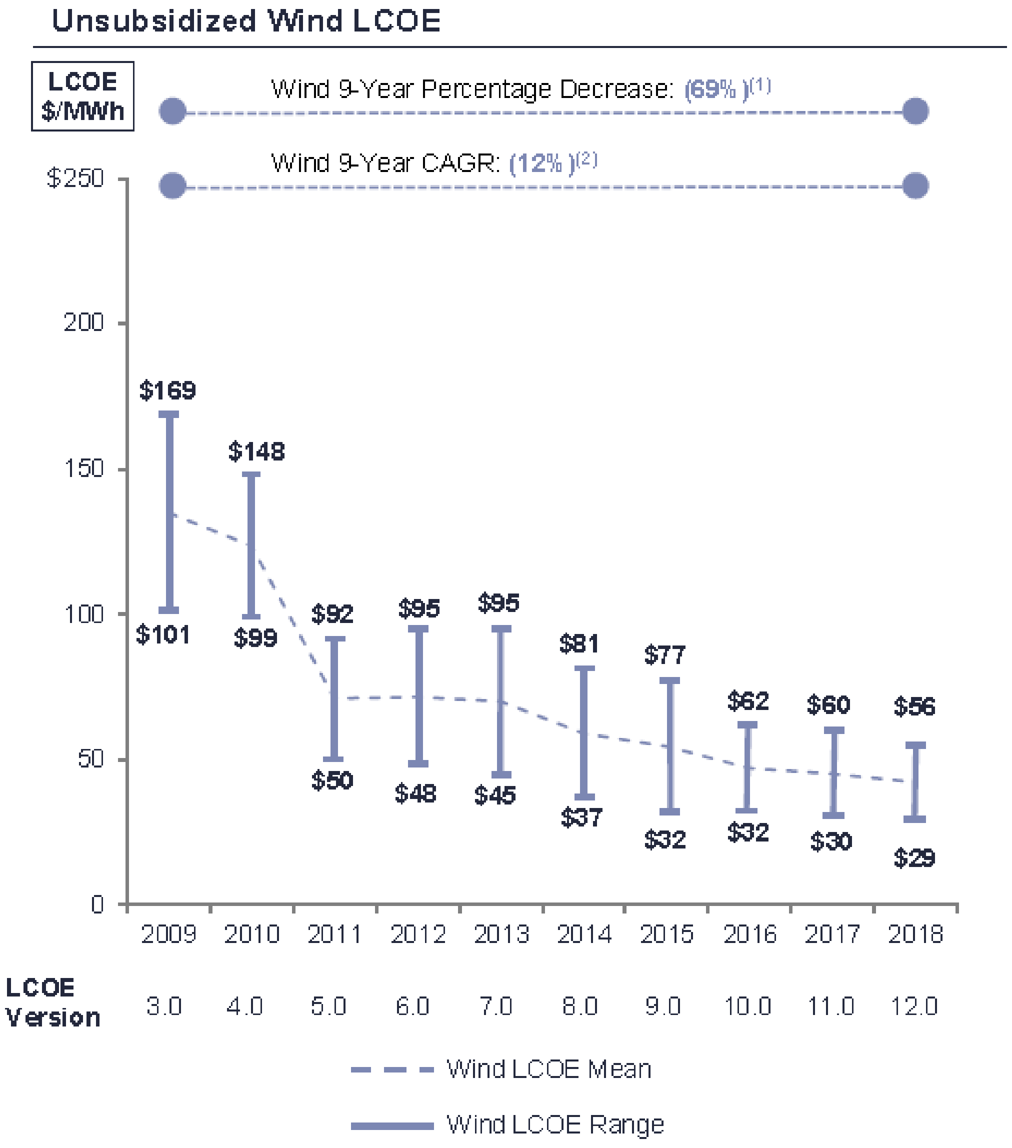
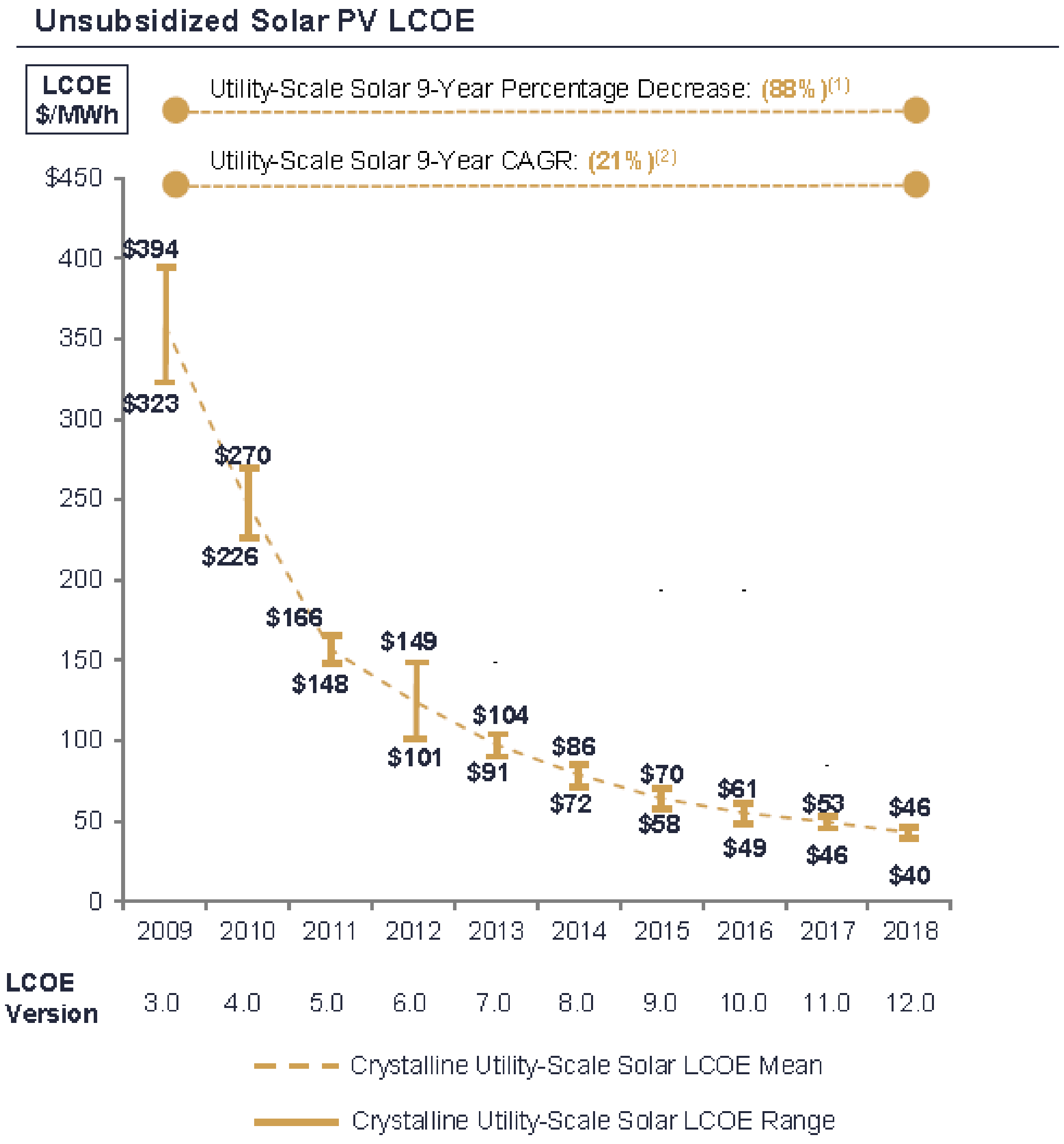
