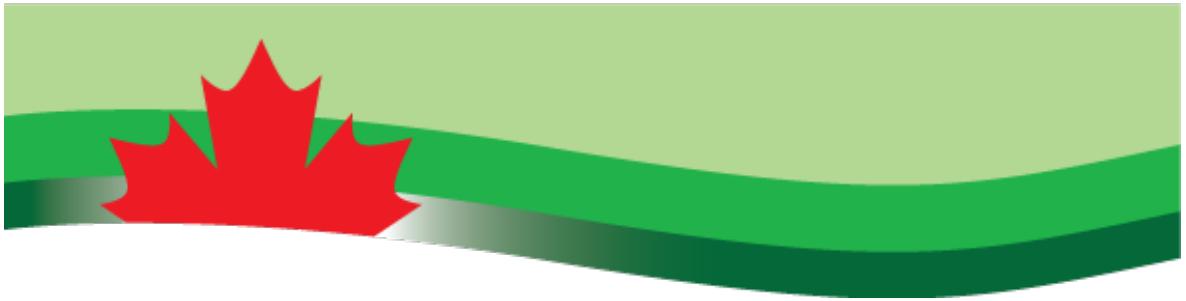
CanGEA

CANADIAN GEOTHERMAL ENERGY ASSOCIATION



What about Geothermal in Alberta?

AN INTRODUCTORY WORKSHOP TO GEOTHERMAL ENERGY, ITS BENEFITS, AND POTENTIAL APPLICATIONS FOR ALBERTA

Acknowledgments

This presentation was developed through the Community Energy Capacity Building Grant, administered through Energy Efficiency Alberta. Thank you!

Thanks to Community Futures West Yellowhead for support in organizing this leg of the series.

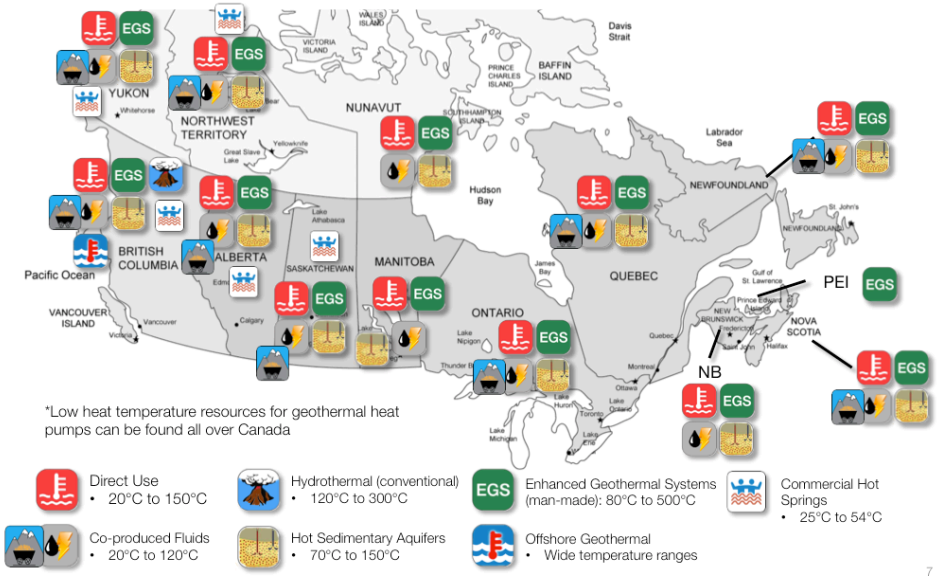
CanGEA would like to acknowledge that we are on Treaty 6 territory, and respects the histories, languages, and cultures of First Nations, Metis, Inuit, and all First Peoples of Canada, whose presence continues to enrich our vibrant community.

Who is CanGEA?

Canadian Geothermal Energy Association

Membership-Based Industry Association:

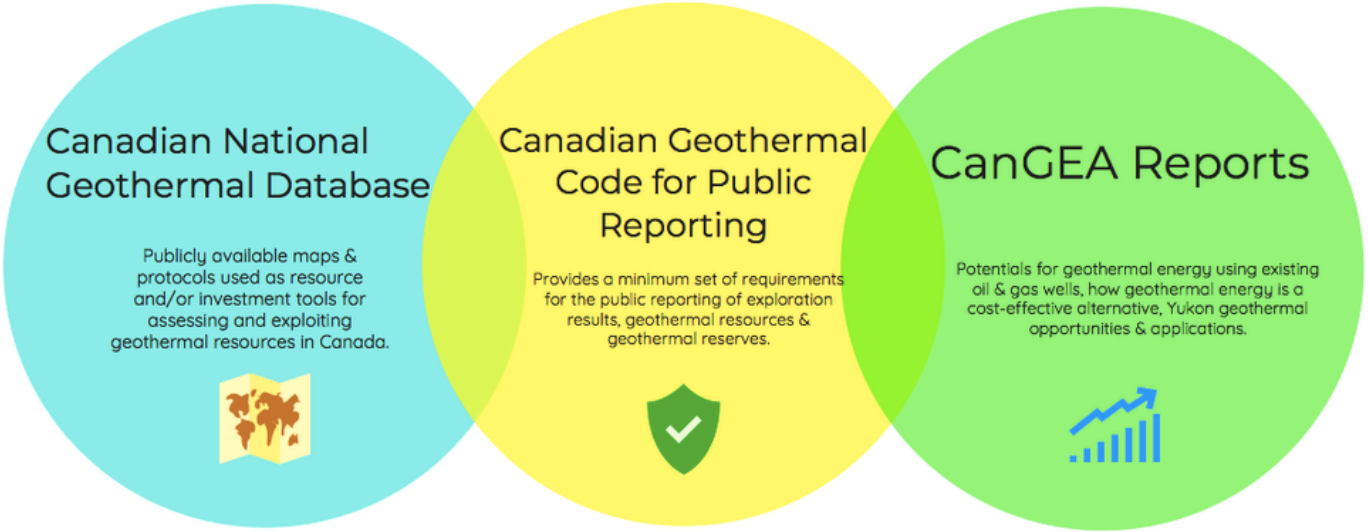
- Geothermal Developers & Support Services Companies
- Municipalities, Associations, Educational Institutions
- Individuals
- Ambassadors



"Accelerating Canadian exploration and development of geothermal resources in order to provide secure, clean and sustainable energy."

Our Role:

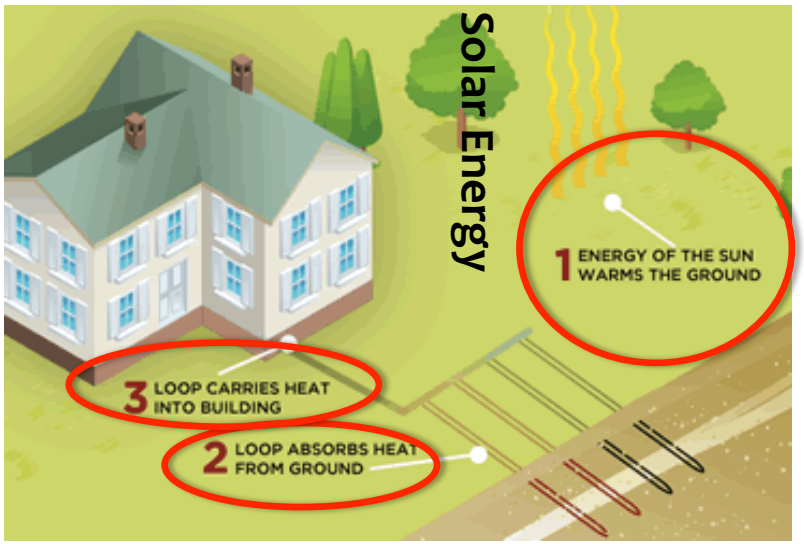
- Represent our member companies
- Public education and outreach
- Support and advocate for the Canadian geothermal industry
- Conduct Feasibility studies



What we don't do at CanGEA

- CanGEA is not involved in the development of low temperature shallow resources utilized for commercial and residential heating, ventilation and air condition systems
- These are usually referred to as geo-exchange or geothermal heat pump systems
- The Canadian GeoExchange Coalition represents this element of geothermal energy utilization and both organizations cooperate in promoting geothermal energy to Canadians

Canadian GeoExchange Coalition
Coalition canadienne de l'énergie géothermique



Service Providers

- Andrea Zaradic — Technical Advisor to NorthLeaf Capital Geothermal Renewable Energy Sector
- McLellan Energy Advisors
- Codeco Consulting (2000) Inc.
- Dewhurst Group — Energy Exploration Development
- Ausenco
- Fuzeium
- Borealis Geopower
- Dicorp — Down to Earth Business
- Marquee Land Services
- Quantec Geoscience
- Behr Integrated Solutions
- CastleRock
- Scovan — Forward Engineering
- Climeon
- Pioneer Petrotech Services Inc. — Proudly Canadian — ISO 9001 Certified
- C-FER Technologies
- Kitselas Geothermal Inc.
- Eolectric
- Mirarco Mining Innovation

Core Operations

- Takhini Hot Pools
- Borealis Geopower
- Eden Geopower Inc.
- E3 Metals Corp

Direct

- Takhini Hot Springs

Government

- Valemount, British Columbia
- Hinton — Gateway to the Rockies
- Cumberland Energy Authority
- ᖃᐅᓪᓚᖅ ᐆᒪᖅᑯᑎᓕᕆᔨᒃᑯᑦ ᑎᒥᖅᑯᑖ
- Qulliq Energy Corporation
- Société d'énergie Qulliq
- Qulliq Alruyaktuqtunik Ikumatjutiit
- Alberta Innovates Energy and Environment Solutions

Knowledge

- WISE — Waterloo Institute for Sustainable Energy
- Alberta Innovates Energy and Environment Solutions

Association

- The Natural Step
- Re|Source YYC
- energyfutureslab
- DEC — Decentralised Energy Canada
- OSEA — Ontario Sustainable Energy Association
- Leduc #1 Energy Discovery Centre
- British Columbia Sustainable Energy Association

Support

- Think Geoenergy
- Gaia Sustainable Geothermal Inc.

Individuals

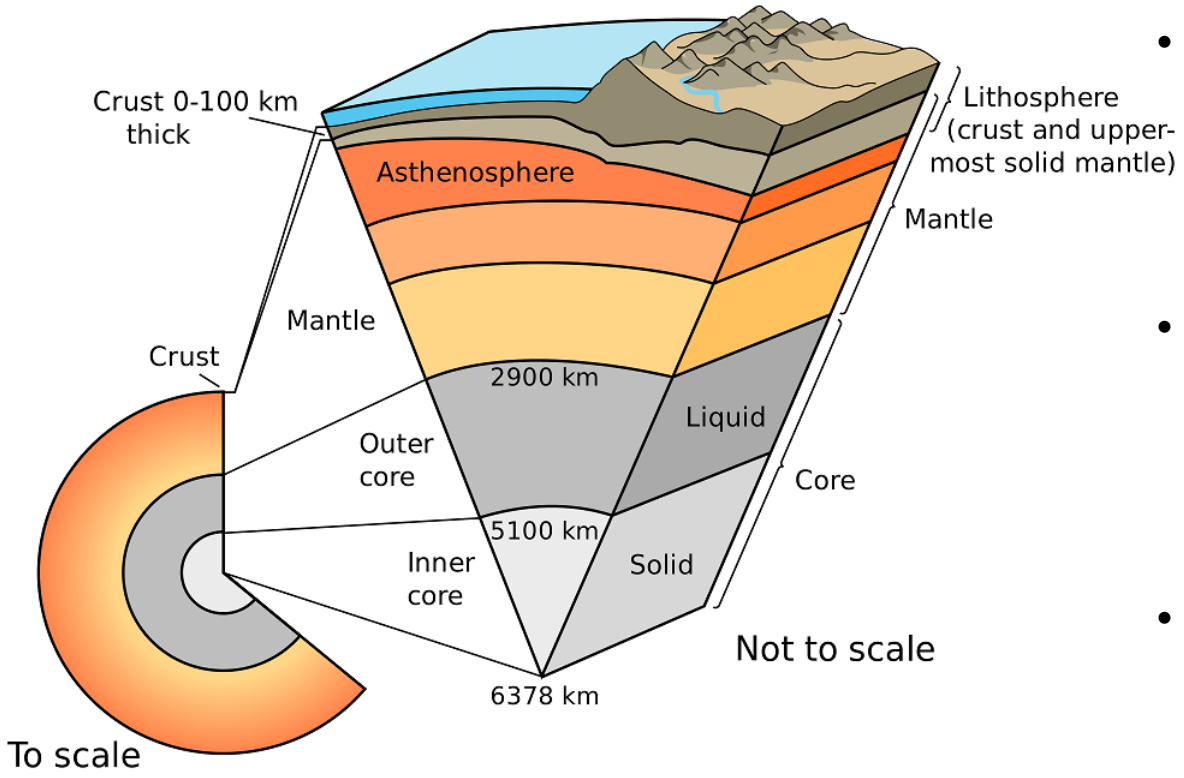
- Individual Members
- Student Members
- Senior Members

What is Geothermal Energy?

Geysers are one of the most commonly known sources of geothermal energy

Geothermal = Earth Heat

Why is the Earth hot?



