



# Direct-use Geothermal Resources in British Columbia, Canada

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*Our independent earth science enables informed resource management decisions  
and attracts investment that creates jobs*

Webinar Modules

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# What is, Where is and Why Geothermal?

(Module 2)

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# OVERVIEW

- What is geothermal?
  - The Geothermal Spectrum: Power → Direct-use → GeoExchange
- Where is geothermal found globally?
  - Where is Geothermal in BC
- Why geothermal?
  - Geothermal Funding in Canada (Quebec, Saskatchewan, Alberta, BC)

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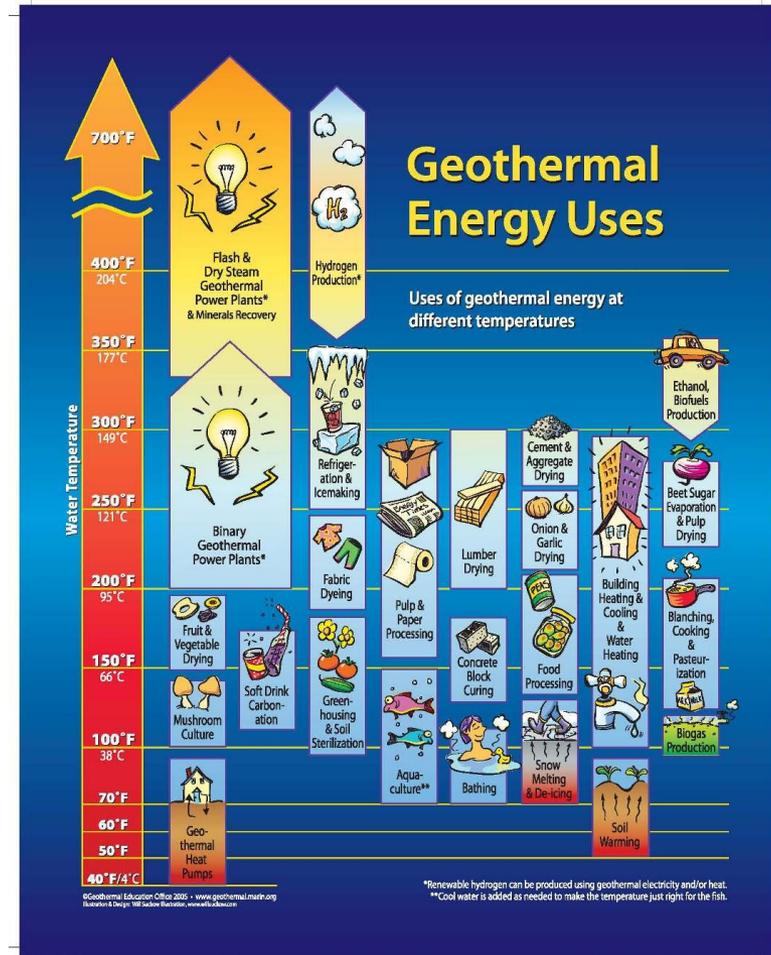
# What is Geothermal?



# What is Geothermal?

## GEOHERMAL ENERGY – new or old?

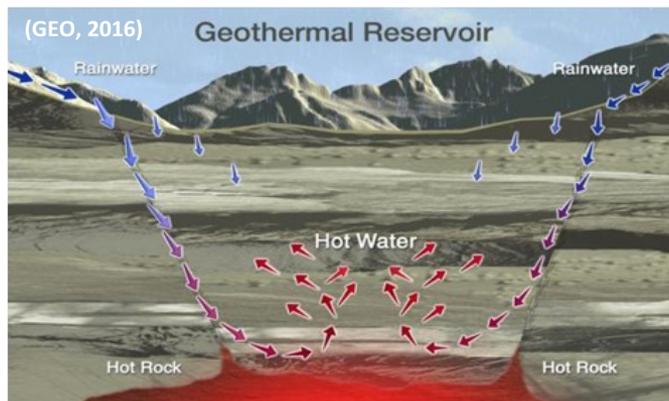
- **Mature** technology – 3 levels of use
  - **Power generation**
    - >100 year old technology
  - **Direct-use applications**
    - Used culturally by indigenous peoples of the world for 1000's of years (ie. Bathing, cooking)
  - **Geothermal heat pumps**
    - In use since the 1940's