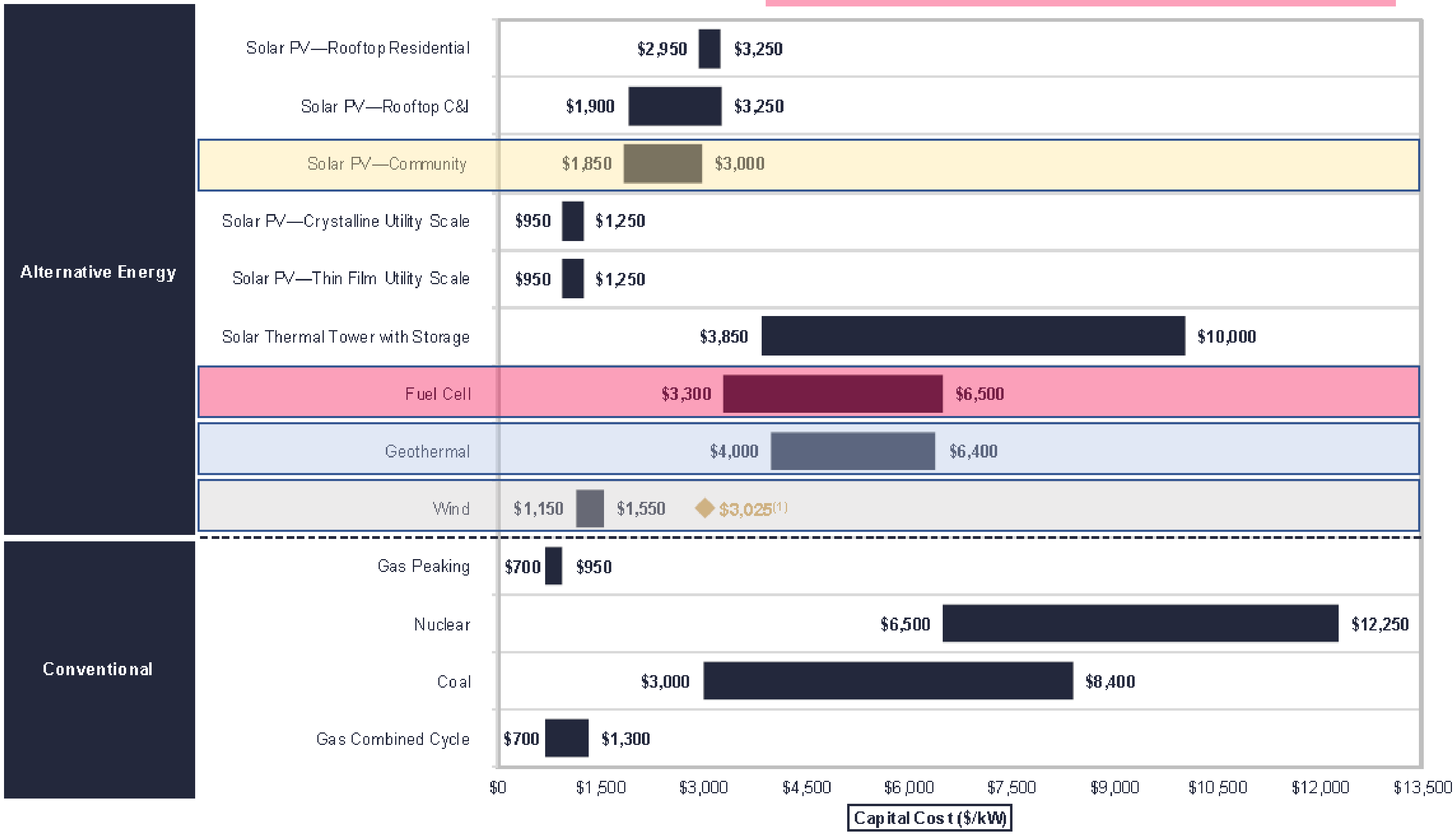