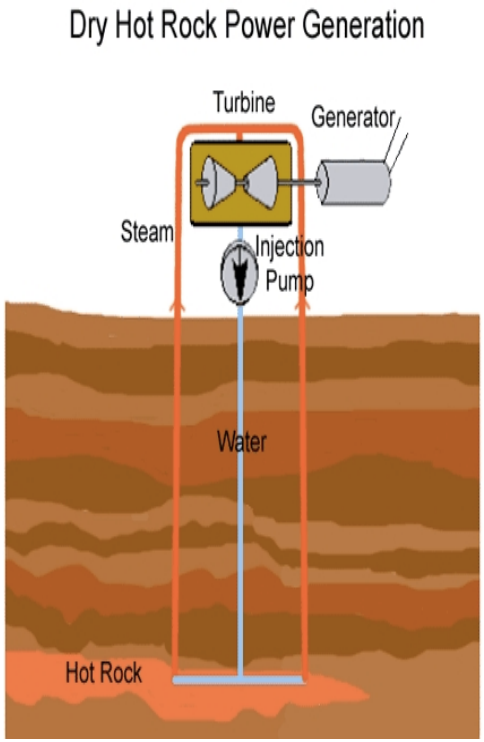
Pubs.usgs.gov

- Radiogenic Heat is the decay of naturally occurring radioactive elements in the Earth's crust
- In Alberta, the geothermal gradient ranges from a low of less than 10°C/km to a high of over 55°C/km
- Thermal gradient near Hinton >30°C/km
  - Anomaly in AB

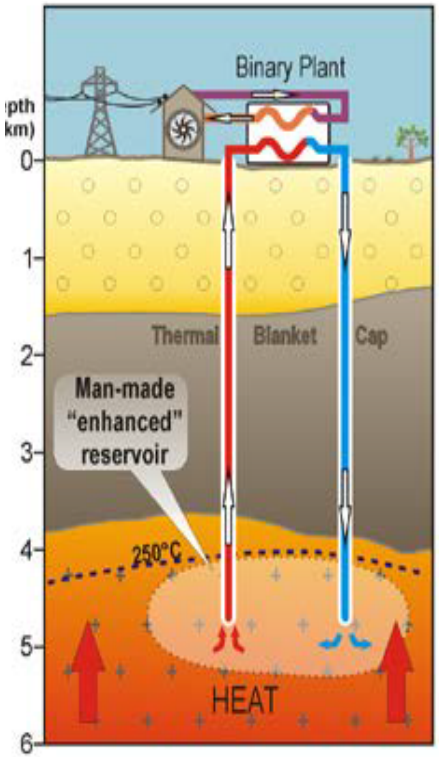
Types of Geothermal Resources

Anywhere

Hot Dry Rocks

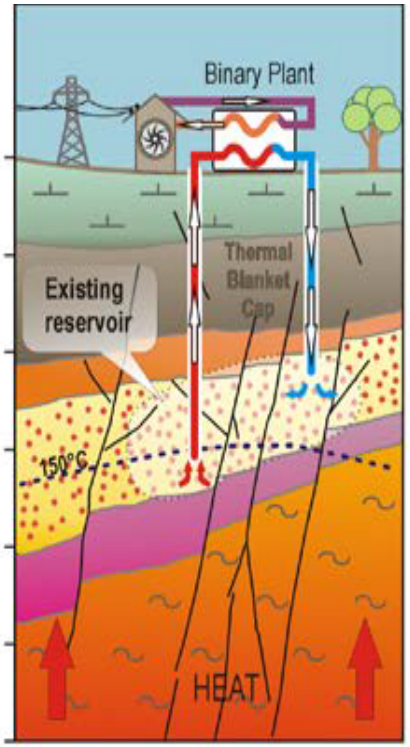


Enhanced Geothermal Systems



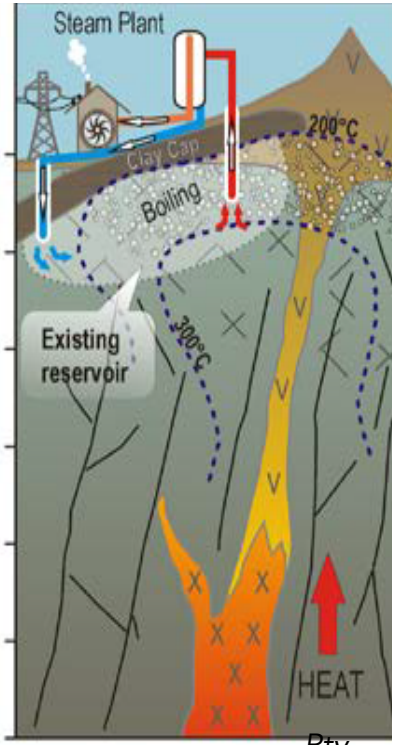
AB, SK, NE BC, YK

Hot/Warm Sedimentary Aquifers



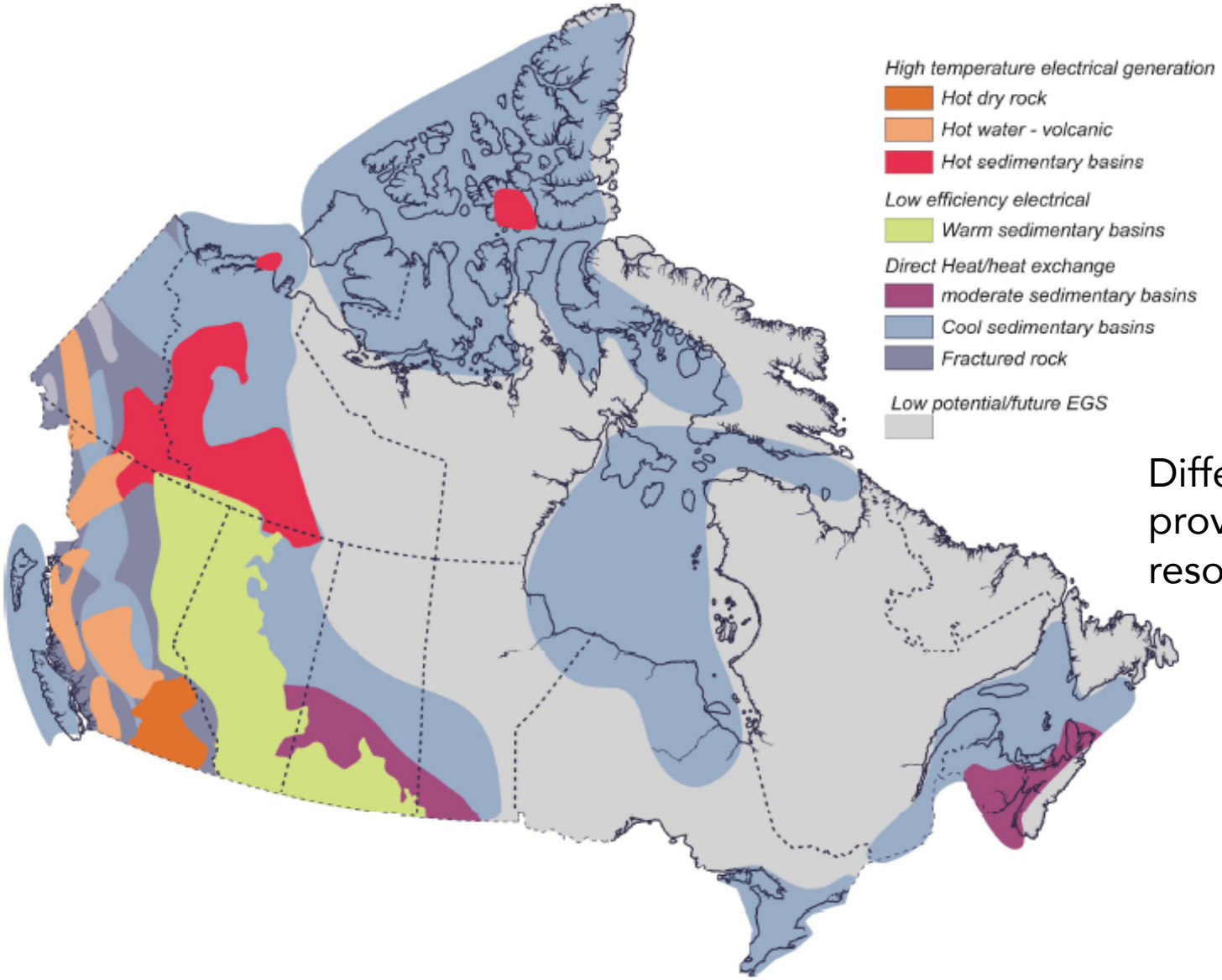
BC

Volcanic



Pty

Canadian Geothermal Resources

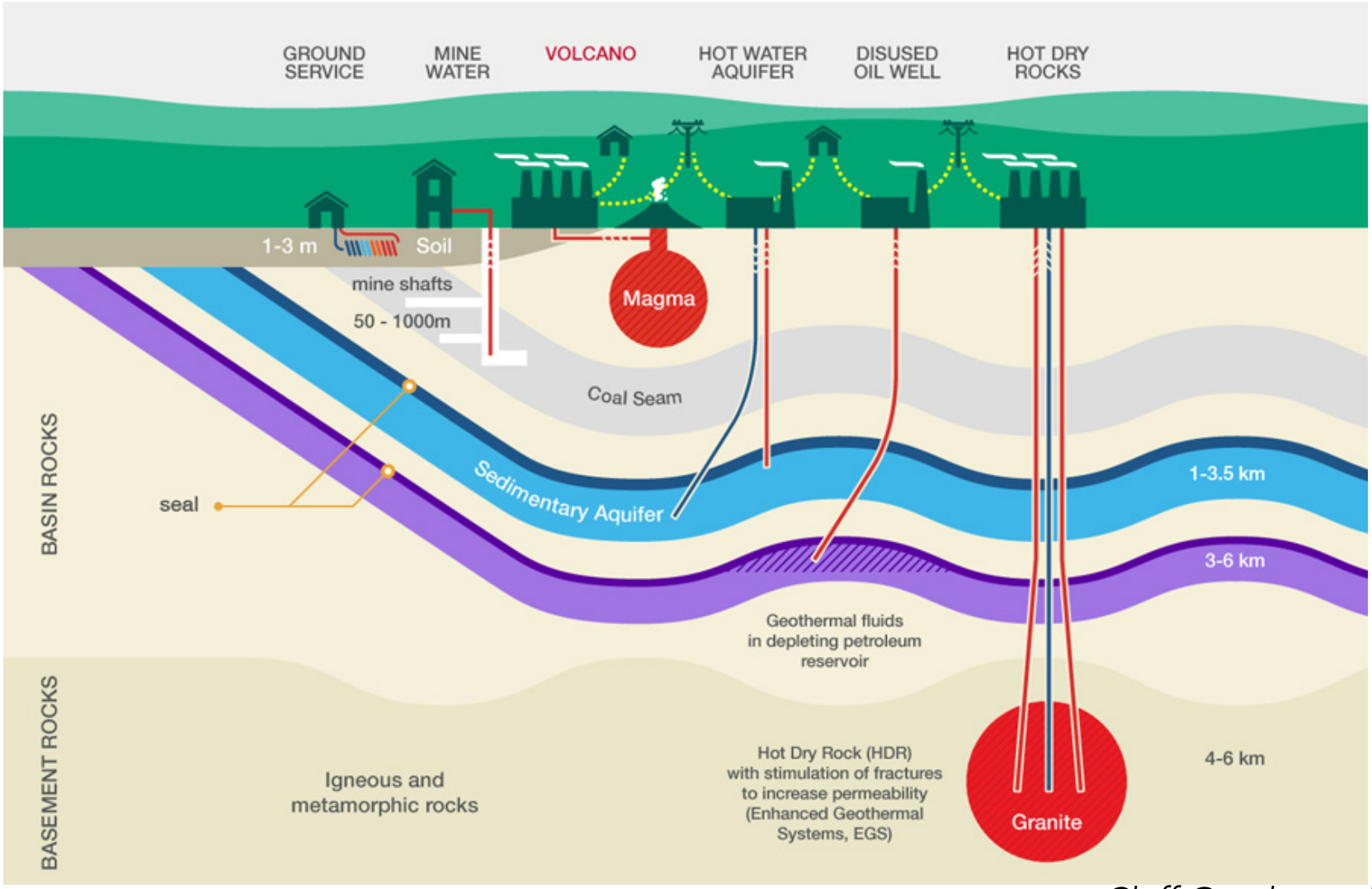


Different formations provide different resources

S. Grasby, GSC
Open File 6914

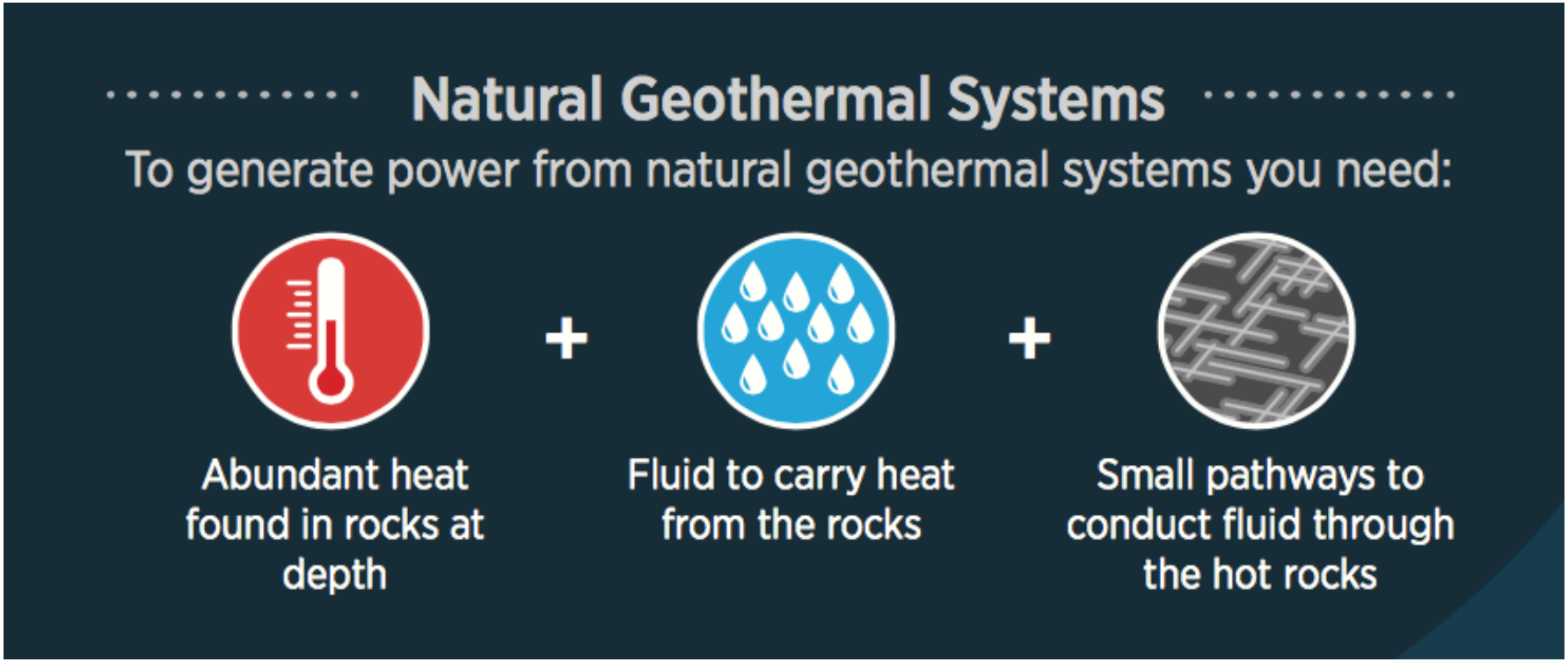
Types of Geothermal Continued

CGC ⟷ CanGEA



Cluff Geothermal

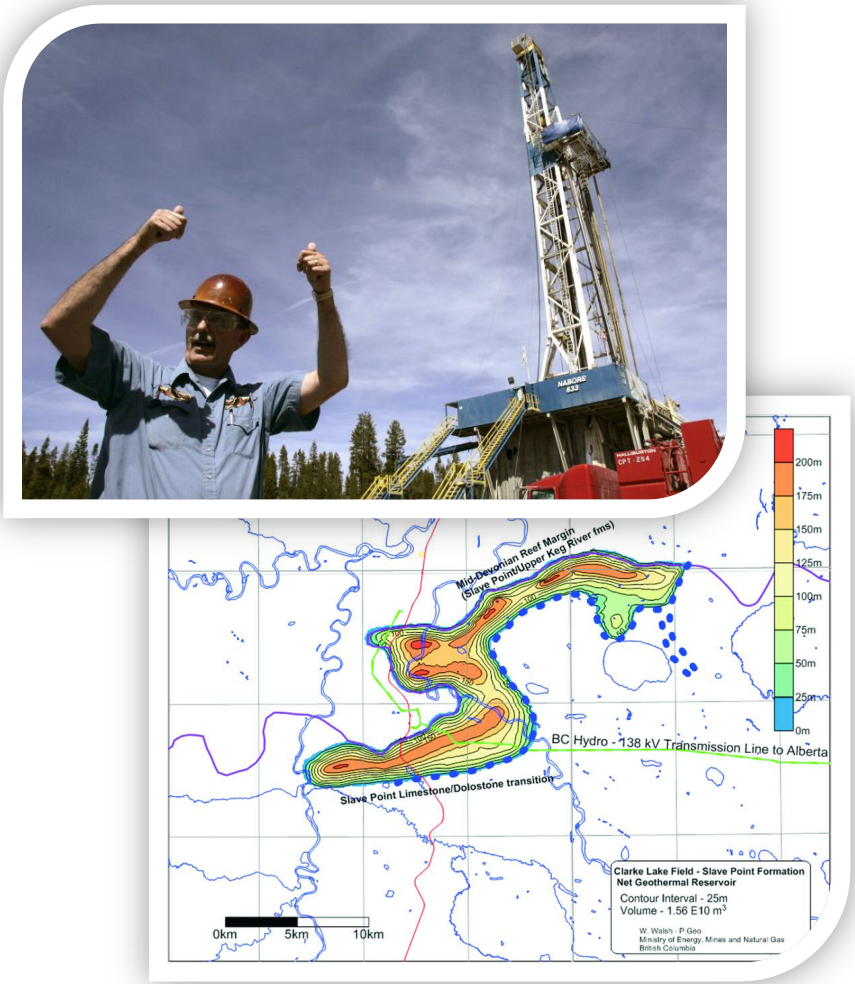
Components of a Natural Geothermal System



US DOE, 2015

Why Geothermal?

- Renewable & Baseload
- Long Term Revenue
- Small Footprint
- Mature Industry
  - The U.S GEA estimates that the international geothermal power market is growing at a sustained rate of 4-5%
- "There is a wholesale transferable opportunity to bring workers from oil & gas over to the geothermal industry" – Alison Thompson
- *Most Importantly, we have significant heat resources in Canada!*



W. Walsh, 2013

Brief History of Geothermal

- Hot springs have been used since ancient times
- Larderello, Italy has been using geothermal since the beginning of the 20th century
  - In 1904, five light bulbs were lit by electricity produced through steam emerging from vents in the ground – geothermal power!
  - In 1911 the first geothermal power plant was constructed in a nearby valley
  - As of 2004, Italy had an installed capacity of 790MW, producing 5340 GWh/a
  - Mature technology!

VEDUTA DEI LAGONI BORACIFERI DI LARDERELLO, NELLA PROVINCIA DI PISA

Brief History of Geothermal

- Commercial heat pumps designed in 1940s
- In 1960, Pacific Gas & Electric began operation of first geothermal power plant in San Francisco, producing 11 MW
- 1973 - oil crisis motivated countries to explore renewable energy
- In the 1980s, the Canadian government (Ministry of Natural Resources and the Geological Survey of Canada) initiated studies to explore Canada's geothermal potential
- As energy prices returned to affordable levels, the work was abandoned with no report published

The Geysers, outside of San Francisco

The Geysers is the world's largest geothermal field, containing 22 geothermal power plants

Misconceptions Regarding Geothermal Energy

- It is overly expensive
- Geothermal energy is finite
- Not a reliable, 24/7 supply
- Power plants are large and unattractive
- Geothermal energy extraction uses fracking techniques

The Hellisheidi geothermal power plant in Iceland

Typical Size of Geothermal Power Plants

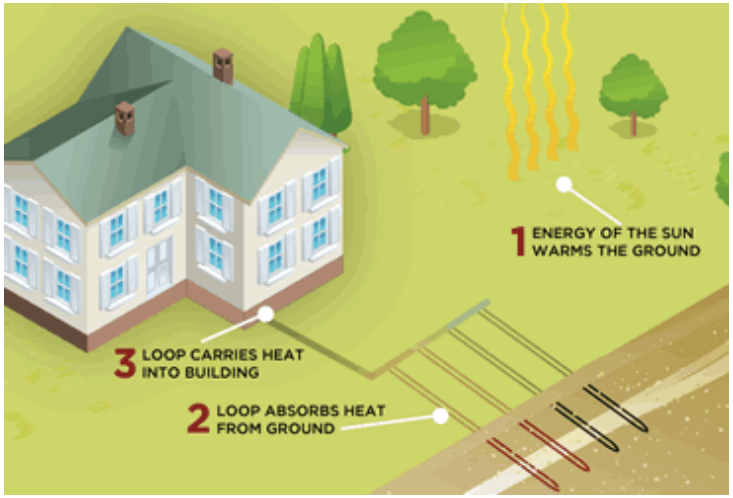
CanGEA
CANADIAN GEOTHERMAL ENERGY ASSOCIATION

Plant Name	Capacity (MW)	Original Developer	Country	Dimensions (approx)*	ha/MW
Raft River Geothermal Plant	16	Ormat	Utah, USA	200 m x 215 m	0.27
Blundell Geothermal Plant	10.6	Ormat	Utah, USA	270 m x 350 m	0.89
Brady Geothermal Plant	21	Brady Power (subsidiary of Ormat)	Nevada, USA	160 m x 300 m	0.23
Desert Peak Geothermal Plant	12.5	Brady Power (subsidiary of Ormat)	Nevada, USA	325 m x 300 m	0.78
Soda Lake I Geothermal Plant	5.1	Magma Energy	Nevada, USA	115 m x 80 m	0.18
Soda Lake II Geothermal Plant	21	Magma Energy	Nevada, USA	250 m x 300 m	0.36
Aidlin Geothermal Plant	17	Calpine	California, USA	160 m x 160 m	0.15
Bottle Rock Geothermal Plant	15	US Renewables Group	California, USA	130 m x 170 m	0.15
West Ford Flat Geothermal Plant	24	Calpine	California, USA	250 m x 175 m	0.18
MP-II Geothermal Plant	15	Ormat	California, USA	180 m x 200 m	0.24
Ormesa IE Geothermal Plant	10	Ormat	California, USA	160 m x 125 m	0.2
Zunil I Geothermal Plant	31.5	Ormat	Guatemala	115 m x 160 m	0.06
Amatitlan Geothermal Plant	20	Ormat	Guatemala	50 m x 50 m	0.01
Momotombo Geothermal Plant	22	Ormat	Nicaragua	325 m x 225 m	0.33
Miravalles V Geothermal Plant	18.1	Ormat	Costa Rica	125 m x 110 m	0.08
Tuzla Geothermal Plant	7.5	Ormat	Turkey	120 m x 140 m	0.22
Dora 1 Geothermal Plant	7.35	Ormat	Turkey	230 m x 150 m	0.47
Bereket Geothermal Plant	6.9	Ormat	Turkey	200 m x 280 m	0.81
Ohdake Geothermal Plant	12.5	Kyushu Electric	Japan	220 m x 165 m	0.29
Onikobe Geothermal Plant	12.5	J-Power	Japan	115 m x 90 m	0.08
				Average	0.3
OUTLIER					
Steamboat Hills Geothermal Power Plant	14.5	Ormat	Nevada, USA	600 m x 675 m	2.79
Site C Hydroelectric Dam	1100	BC Hydro	BC, Canada	56,610,000 m^2	5.15

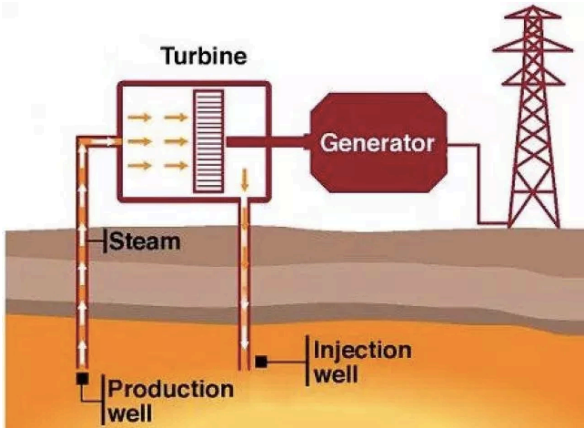
Or 7524 x 7524 m

Geoexchange vs. Geothermal Energy

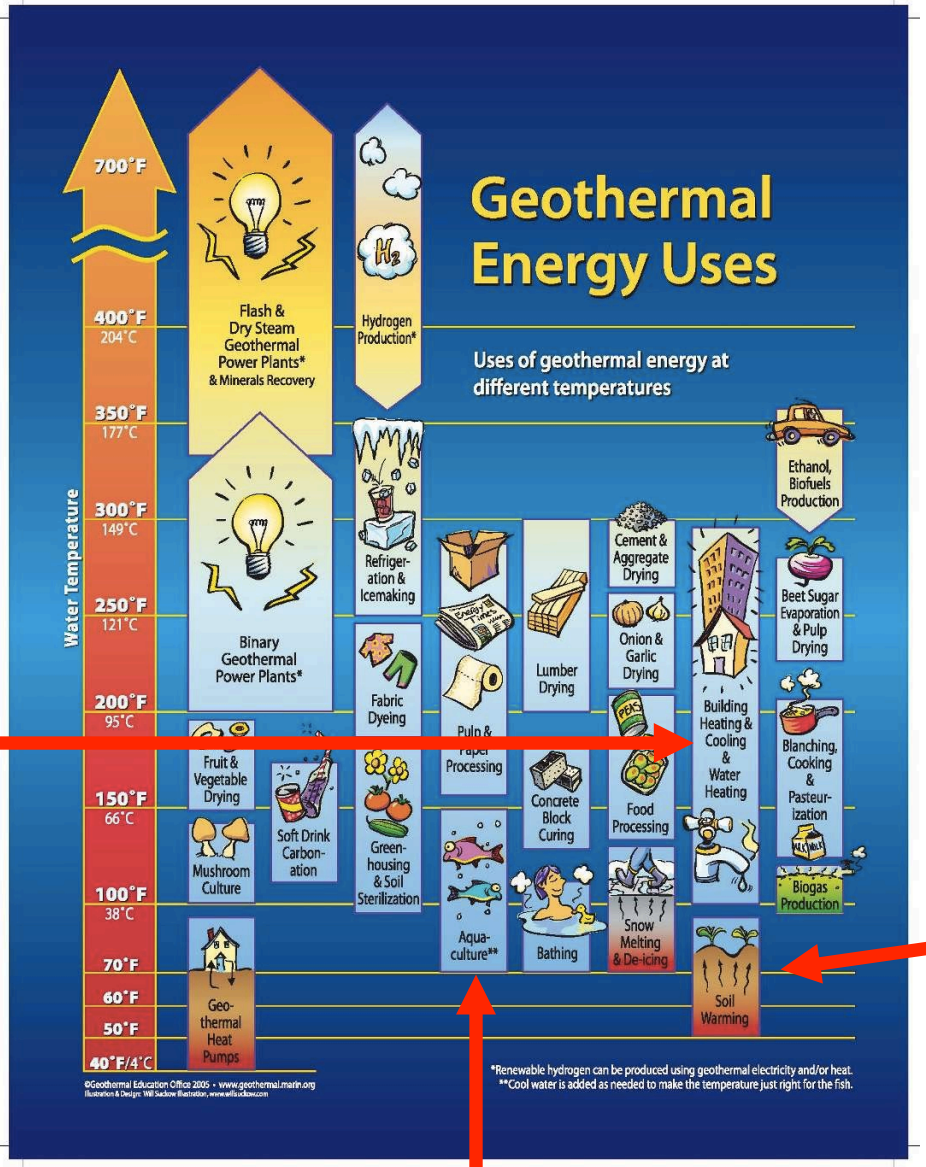
- Geoexchange involves "exchanging" heat from the earth's crust
- This is at a much lower depth than the earth's core
- The crust maintains a constant temperature year round, sourced from the sun (not the earth's core)
- Geoexchange systems simply harvest this heat!