Levelized cost of electricity: CAPEX

Geothermal result: $USD $4M – 6.5M



Capital Cost Comparison
While capital costs for a number of Alternative Energy generation technologies are currently in excess of some conventional generation technologies, declining costs for many Alternative Energy generation technologies, coupled with uncertain long-term fuel costs for conventional generation technologies, are working to close formerly wide gaps in LCOE values

LAZARD'S LEVELIZED COST OF ENERGY ANALYSIS—VERSION 12.0
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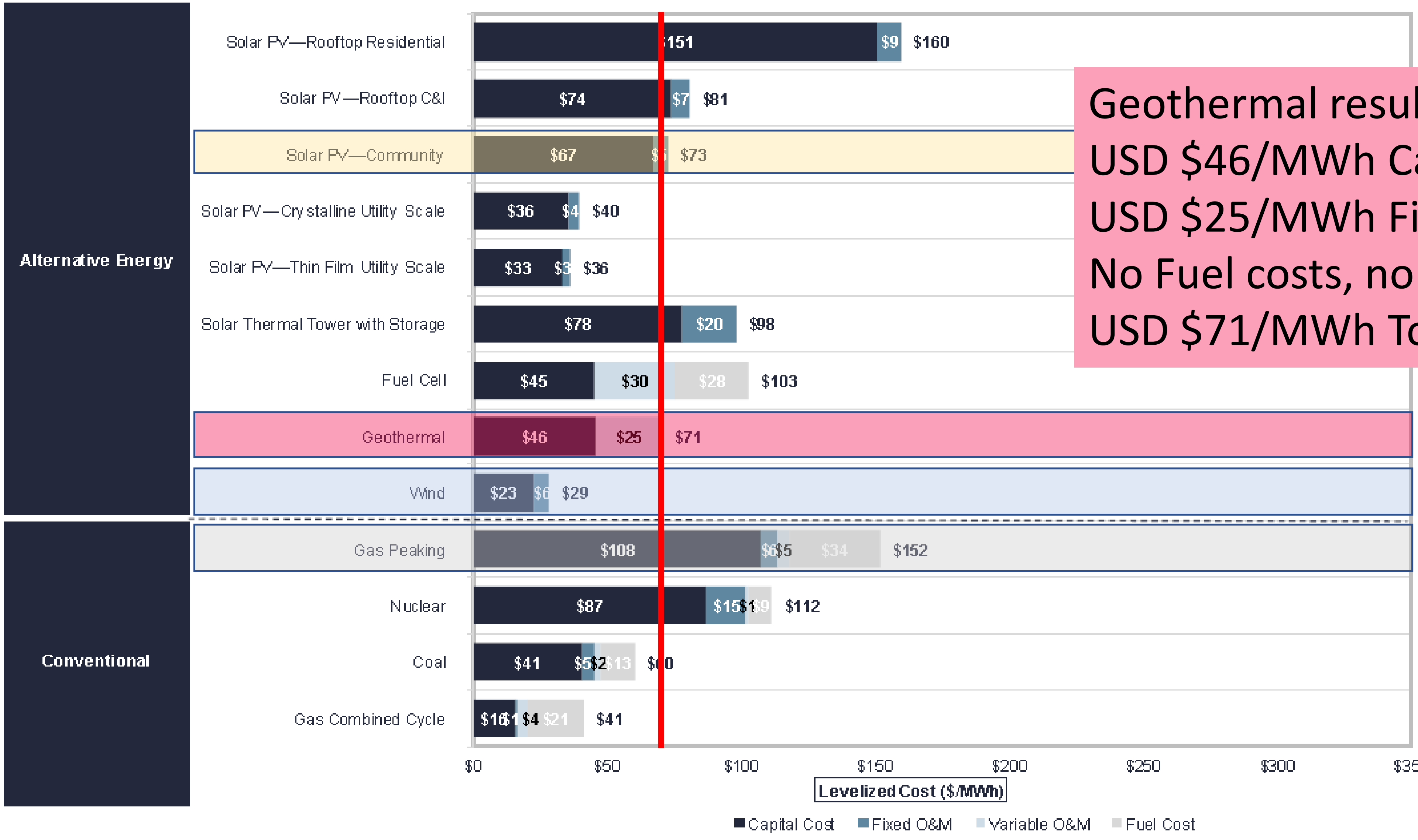
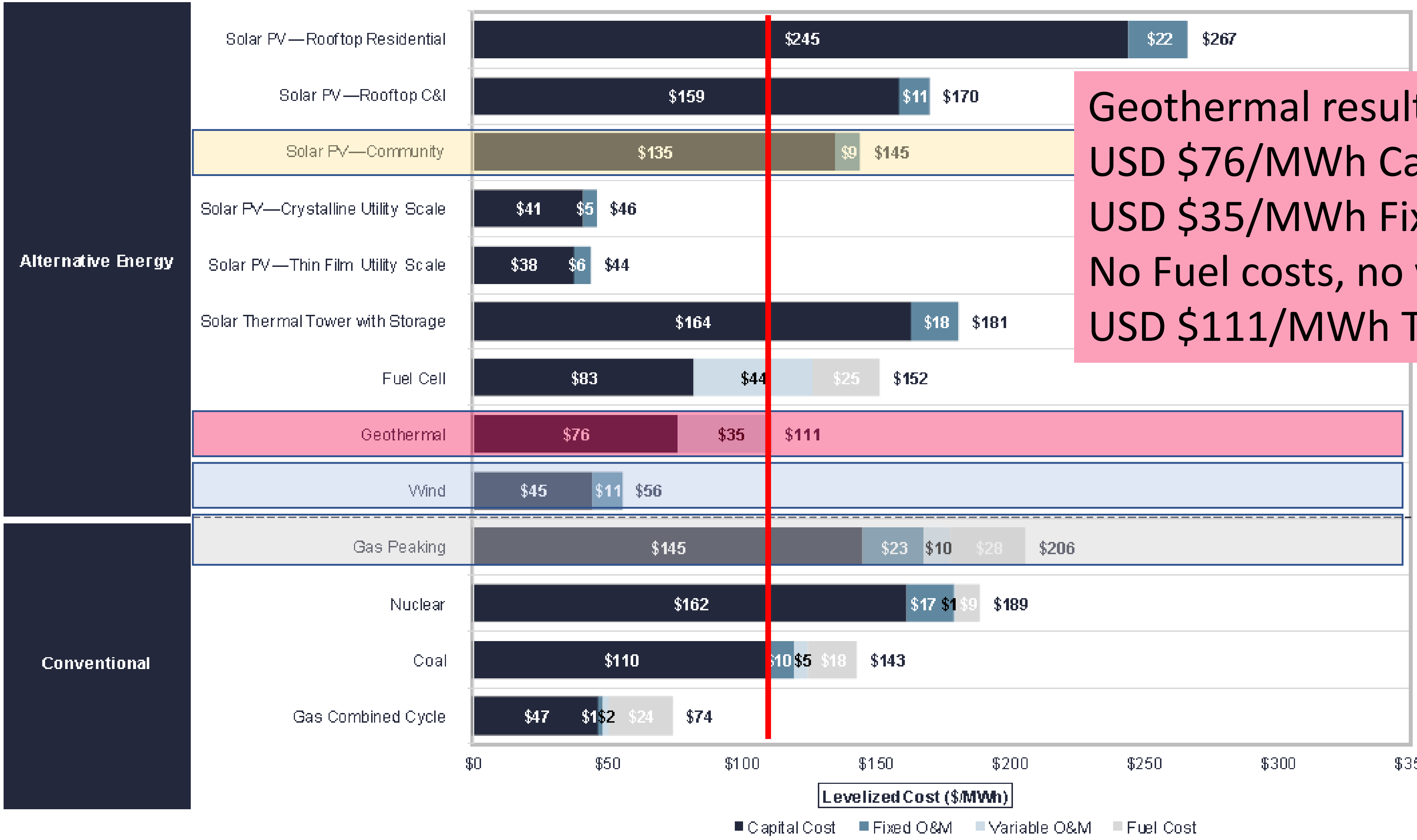
Levelized Cost of Electricity Components—Low End