- Extracting heat in the form of hot water or steam from the earth's core (kilometers deep)
- This water is heated from the decay of naturally occurring radioactive elements in the earth's crust
- This heat generates power through turbines in a power plant
- Ideal locations for this source heat are referred to as being part of the "ring of fire"



How can we use Geothermal Energy?



Building heating & cooling

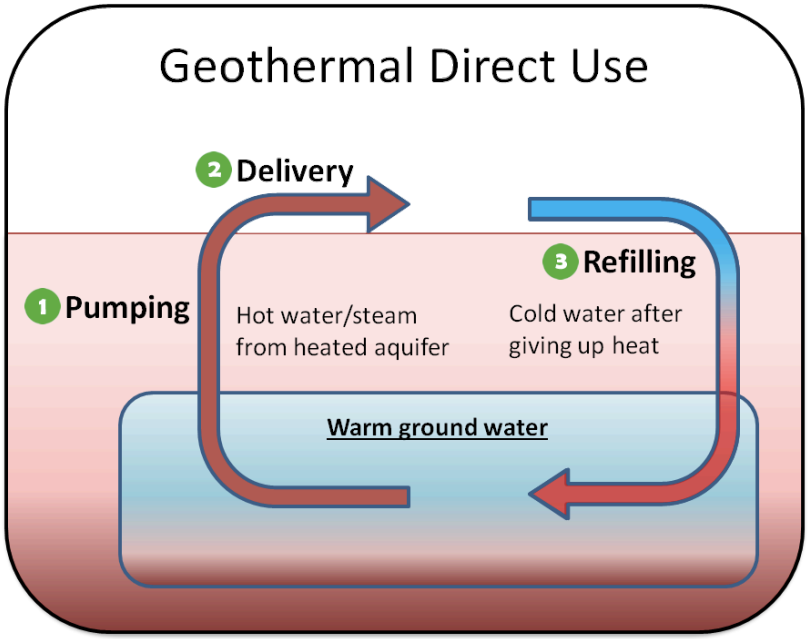
Soil Warming

Aquaculture

Lower temperature resources still have many uses:

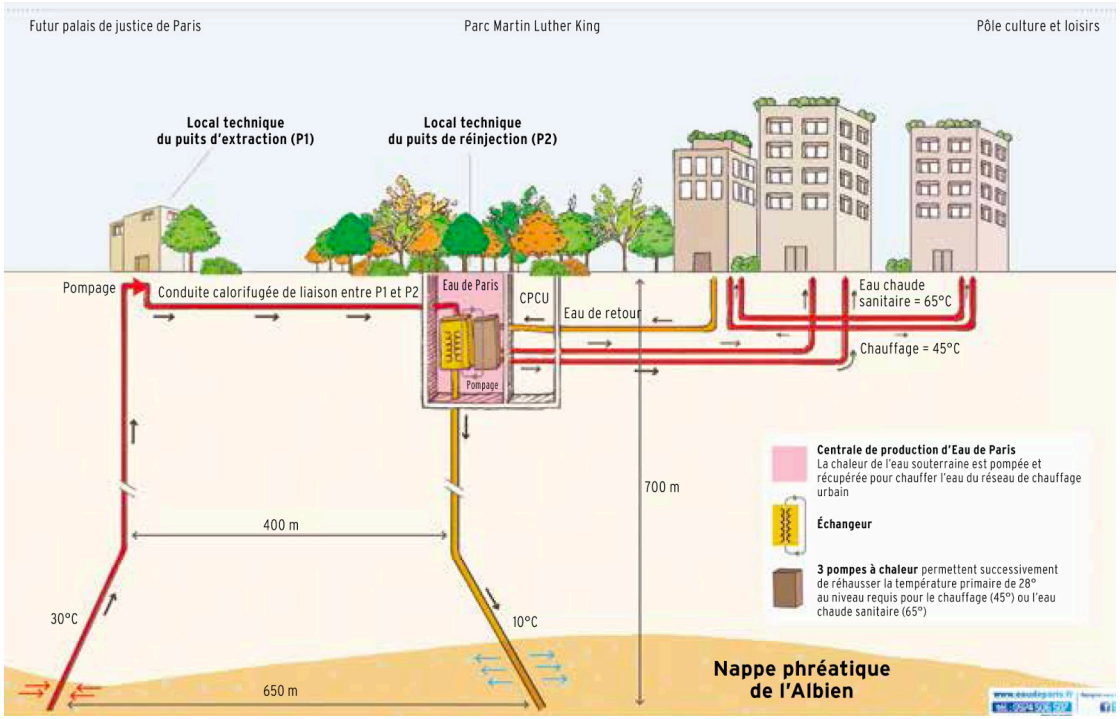
- Horticulture
- Aquaculture
- Tourism

What is Direct Use Geothermal?



- The use of warm or hot water/brine directly for: space heating/cooling, agriculture, recreation (spas), snow melting and industrial process heating
- Temperature of the resource influences both the technology for development and the potential end use
  - Direct use application temperatures are typically less than 80°C

Direct Use Continued



- <15% of heat resources converted to electricity, leads to very low cost "waste" thermal energy
- Heating/cooling, rather than converting to electricity
- The geothermal fluid temperatures required for direct-heat use are generally lower than those for economic electric power generation

Geothermal: A Heat Resource

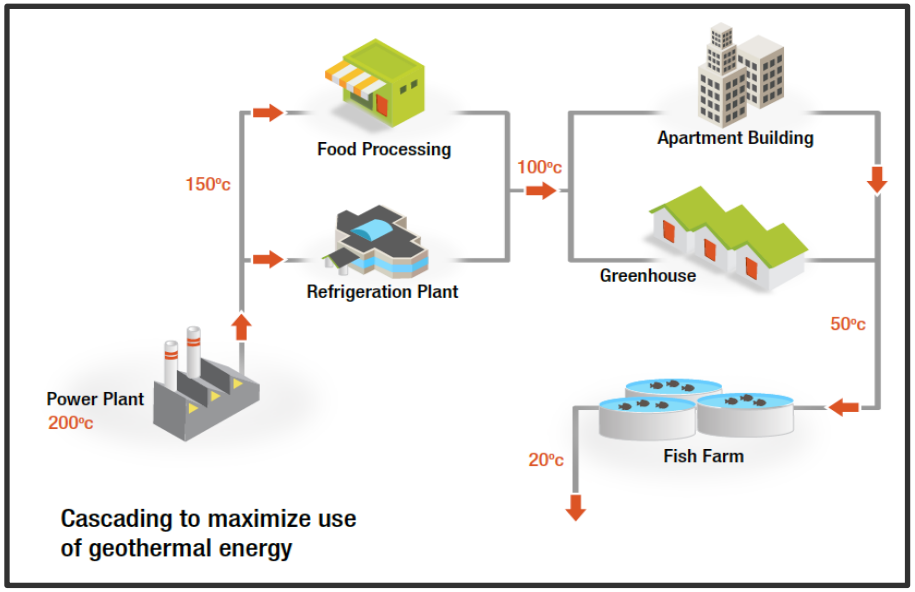
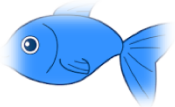


Figure 3: Cascading of Geothermal Energy

- 2-for-1 value
  - Power production
  - And/or heat
- All geothermal resources can be used for a variety of heating applications
- Cascading geothermal systems = most efficient

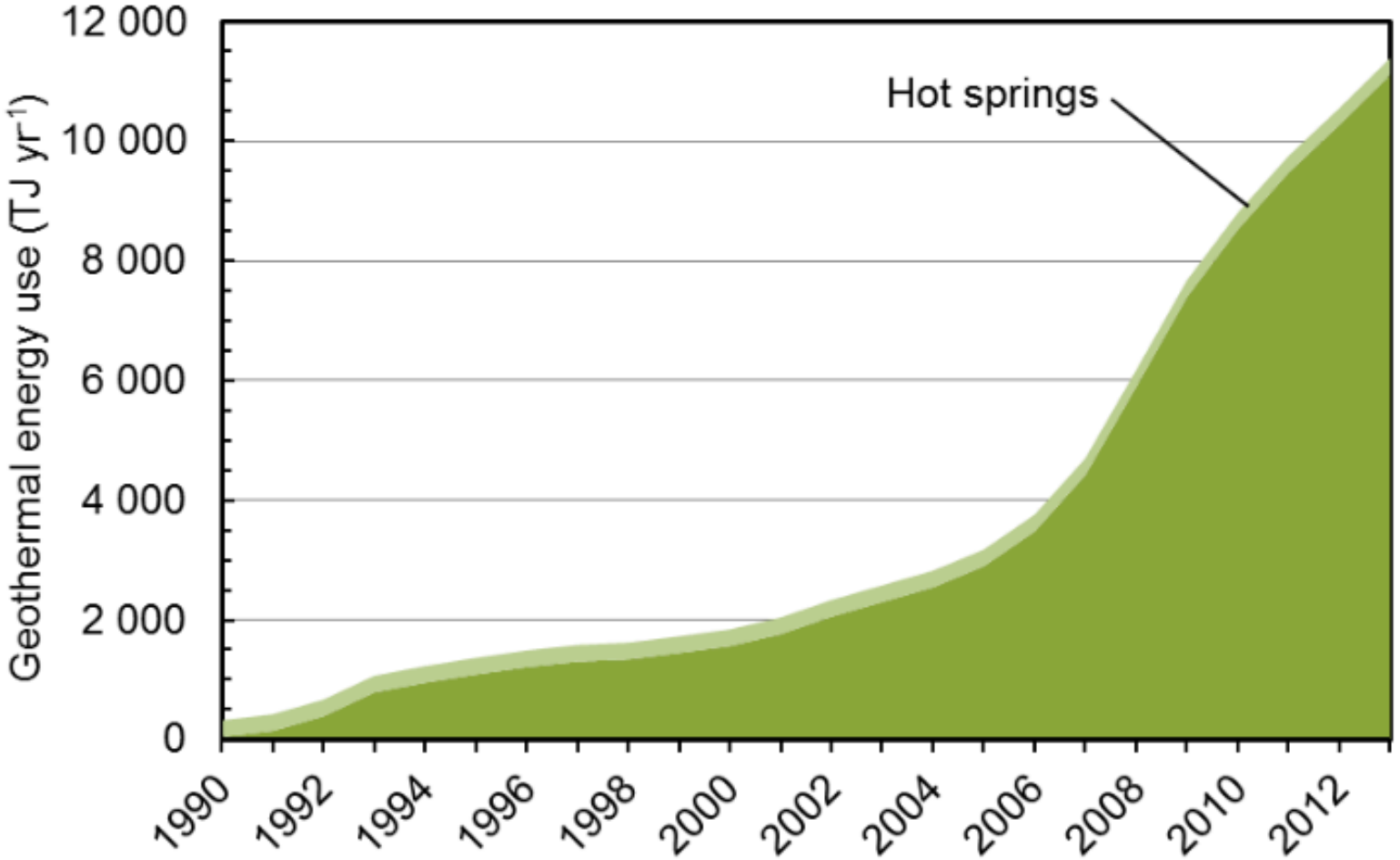







Direct Use

A Growing Industry: 5th in the World



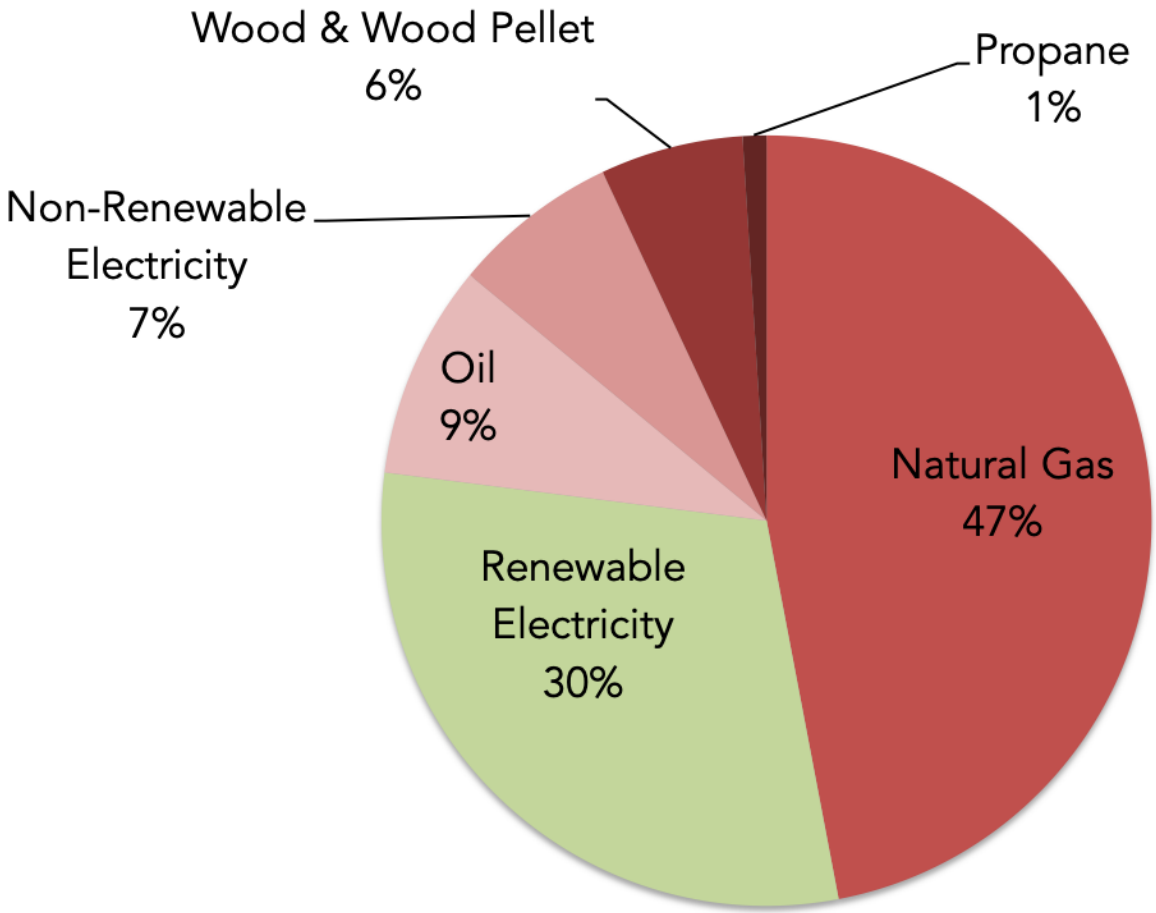
Raymond et. al., 2015

History of Direct Use in Canada

- Early direct use of geothermal energy was made by the First Nations as well as the workers of the Canadian Pacific Railway who discovered the Cave and Basin Hot Springs in Banff, Alberta in 1822
  - This led to the creation of Banff National Park, the first of Canada's National parks
- Hot Springs are primarily exploited in Western Canada while the use of geo-exchange heat pumps is a nationwide economic activity

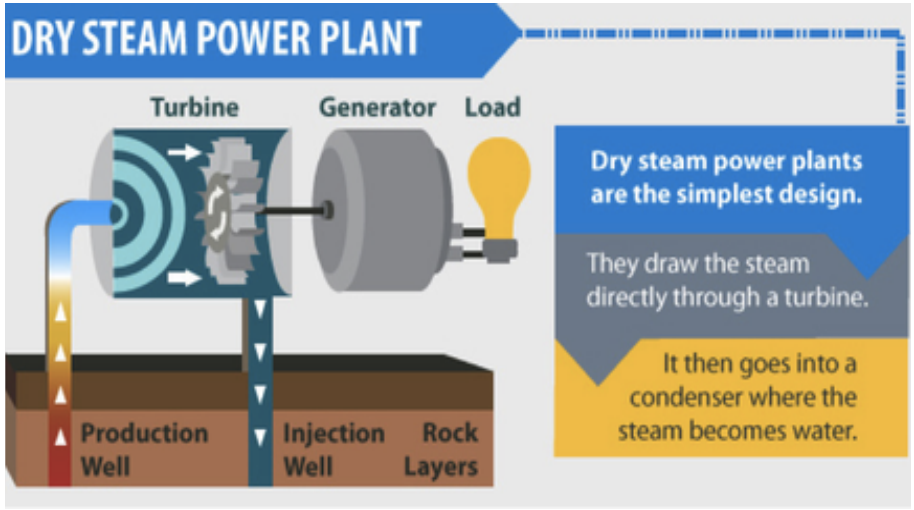
Source: banfflakelouise.com

Residential Heating in Canada By Type

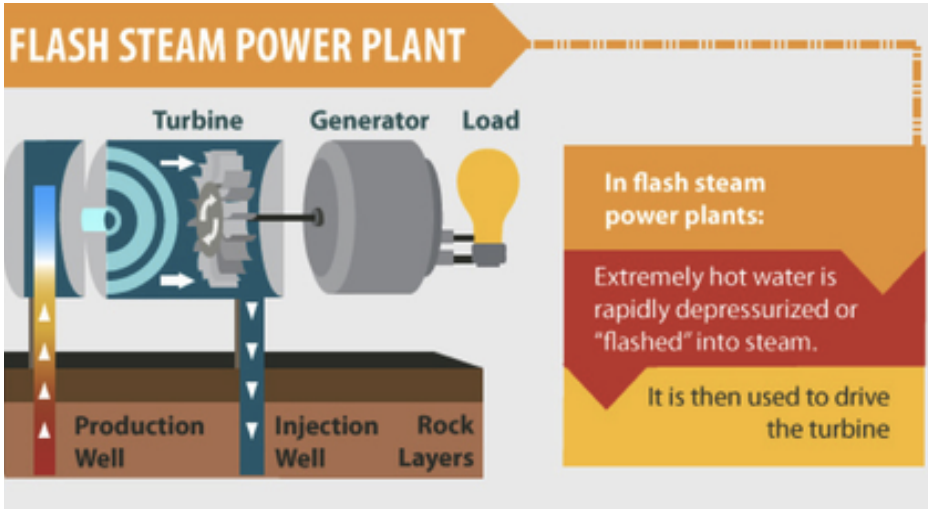


Sources available upon request

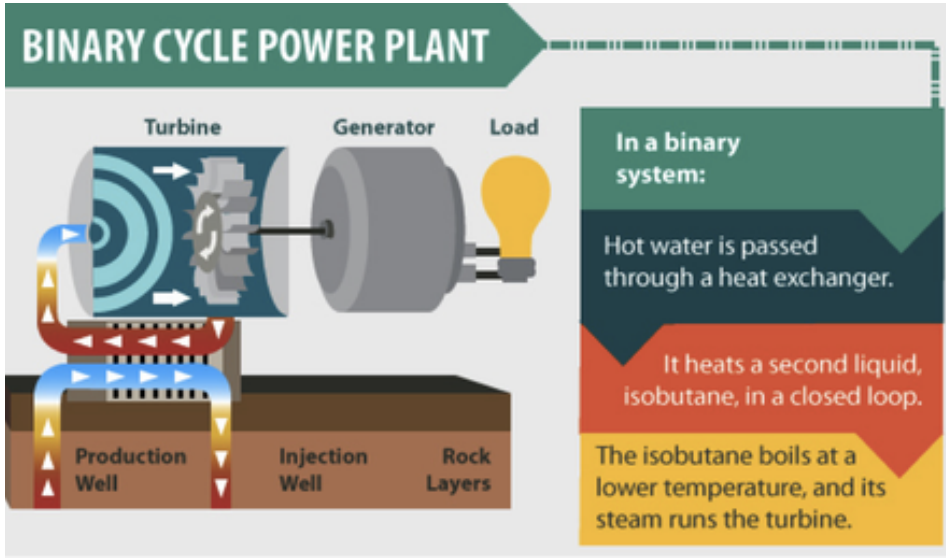
Types of Geothermal Power Plants



Ex. US & Italy



Ex. US

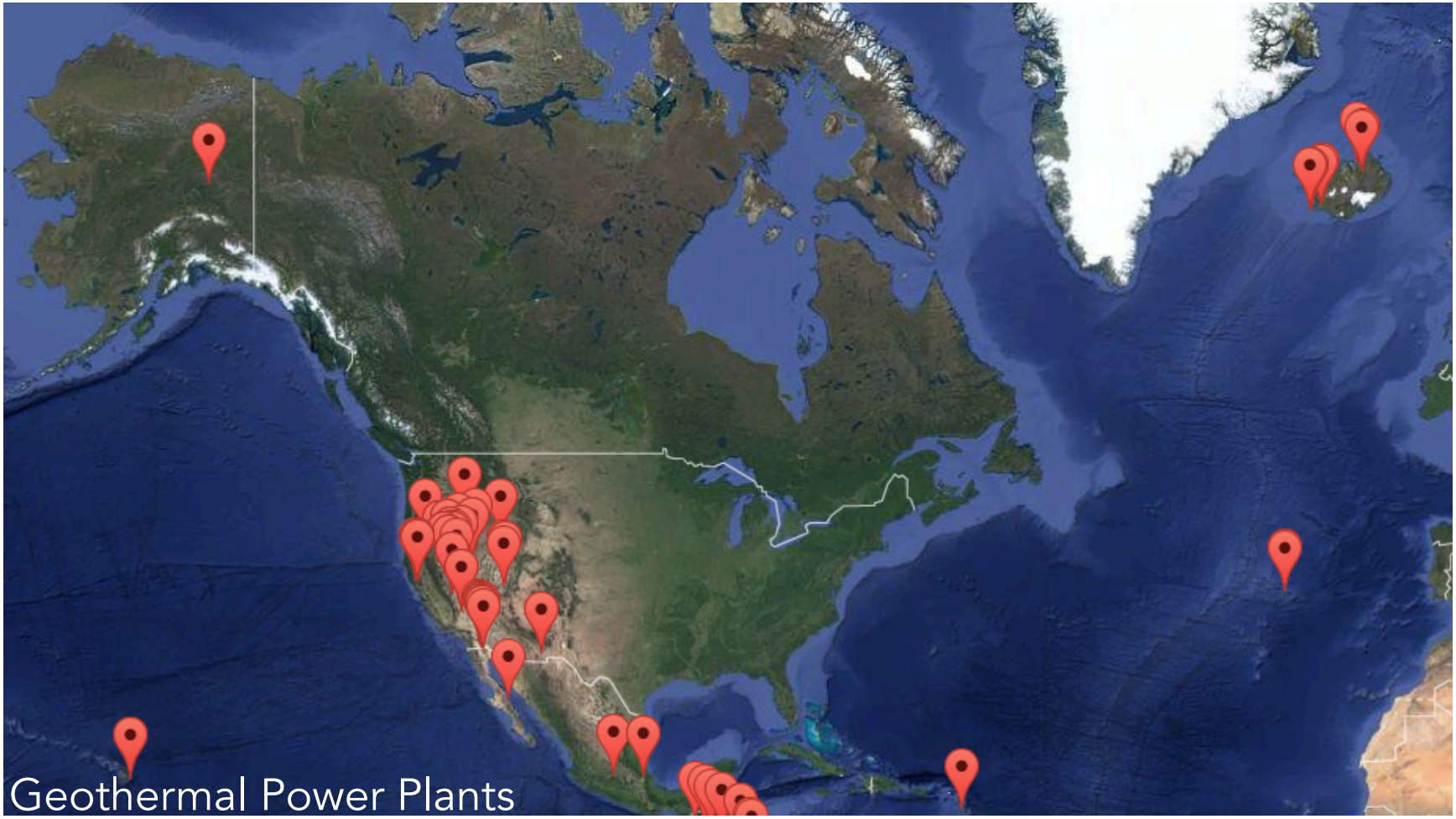


Ex. Canada (soon), US, Japan, etc.

Short Break

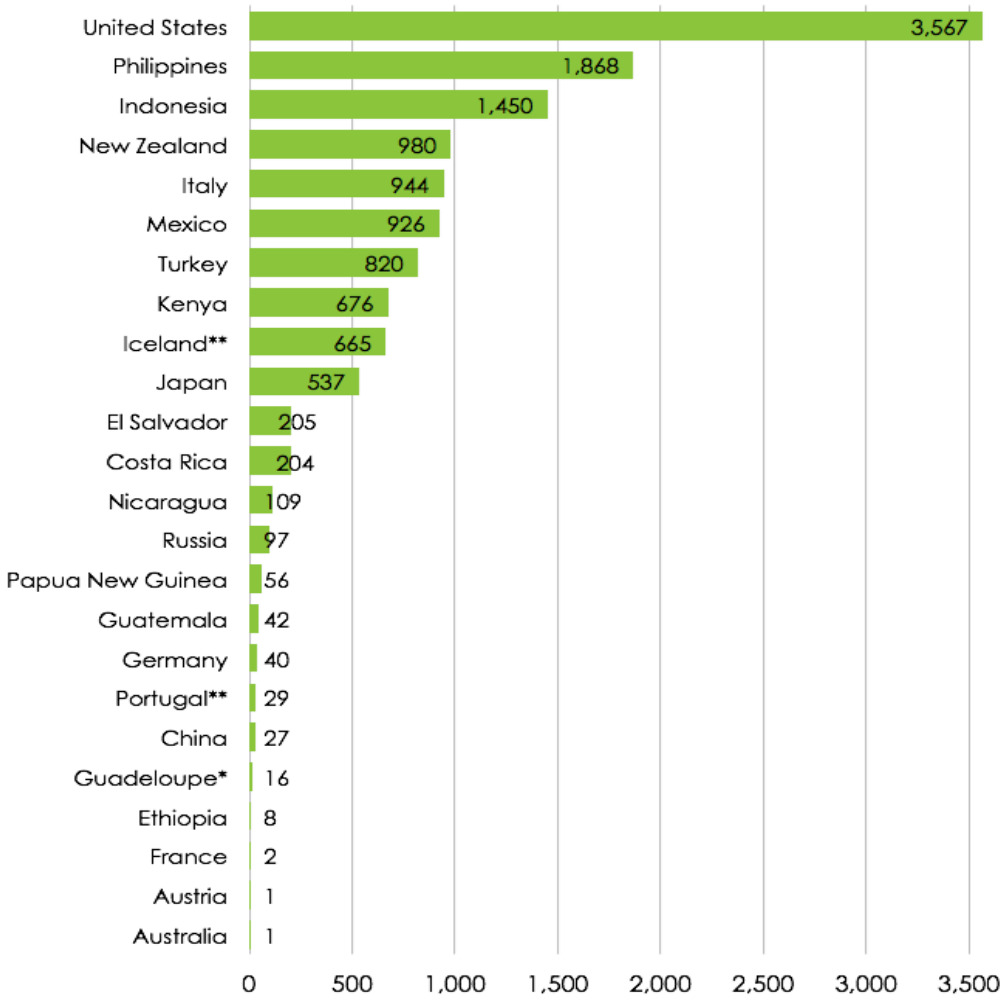
Zero Geothermal Plants in Canada

Canada's Resource Estimate: 5,000+ MWe (CanGEA)