Geothermal result (low end):
USD $46/MWh Capital costs
USD $25/MWh Fixed O&M
No Fuel costs, no variable O&M
USD $71/MWh Total

Levelized Cost of Electricity Components—High End



Geothermal result (high end):
USD $76/MWh Capital costs
USD $35/MWh Fixed O&M
No Fuel costs, no variable O&M
USD $111/MWh Total

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Energy Resources—Matrix of Applications

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		Carbon Neutral/ REC Potential	Location			Dispatch			
			Distributed	Centralized	Geography	Intermittent	Peaking	Load-Following	Base-Load
Alternative Energy	Solar PV[1]	✓	✓	✓	Universal[2]	✓	✓		
	Solar Thermal	✓		✓	Varies	✓	✓	✓	
	Fuel Cell	✗	✓		Universal				✓
	Geothermal	✓		✓	Varies				✓
	Onshore Wind	✓		✓	Varies	✓			
Conventional	Gas Peaking	✗	✓	✓	Universal		✓	✓	
	Nuclear	✓		✓	Rural				✓
	Coal	✗[3]		✓	Co-located or rural				✓
	Gas Combined Cycle	✗		✓	Universal			✓	✓

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Levelized cost of electricity – key assumptions

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	Units	Solar Thermal Tower with Storage	Fuel Cell	Geothermal	Wind—Onshore	Wind—Offshore
Net Facility Output	MW	135 – 110	2.4	20 – 50	150	210 – 385
Total Capital Cost [1]	$/kW	$3,850 – $10,000	$3,300 – $6,500	$4,000 – $6,400	$1,150 – $1,550	$2,250 – $3,800
Fixed O&M	$/kW-yr	$75.00 – $80.00	—	—	$28.00 – $36.50	$80.00 – $110.00
Variable O&M	$/MWh	—	$30.00 – $44.00	$25.00 – $35.00	—	—
Heat Rate	Btu/kWh	—	8,027 – 7,260	—	—	—
Capacity Factor	%	43% – 52%	95%	90% – 85%	55% – 38%	55% – 45%
Fuel Price	$/MMBtu	—	3.45	—	—	—
Construction Time	Months	36	3	36	12	12
Facility Life	Years	35	20	25	20	20
Levelized Cost of Energy	$/MWh	$98 – $181	$103 – $152	$71 – $111	$29 – $56	$62 – $121

Levelized cost of electricity – key assumptions Geothermal

LAZARD'S LEVELIZED COST OF ENERGY ANALYSIS—VERSION 12.0

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Net output facility: 20 – 50 MWe
Total Capital Cost: $USD 4 - 6.4 million
Fixed O&M: n/a
Variable O&M: $USD 0.25 – 0.35 million
Heat Rate: n/a
Capacity Factor: 90 – 85%
Fuel Price: n/a
Construction time: 36 months
Facility Life: 25 years
Levelized cost of Energy: $USD 71 – 111 MWh

Where are there additional economic savings and/or advantages?

- Value of thermal energy
- Facility Life
- Capacity Factor

Lazard Geothermal result
USD $46 - 76/MWh Capital costs
USD $25-35/MWh Fixed O&M
No Fuel costs, no variable O&M
USD $71 – 111 /MWh Total

Levelized cost of electricity

LAZARD'S LEVELIZED COST OF ENERGY ANALYSIS—VERSION 12.0

LAZARD

Lazard has **not manipulated capital costs or capital structure for various technologies**, as the goal of the study was to compare the **current state of various generation technologies**, rather than the benefits of financial engineering. The results contained in this study would be altered by different assumptions regarding capital structure (e.g., **increased use of leverage**) or capital costs (e.g., a **willingness to accept lower returns than those assumed herein**).

Key sensitivities examined included **fuel costs and tax subsidies**. Other factors would also have a potentially significant effect on the results contained herein, but have not been examined in the scope of this current analysis. These additional factors, among others, could include: import tariffs; capacity value vs. energy value; stranded costs related to distributed generation or otherwise; network upgrade, transmission, congestion or other integration-related costs; significant permitting or other development costs, unless otherwise noted; and costs of complying with various environmental regulations (e.g., carbon emissions offsets or emissions control systems). This analysis also does not address potential social and environmental externalities, including, for example, the social costs and rate consequences for those who cannot afford distribution generation solutions, as well as the long-term residual and societal consequences of various conventional generation technologies that are difficult to measure (e.g., nuclear waste disposal, airborne pollutants, greenhouse gases, etc.).

Levelized cost of electricity

Levelized Cost of Energy Comparison—Historical Alternative Energy LCOE

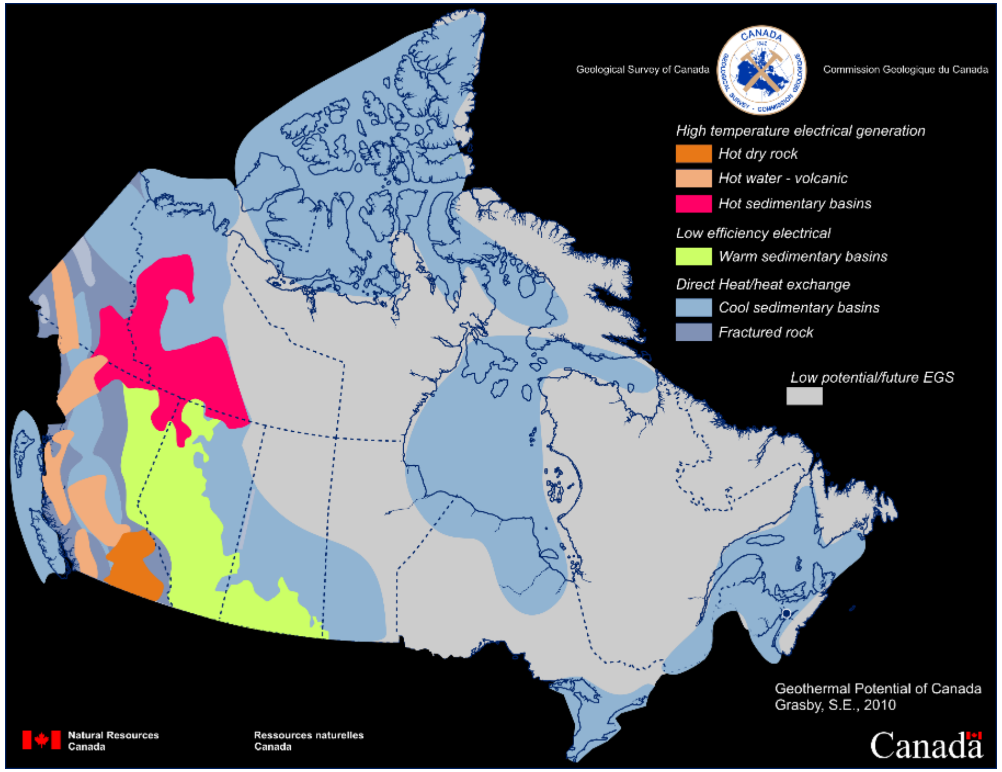
Declines

In light of material declines in the pricing of system components (e.g., panels, inverters, turbines, etc.) and improvements in efficiency, among other factors, **wind and utility-scale solar PV have seen dramatic historical LCOE declines**; however, over the past several years the rate of such LCOE declines have started to flatten

Capital Cost Comparison

While **capital costs for a number of Alternative Energy generation technologies are currently in excess** of some conventional generation technologies, declining costs for many Alternative Energy generation technologies, coupled with **uncertain long-term fuel costs** for conventional generation technologies, are working to close formerly wide gaps in LCOE values

Economic factors: Direct use



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Economic Considerations

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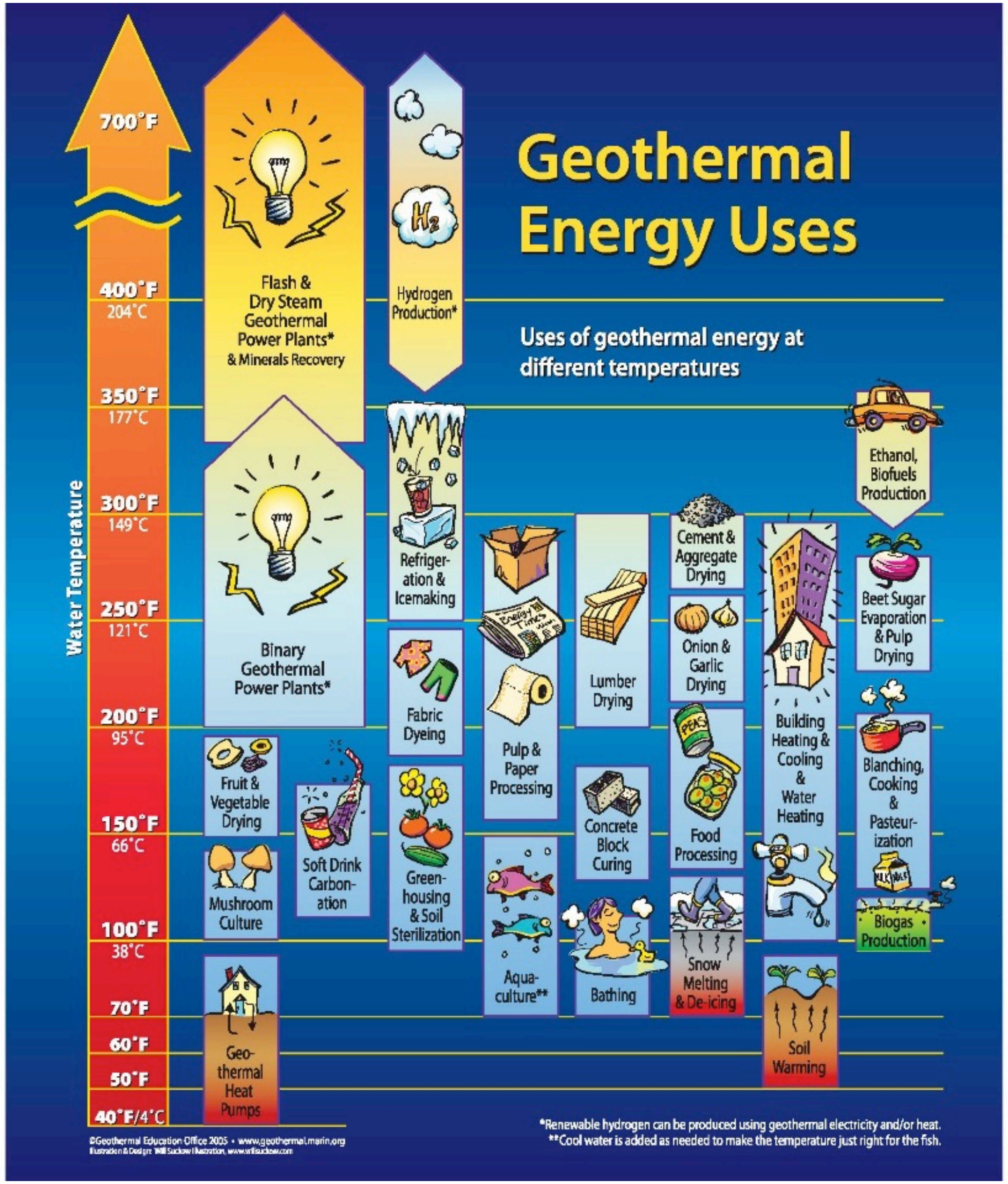
3. Electrical Generation income - PPA
4. **Direct-use income – thermal**
5. Carbon Off-set income – thermal and electrical

Direct use energy applications

One of the key factors missing from economic evaluations is “credit” for direct use energy applications. As it is more difficult to transport the power long distances, a local “load” is required to make economic use of the energy.