www.thinkgeoenergy.com

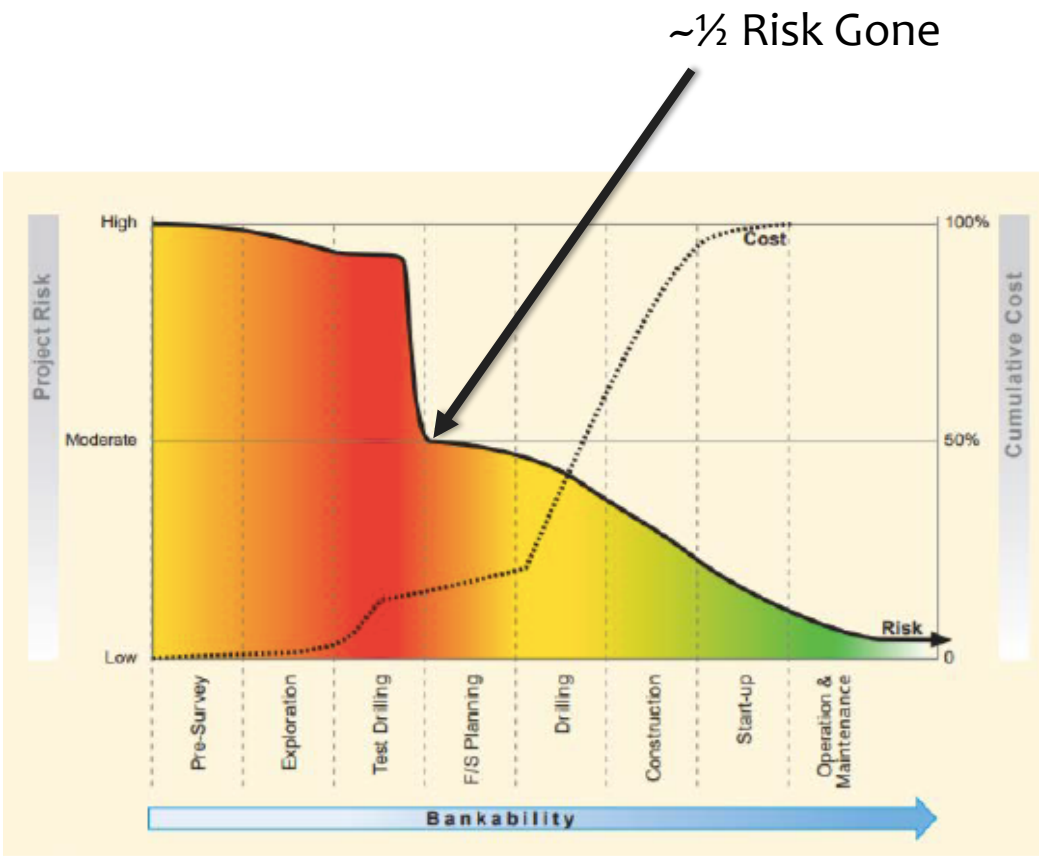
Worldwide Geothermal Power Production



Source: TGE Research (2017), GEA (2016), IGA (2015), Enerji Atlasi (2017)

Challenges for Geothermal

- **High upfront risk**
  - Locating the resource
  - Drilling
  - Mitigated with Existing Data
- **Poorly understood**
- **Lack of Canadian precedent**
- **Lack of policy framework**



Policy Challenges in Alberta and Canada

Federal Level:

- No federal data repository
- No geothermal specific grants, such as risk mitigation
  - i.e. Well drilling grant
- Government still has relatively low level of knowledge but is learning

Provincial Level:

- British Columbia and Saskatchewan are the only provinces with framework
- Alberta has no framework
  - This results in a de facto moratorium
- Lots of interested developers
- A "chicken and egg" scenario

What CanGEA Has Accomplished

Federal achievements:

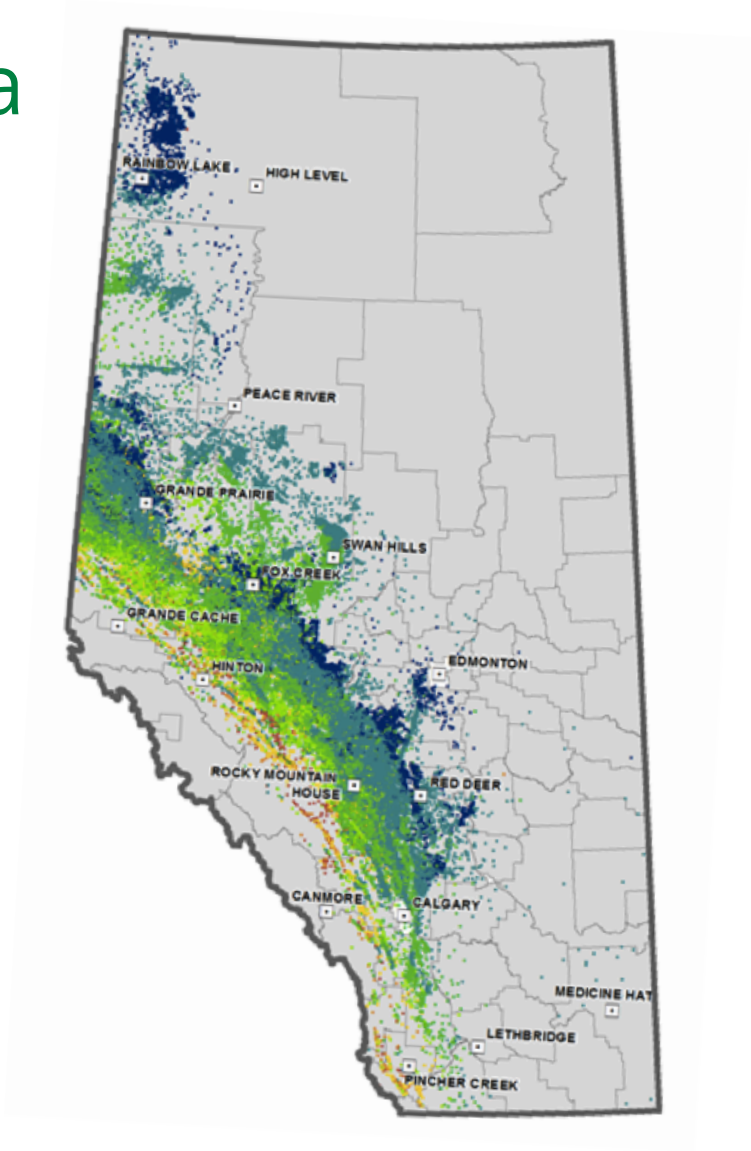
- Recognized as a renewable alternative for heat and power
- Eligibility for funding and tax expense programs
- Recognized more data and support is needed

Alberta achievements:

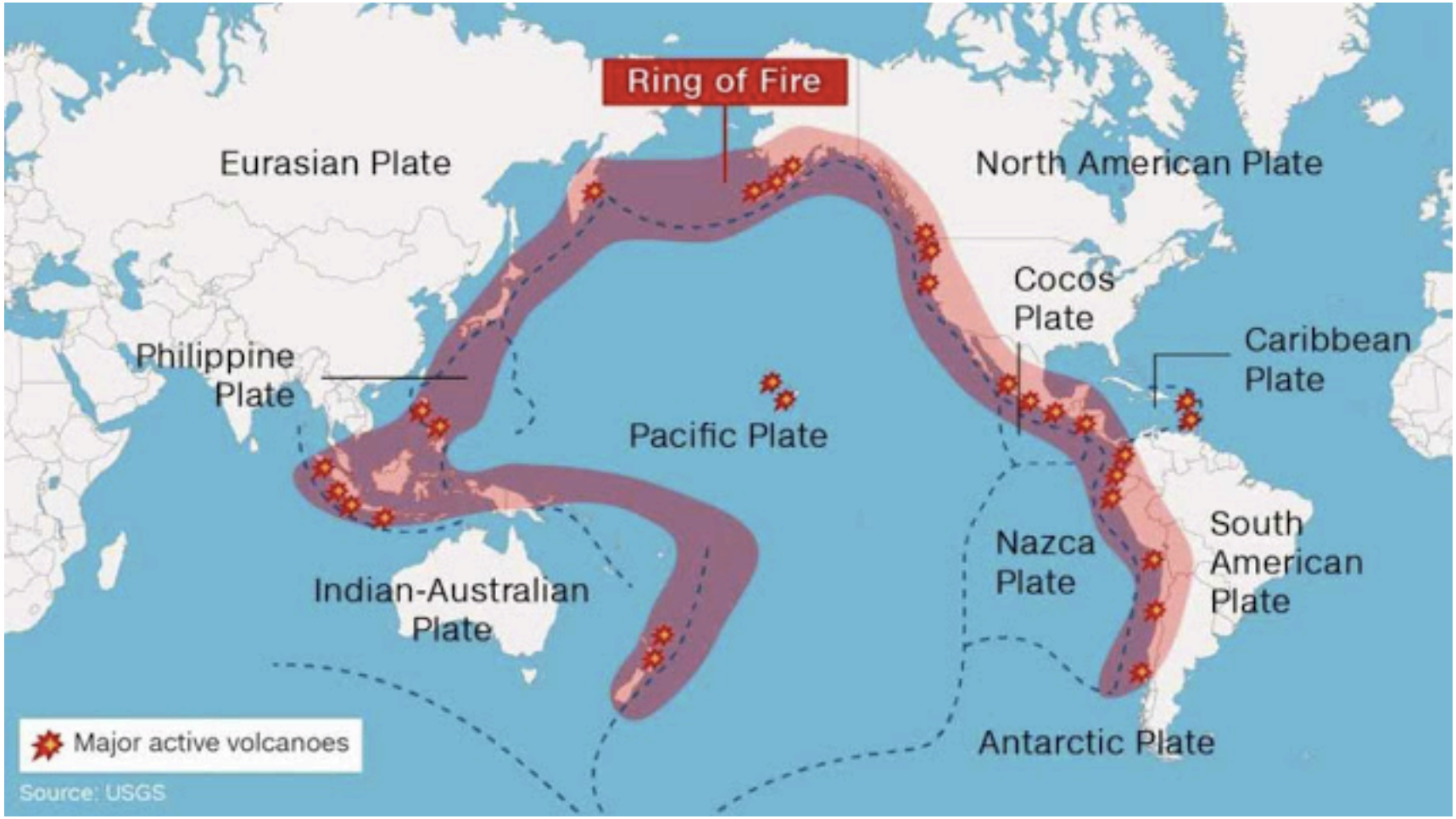
- Currently no legislative framework – what does this mean?
- No easy way to begin a project
- Alberta Energy Stakeholder Engagement (occurred summer 2018)
- Geothermal projects eligible for funding programs
  - This is a result of our continued advocacy

CanGEA's Work in Alberta

- Alberta Geothermal Favourability Study
- Alberta Well Filtering Study
  - Used to inform the Hinton Geothermal Project
- Tsuut'ina Nation Geothermal Feasibility study
- Travelling Geothermal 101 Series

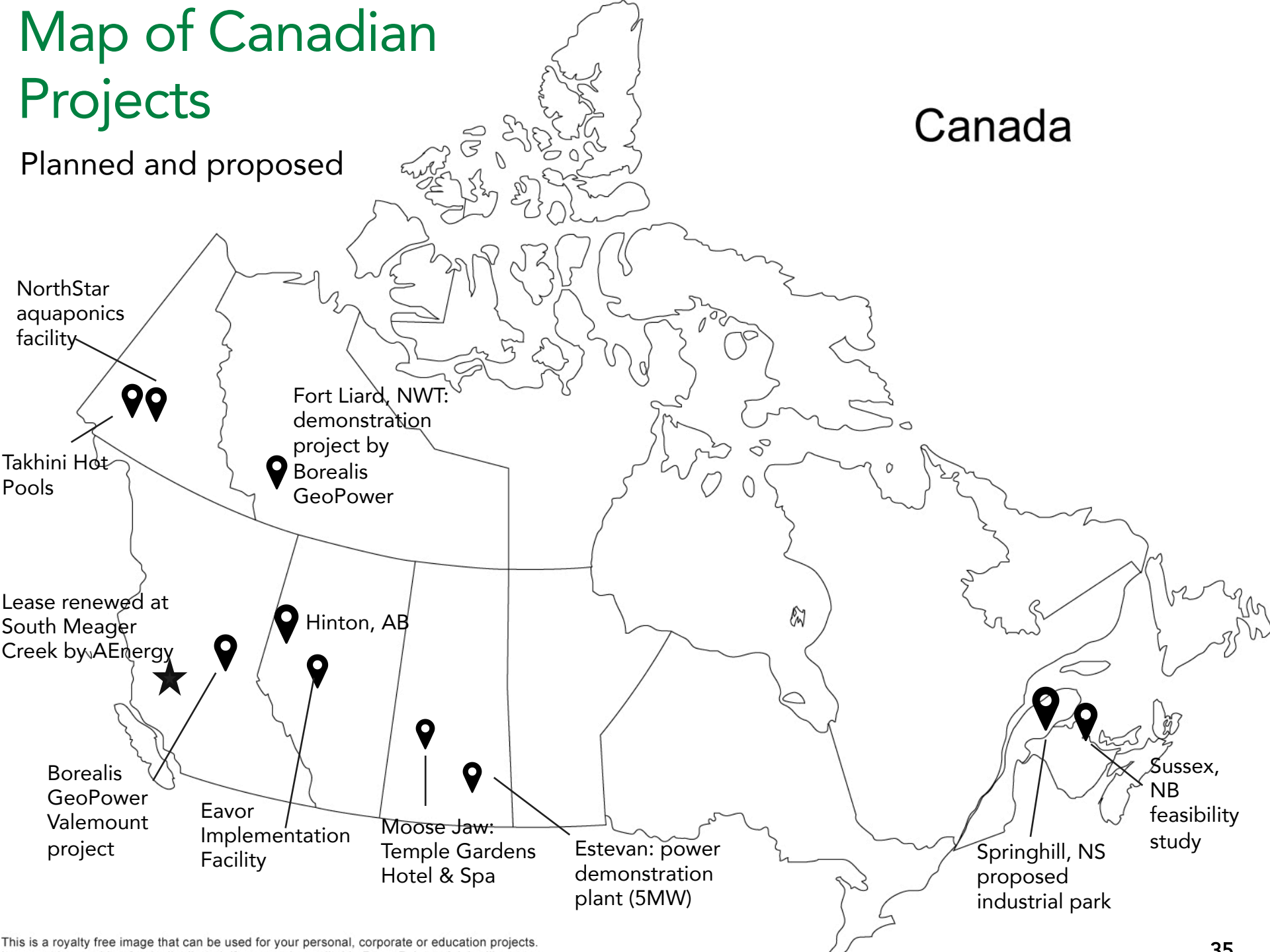


Where Most Geothermal Potential Exists



Map of Canadian Projects

Planned and proposed



Temple Gardens Spa, Moose Jaw, Saskatchewan

- This resort is not on the site of a naturally occurring hot spring
- The geothermal waters were discovered accidentally in 1910 during deep drilling to locate natural gas
- In 1980 the city of Moose Jaw drilled a new twin well which now provides the resort with therapeutic mineral water
- Well head temperature is approximately 45°C with flow rates of 166 gpm
- The facility is enjoyed year round and is a first of its kind in Canada