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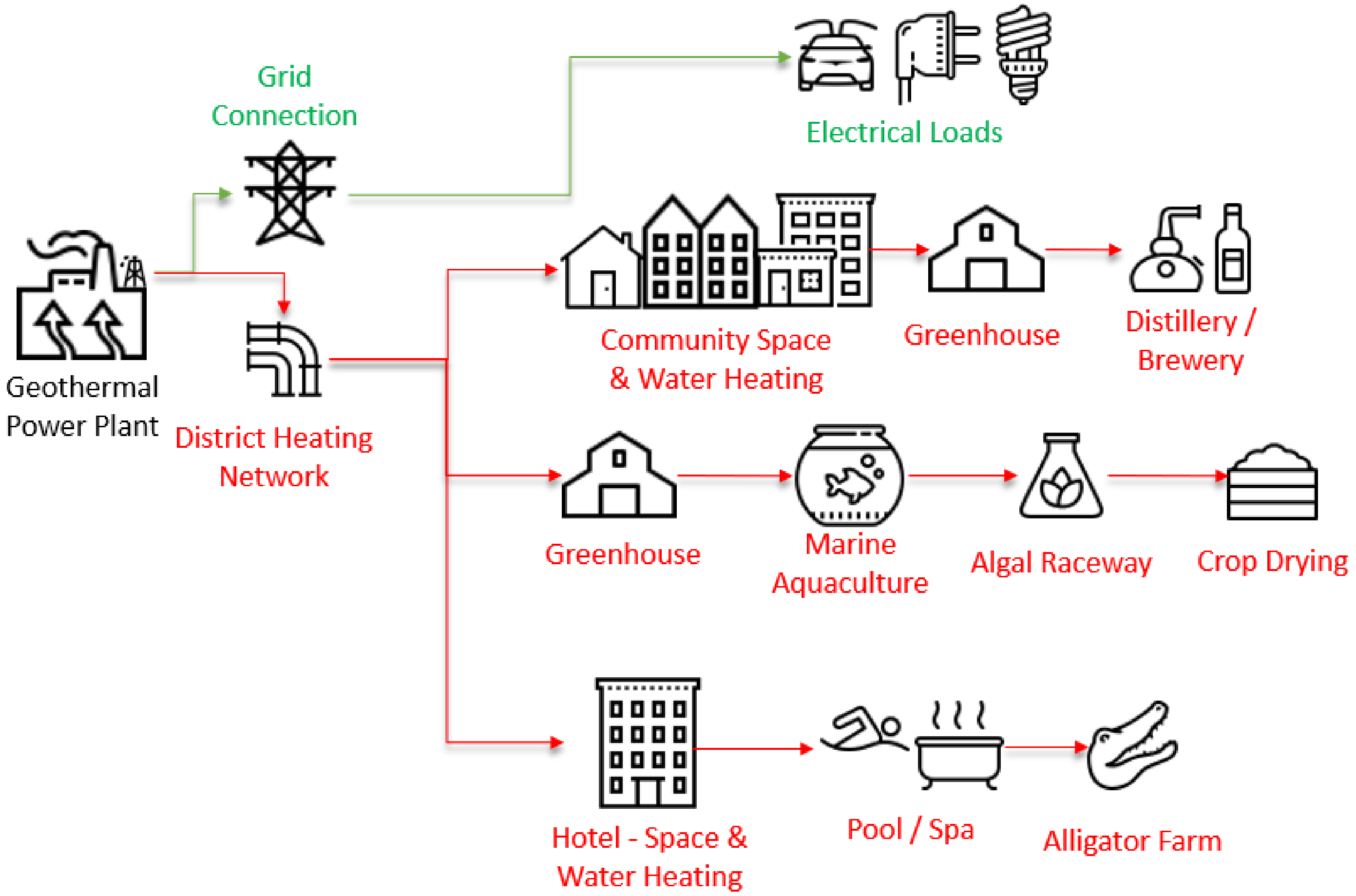
Direct use energy applications



Cascade Pathways:

Community Pathway

Agriculture Pathway

Food security for northern communities.

Tourism Pathway

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Direct use energy applications – value of heat energy

After the geothermal fluids have been utilized in the ORC generation facility, the geothermal facility will produce approximately 143.95 GJ/hour of usable thermal energy from the discharged warm geoth ermal fluids. As can be seen in estimates in this table, selling this supplementary waste heat to users at the same value of current natural gas p rices ($2.25/GJ in April 2018) would equate to $ 2.27 million annually and $1.5 million in GHG offsets annually.

Plant cost is 8,000,000 euros

Economic Value of Waste Heat and Offsets		
Waste Heat for Utilization	143.95	GJ/hour
Hours / Annually	8760	
Plant Capacity Factor	80%	
Hours of heat production	7008	
Annual Heat Production	1,008,801.60	GJ
Price of Natural Gas	$ 2.25	GJ
Annual Heat Sale Revenue	$ 2,269,803.60	
Carbon Intensity of Natural Gas	56	kg CO2/GJ
GHG offset from geothermal heat	56,492,889.60	kg
	56,492.89	tonne
Carbon Tax Rate	$30	tonne
Sale of offset (discounted)	90%	
Value of Offset Sale Annually	$1,525,308.02	
Economic Value of Waste Heat & Offsets	$3,795,111.62	Annually

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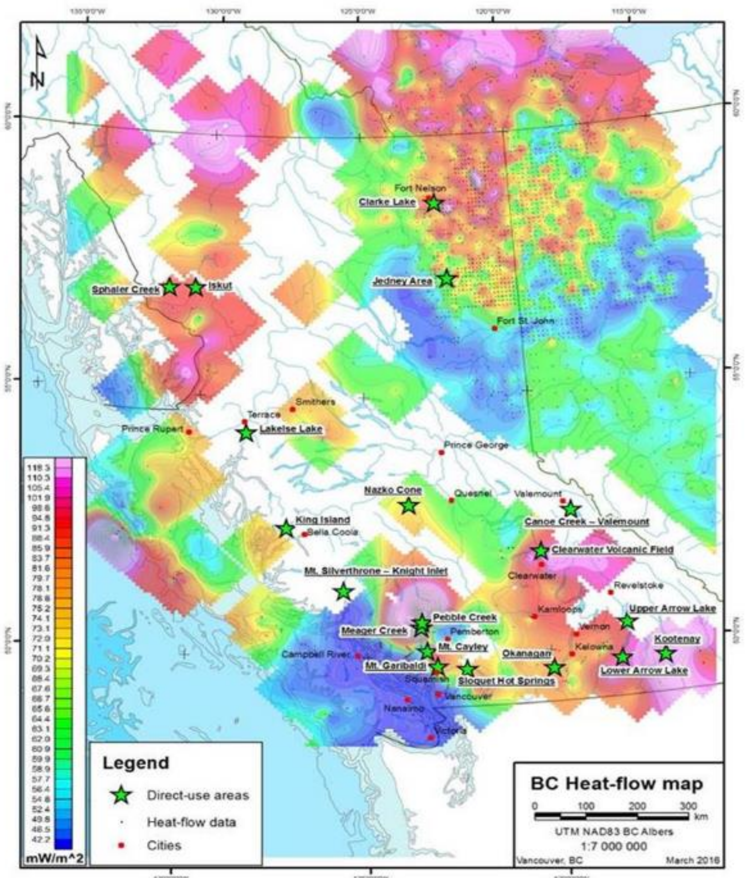
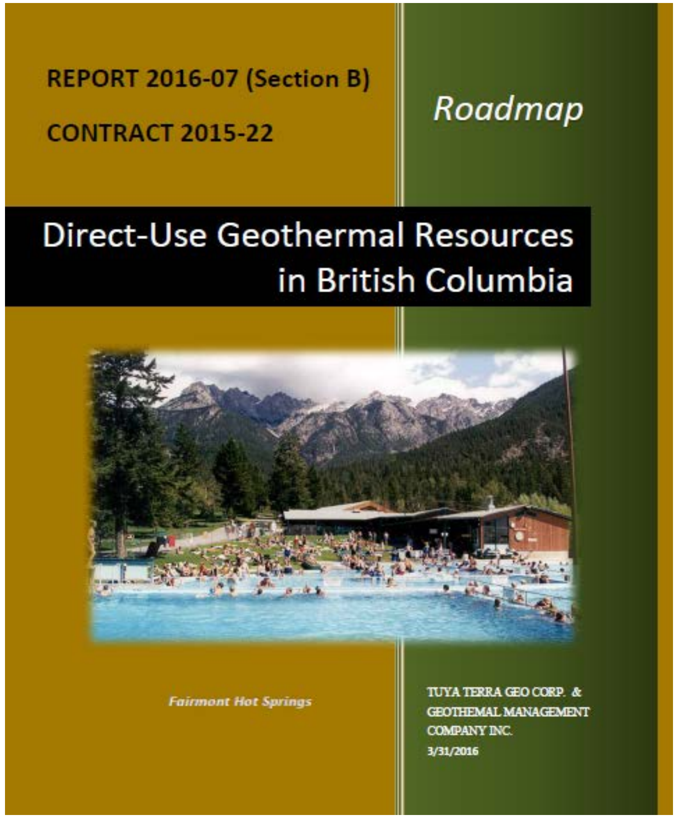
Recent focus on Direct-Use Geothermal Resources in British Columbia



Heat flow map by J. Majorowicz, U of Alberta

Low to moderate temperature resource inventory

- 63 communities contacted, primarily in remote areas
- Most communities not aware of technologies for direct geothermal use
- Roadmap for development as a guide book for communities.



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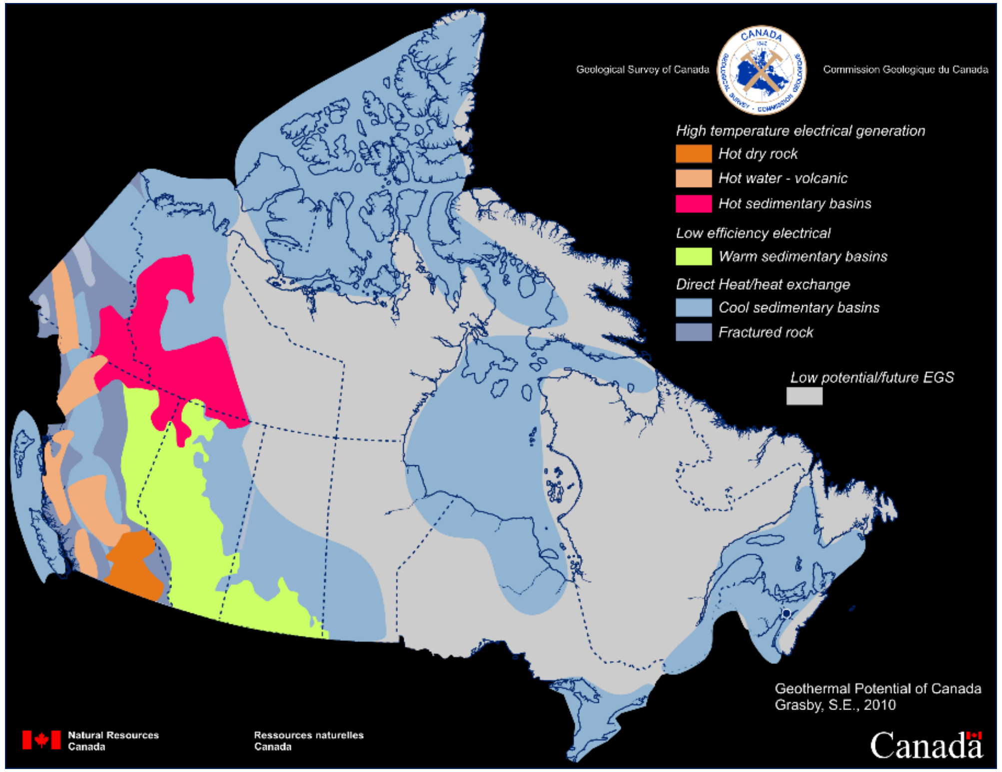
Economic factors: Carbon offsets



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Initial Production Estimates and GHG Avoidance Potential

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Value of Offset Sale Annually	$1,525,308.02	
Economic Value of Waste Heat & Offsets	$3,795,111.62	Annually

Annual Electricity Production: Net (AP_{net})
Ap_{net}=($Capacity_{net}$* Hr_{annual})*$C_{apacity}F_{actor}$
Ap_{net} = (5 MW * 8760hr)*0.8 = 35,040 MWh/yr = 35.04 GWh/yr

Grid Displacement Factor for 2022 and 2031
G_{rid} $D_{isplacement}$ F_{actor} (tCO_2e/MWh)$_{2022}$ = GDF_{2018} – 5% = 0.59tCO_2e -0.0295 = 0.56tCO_2e
GDF_{2031} = GDF_{2022} – 20% = 0.56tCO_2e – 0.112 = 0.45tCO_2e

Annual GHG Reduction
$GHG_{reduction}$= AP_{net}*$G_{rid}D_{isplacement}F_{actor}$($tCO_2e$/MWh)$_{2022}$
$GHG_{reduction}$ = 35,040 MWh * 0.56tCO_2e = 19,622.4 tCO_2e = 0.0196 $MtCO_2e$

Facility Lifespan (35 Years) GHG Reductions	
$GHG_{reduction(2022-2030)}$= ($AP_{net}$*$9_{yr}$)* GDF_{2022}	= (35,040*9)*0.56tCO_2e = 176,601.6 tCO_2e = 0.1766 $MtCO_2e$
$GHG_{reduction(2031-2057)}$ = (AP_{net}*26_{yr}) * GDF_{2030}	= (35,040*26)*0.45tCO_2e = 409,968 tCO_2e = 0.4100 $MtCO_2e$
$GHG_{reductions(total)}$ = $GHG_{reduction(2023-2030)}$ + $GHG_{reduction}$ (2031-2057)	= 176,601.6 tCO_2e + 409,968 tCO_2e = 586,569.6 tCO_2e = 0.5866 $MtCO_2e$