Source: templegardens.sk.ca

Active Canadian Projects: Valemount, B.C

BOREALIS GEOPOWER

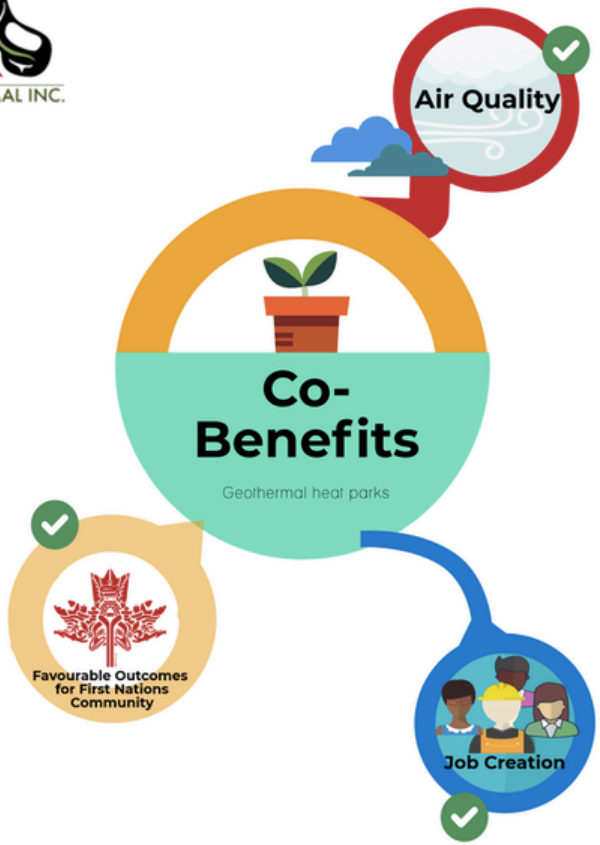
- End of BC Hydro Transmission line
  - Known for "brown-outs"
- Significant geothermal potential
- 3-phase approach
  - 450kw micro power demonstration
  - Construction of Geoheat park
    - Featuring a brewery
  - 15 MW GeoPower Plant
- Opportunity for stable, reliable electricity and economic stimulation!

Active Canadian Projects: Terrace, B.C

BOREALIS GEOPOWER

KITSELAS GEOTHERMAL INC.

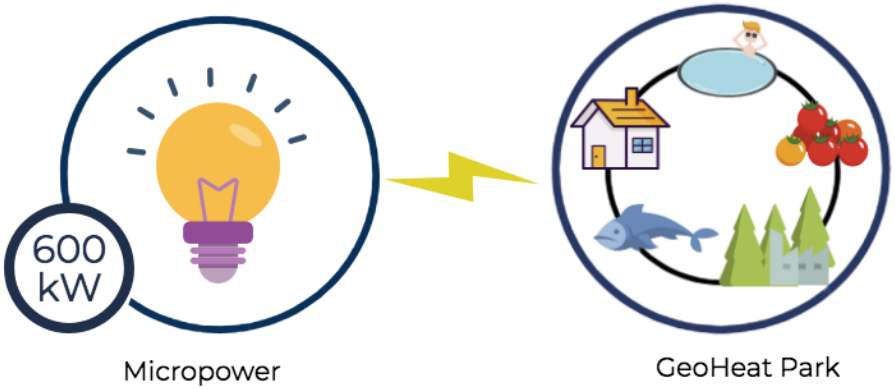
- Partnered with local Kitselas First Nation
- Parallels with Valemount project
- Pre-feasibility stage concluded in April 2018
- +/- 15 MW power plant proposed
- Heat GeoPark also planned



Active Canadian Projects: Fort Liard, NWT

- This project has a two phase approach
  - Phase 1 is a 600 Kw micropower project
  - Phase 2 is a geoheat park

Acho Dene Koe
FIRST NATION



Active Canadian Projects: Springhill, N.S

- 1985 Springhill explored idea of using flooded mines
- By 1994 there were eight users of the resource
  - Retail or commercial
- Ropak Packaging has been using geothermal energy for climate control for 26 years
- Springhill is looking to expand their use of flooded mines based on previous success

Active Canadian Projects: Sussex, N.B

- Recent Feasibility Study
- The Town has been actively engaging with the population
- Study proposes:
  - 20 Acre Greenhouse and 10 Refrigeration Warehouses
    - Capital investment of ~$11.3M
  - Cost sharing: $5.7M from utility and $5.6M from collective users
  - Annual operation/maintenance costs are ~$98,000
  - System energy consumption is ~$1.9M, leaving system savings at ~$1.7M
  - Pay back period of 7 years
  - Reduces 12,400 tonnes of $C0_2$

Spring of 2020 is earliest that the mine use geothermal energy

Active Canadian Projects: Saskatchewan DEEP

- Near Estevan, SK, using a hot sedimentary aquifer more than 3000m deep
- Deep Earth Energy Production
  - 5 MW power plant proposed would power approximately 5000 households
  - Long term goal is to increase baseload power facilities from repeatable 5 megawatt (MW) power plants.
  - SaskPower and DEEP signed the first power purchase agreement (PPA) issued in Canada in May 2017
    - Allows further research into the potential for Saskatchewan's first geothermal power project

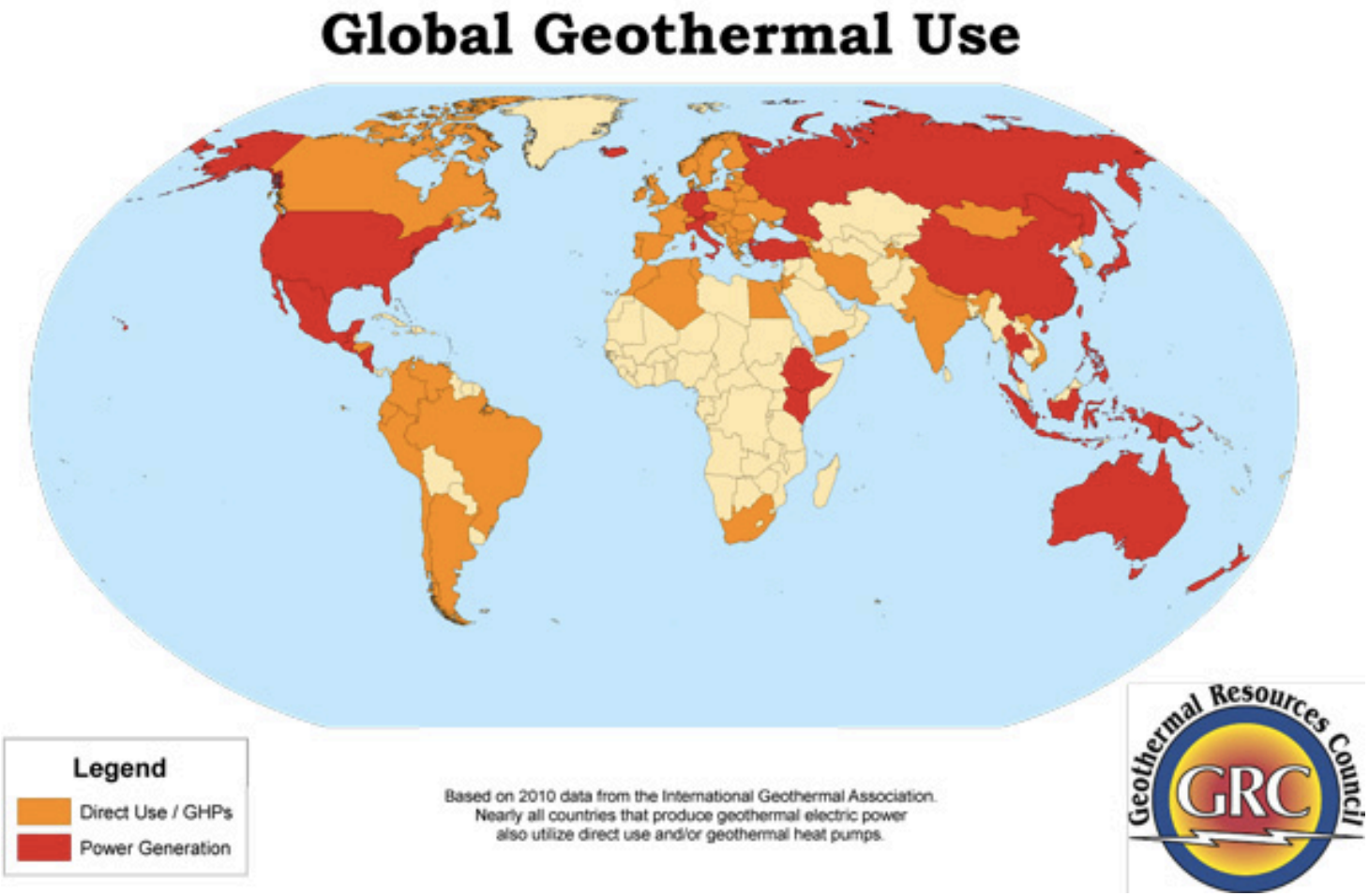
Other Geothermal Projects in Canada

- **Yukon: Takhini Hot Springs**
  - Geothermal pool and spa
  - Greenhouses and animal barn heating
  - Future 5 – 10 MW power plant possible

- **Central Alberta: E3 Metals Petro-Lithium Extraction Facility**

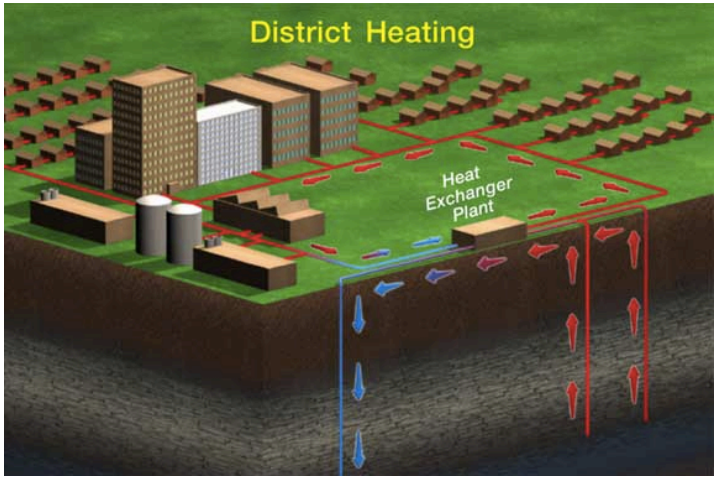
- **Yukon: Aquaponics Project**
  - Collaboration with local Indigenous community
  - Constructing a small scale facility north of Whitehorse
  - Will be heated and cooled by geothermal waters

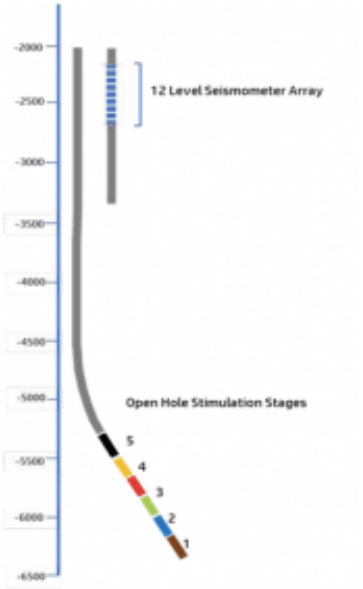
Global Case Studies



Espoo, Finland: Deep Well, Big Rewards

- 6.4km deep well (first of two) that will provide clean, renewable heat to approximately 26,000 residents using district heating
  - District heating is a system for distributing heat generated in a centralized location through a system of insulated pipes for residential and commercial heating requirements such as space heating and water heating
- Well was drilled through hard bedrock
- Alberta has some of the most advanced drilling technology in the world, there is no doubt we could do this here as well





Reykjavik: Geothermal Resource Park

- 2 Power Plants with Total Capacity of 175MW
- Businesses in resource park employ over 840 people
- Heat used to run businesses
- Businesses include:
  - Mineral Spa
  - Bioresearch
  - Food drying and processing

Kirchweidach, Germany: Jobs, GDP, and no GHGs

- Similar geology to parts of Western Canada (sedimentary basin)
- Geothermal energy is directly used in a 12 hectare greenhouse

Results

- Local food
- Reduced GHGs
  - 6.5 million litres of fuel are saved = ~2,150 million tonnes of $C0_2$
- Local jobs
  - Greenhouse employs 150 full time staff

Case Study: Netherlands

The Netherlands have focused their efforts on the direct use of geothermal heat for greenhouses and industry.

The Netherlands have mitigated the main challenges of geothermal energy development by prudent policy:

- Netherland Oil & Gas Portal: a public database of all subsurface data
- State owned risk mitigation fund

The Netherlands' prudent use of policy to minimize risks allows for geothermal energy to reach its potential

Giant Geothermal Opportunity

Right Here in the Oil Patch

North Dakota's first successful commercial enterprise to co-produce electricity using geothermal water from hydrocarbon production in the Williston Basin. Source: Kirby Baier of Continental Resources

- Delineated Resource
- World-class resource extraction talent
- Co-production of heat and hydrocarbons
- End-of-Life strategy for oil and gas wells

Retraining Oil and Gas Workers for Geothermal Jobs

2017 Study

	Alberta	Mining and Oil and Gas Extraction Industry
Unemployment	194,700	8,800
Unemployment Rate	7.80%	5.90%

Geothermal has the potential directly hire un(der)employed Oil and Gas expertise

- Geothermal development uses the same world leading professionals and trades that built Canada's oil patch

CanGEA has and continues to work with academic institutions and NGOs to develop opportunities for underemployed oil and gas workers

Retraining Oil and Gas Workers for Geothermal Jobs

High degree of transferability between the technical portion of the work

- Similar trades needed as in O&G
- Similar positions as O&G
- Similar wage and overall job

Highest degree of transferability among all renewable energy development

Most jobs created during construction phase and operations phase

Renewable Sector	Jobs per MW	
	Construction	Operations
Wind Energy	.6	.09
Solar Energy	3.9	.32 (residential); .16 (commercial)
Geothermal Energy	4	1.7

Technology and Skill Transfer

Transfer Areas:

- Exploration and geoscience
- Drilling
- Completions (zonal isolation)
- Cyclic steam stimulation
- Co-production (power and heat)
- Reservoir management and simulation
- Remote sensing
- Power plants
- And more!

The techniques used for exploration, evaluation, and production of petroleum resources are applicable for geothermal energy

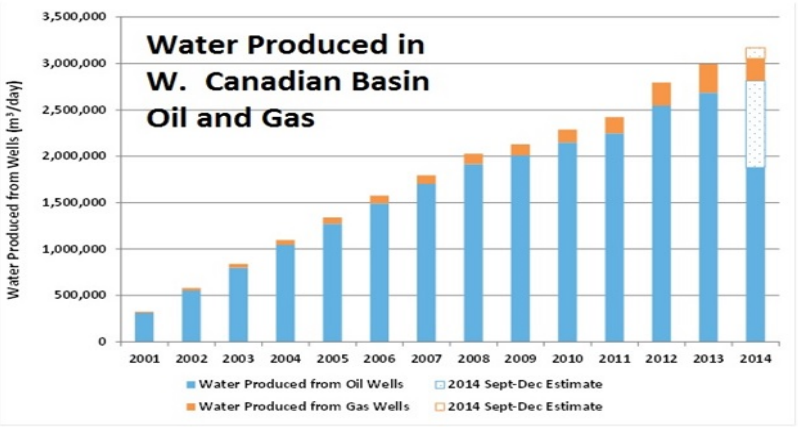
With credit to Pat Hufnagel-Smith of Creative Links

Repurposing Inactive Wells

Rebranding Liabilities as Assets

- Co-Produced Fluids
  - High-water cut wells
  - Enhanced Oil Recovery
  - Install insulated gathering systems to collect heat
- Closed System Heat Exchangers

Geothermal Greenhouse in Germany



Alberta has drilled 60,395 wells with bottom hole temperatures greater than 60 °C.
"If 10% of these geothermal opportunities are developed, that would still equate to 6,093 new geothermal systems in Alberta, providing heat, power, and employment opportunities for Albertans."

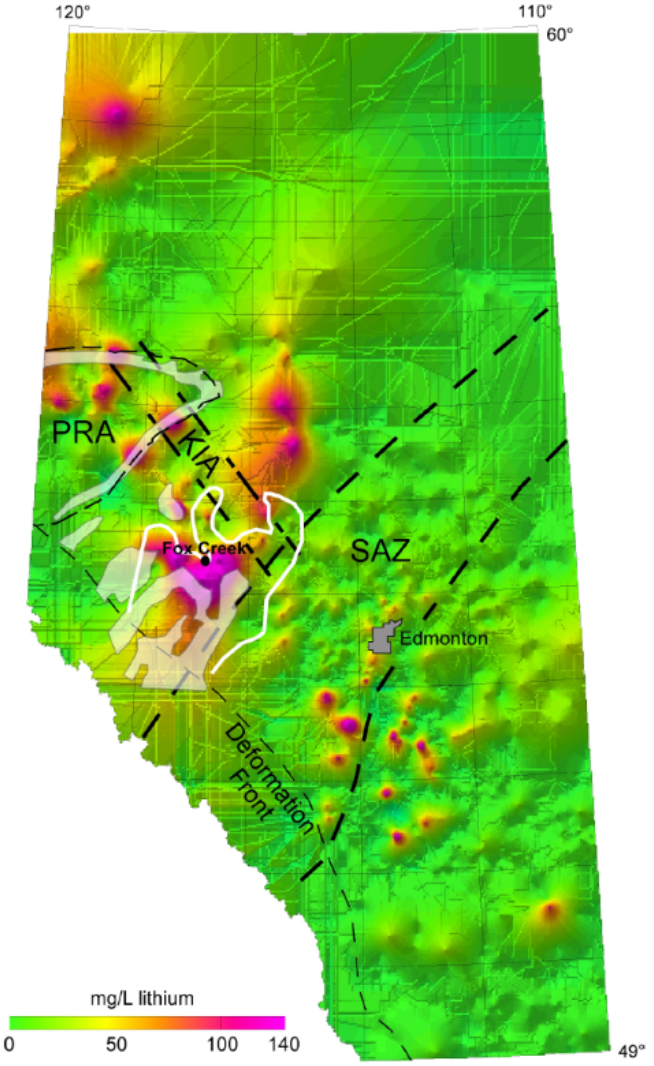
Oil and Gas Investments Bulletin, 2014

Mining Sector Opportunities

Three main opportunities:

1. Overlap of high temperature geothermal resources and mining in BC
2. Petrolithium extraction
   i. Lithium in Alberta/ Saskatchewan
   ii. See map
   iii. CanGEA member E3 Metals
3. Flooded mines for district heating applications
   i. Springhill and Sussex examples

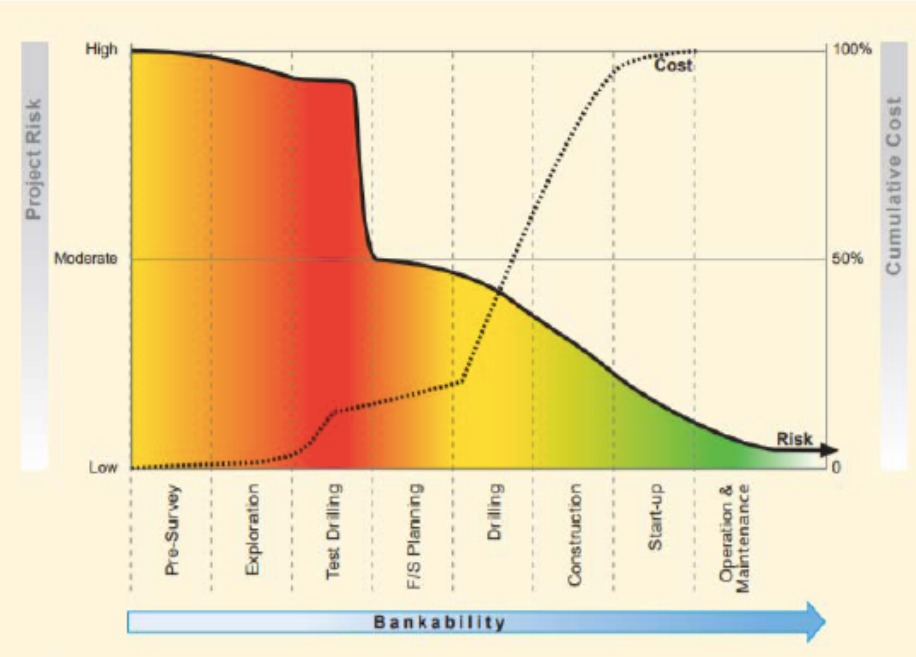
Alberta's Lithium Potential



ERCB/AGS Open File Report 2011-10

5 Phases of a Project

1. Venture Capital
    i. Developers, independent power producers, venture capitalists, resource speculators
2. Exploration/Pre-Feasibility
    i. Here it is hardest to attract financing
3. Feasibility/Resource Verification
    i. If feasible, risk is greatly reduced
4. Detailed Design and Construction
    i. Incentivizes additional funding, less risk
5. Start of Operation



Relating Geothermal to Other Renewable Industries

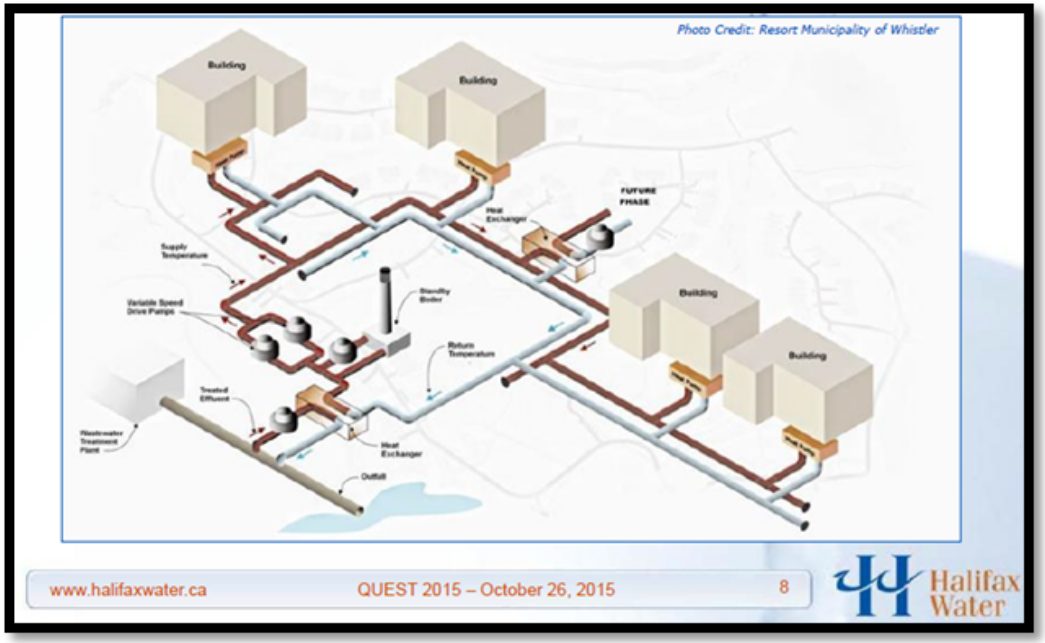
- Geothermal plants can quickly have their production ramped up/down
- In areas with solar power (for example) the geothermal plants could be ramped down during the day and up during the evening to provide consistent energy
- "Geothermal energy has many advantages compared with solar and wind systems. These advantages include weather proof, base load, great stability, and high thermal efficiency"
  - Li, 2015

Relating Geothermal to Non-Renewable Industries

- Our goal is not to run oil and gas out of town
- Rather, we want to foster cooperation
- In places where heat sources are too low for full geothermal capacity, we recommend **topping**
- Topping consists of using available geothermal energy and "topping up" the rest with oil and gas to mitigate emissions
- We are not "the anti-oil and gas" association but rather the "efficient energy use" association

Direct Use in Hinton, Alberta

- 4000+ wells drilled below 2,500m within a 70km radius of the town
  - Some bottom hole temperatures higher than 140°C
- In partnership with the University of Alberta and Alberta Innovates, commissioned a study in 2015 to determine the volume of energy available
- Looking to see if the geothermal resource can be utilized for a district heating system for approximately 12 municipal buildings



Hinton Project Continued

- A $1.2 million federal and provincial grant was received to explore the feasibility with a commissioned study to be released at the end of 2018
- Calgary based Epoch Energy conducted the study
  - ~15 wells with geothermal potential within close proximity
- Epoch says 2020 timeline for project completion
- Results are expected soon
- Project would be a first for Canada

What can you do?

- Our website, www.cangea.ca, has the most up to date information on Canadian geothermal energy
- Sign up for our newsletter and stay informed!
- Participate in future CanGEA seminars!
- Visit www.powearthful.org to send a letter to your MP and MLA
  - PowEARTHful is CanGEA's public engagement initiative

Please contact info@cangea.ca with inquiries regarding slide sources

Hinton Citations

Images (by slide):

5 CGC images and geoexchange graphic are from CGC's website.
6 All member logos were received by CanGEA.
7 Geyser image is a stock photo
8 Graphic from *Pubs.usgs.gov*
10 Graphic from S. Grasby, GSC Open File 6914
11 Graphic from Cluff Geothermal
12 Graphic from US Department of Energy, 2015
13 Graphics from W. Walsh, 2013
14 Graphics from www.reuk.co.uk
16 Graphics are stock photos
19 Graphic from Geothermal Education Office 2005
20 Graphic from https://www.epa.gov/rhc/geothermal-heating-and-cooling-technologies
23 Graph from Raymond et. al. 2015
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28 Graphic from www.thinkgeoenergy.com
29 Graph from TGE Research 2017 et al
34 Map from US Geological Survey
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37-39 Graphics from www.borealisgeopower.com
40 Graphics from https://www.cbc.ca/news/canada/new-brunswick/springhill-geothermal-1.4006309 and Google maps
41 Graphic from https://www.cbc.ca/news/canada/new-brunswick/mineshaft-geothermal-sussex-1.4004596
42 Graphic taken from www.deepcorp.ca
43 Graphics taken from respective websites
44 Map taken from Geothermal Resources Council
45 Graphics from www.inhabitat.com, https://blog.smu.edu/geothermallab/2018/07/08/stimulation-underway-at-st1-deep-heat-project/
45 Graphic is a stock photo
47 From http://www.thinkgeoenergy.com/german-geothermal-project-tapping-into-heat-power-modules-to-expand-power-generation/
48 From https://www.nationalgeographic.com/magazine/2017/09/holland-agriculture-sustainable-farming/
49 Kirby Baier of Continental Resources
53 Graph from Oil and Gas Investments Bulletin 2014
54 Alberta image from ERCB/AGS Open File Report 2011-10
58 Graphic from Halifax Water
59 Graphic from www.hinton.ca

Facts and Figures (by slide):

13 Figure from US Geothermal Energy Association
14 Figure about Italy 2004 capacity from https://pangea.stanford.edu/ERE/pdf/IGAstandard/SGW/2005/lund.pdf
25 Figures from https://www150.statcan.gc.ca/n1/pub/11-526-s/11-526-s2013002-eng.pdf and https://www150.statcan.gc.ca/t1/tbl1/en/cv.action?pid=2510001501
52 Pat Hufnagel-Smith of Creative Links
56 Li quote "Comparison of geothermal with solar and wind power generation systems" in Renewable and Sustainable Energy Reviews Volume 42, February 2015, Pages 1464-1474