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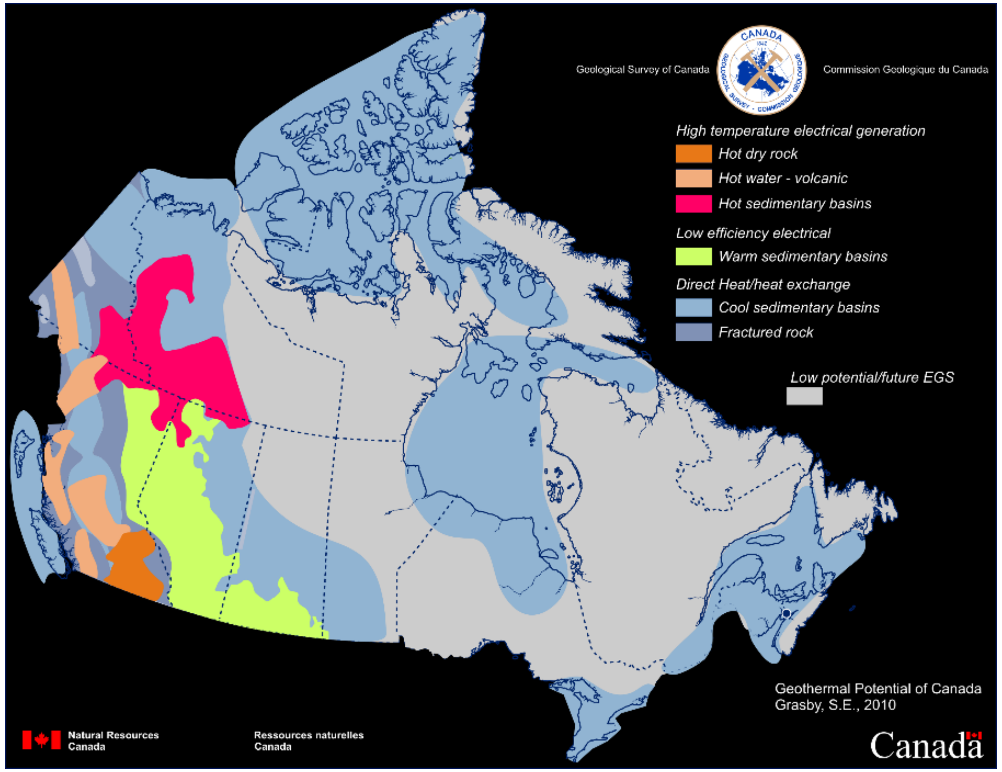
Key Economic factors



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Key factors for an economically viable project (1/2)

Key factors affecting project costs:

- Drilling costs (depth and size)
- Plant development cost (reservoir size and type – flash vs binary)
- Piping distances for Direct-use

Three key factors needing more work are:

- Reduce uncertainty regarding size of geothermal reservoirs
- Estimate achievable brine flow rates
- Determine the commercial value of heat

Ability to obtain, low cost financing that recognizes the risk profile of geothermal; high risk investment dollars to fund early stage projects.

Key factors for an economically viable project (2/2)

Economic viability:

- Price of electricity – how much is someone willing to pay?
- Ability to sell power.
- Price of thermal energy – what is the load and how much is it worth?
- Carbon offset credits
- cost of money

Power Purchase agreements must be available and provide incentives for dispatchable, base load power

Regulatory framework

Lack of long term vision and competition with solar, wind and natural gas generation.

GEOTHERMAL CANADA

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terrapin Heat Value Experts

Tuya Terra Geo Corp.

The role of Government

What is needed from government for geothermal development?

- Creating a regulatory framework for development, including PPAs
- Recognition that geothermal resources will fill the basic infrastructure needs of the north and support continued development and occupation of the land (sovereignty).
- Like bridges, roads and highways, geothermal energy must be considered “infrastructure” and the costs born across the tax payer base of Canada. “What is good for the north is good for the rest of Canada.”
- Projects in Finland, Sweden, Denmark and elsewhere are proving EGS technology; *Canada needs to get on-board and support geothermal.*

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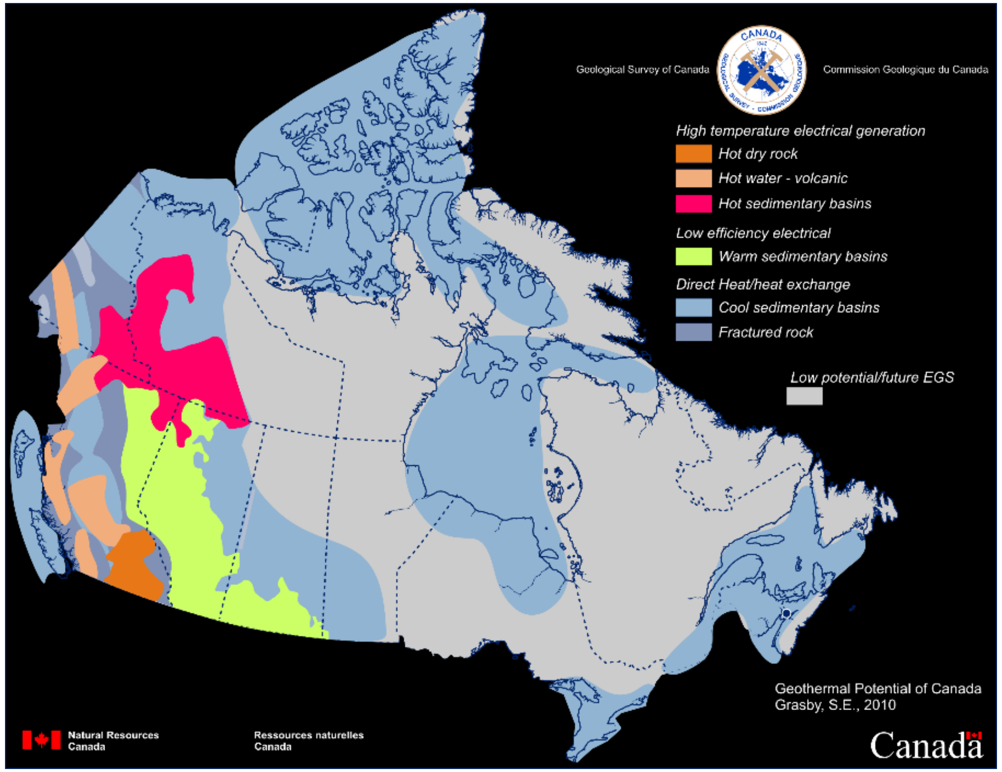
Thank you!



Canada's geothermal future!

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