# What is Geothermal?

## The Geothermal Reservoir

- Geothermal reservoirs are formed when rising hot water and steam is trapped in permeable and porous rocks under a layer of impermeable rock (rock through which water can't flow)
- Rainwater can seep down faults and fractured rocks for kilometres, being heated and returning to the surface as steam or hot water
- Many geothermal areas have visible surface manifestations of the underground heat source, such as hot springs, fumaroles, and geysers

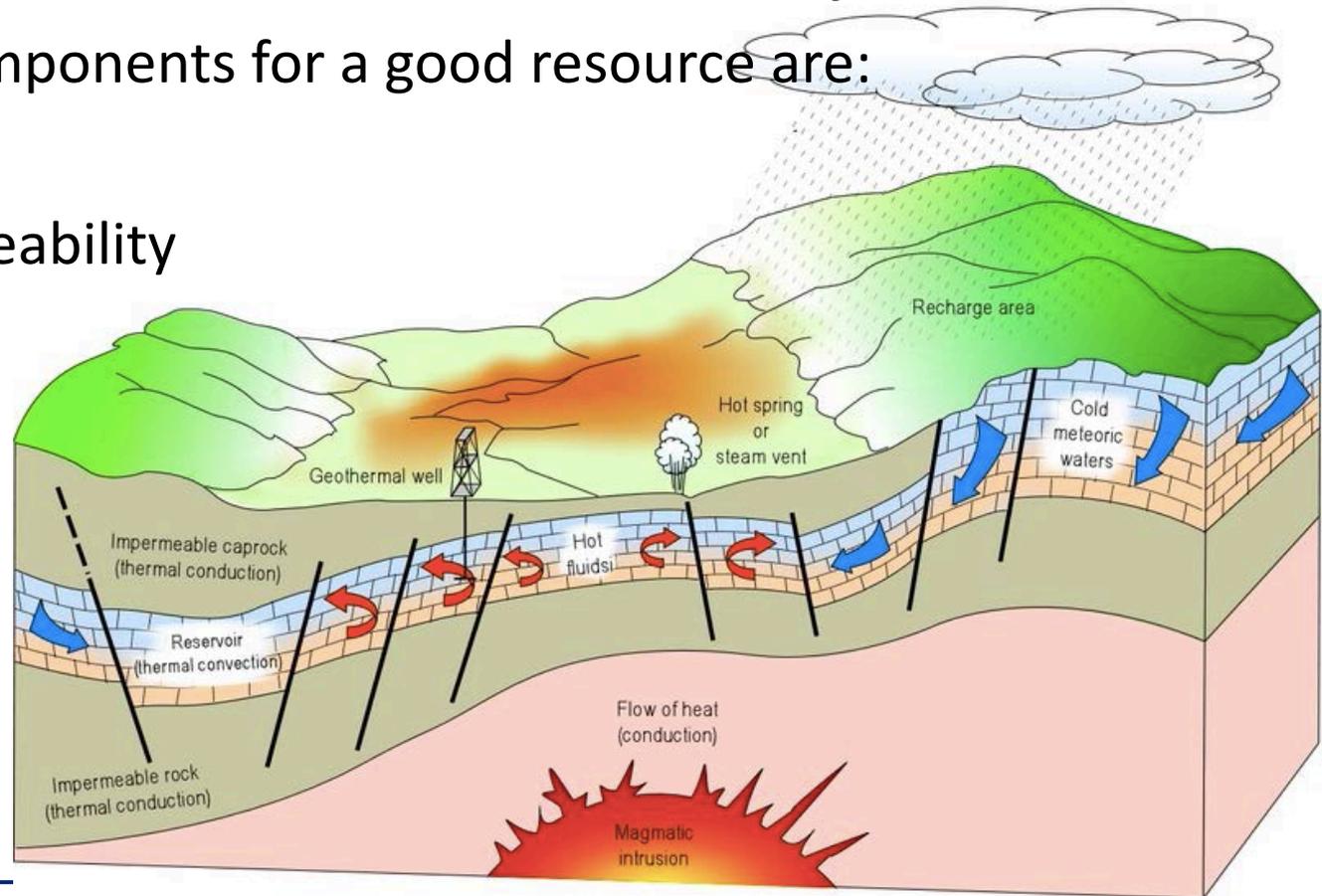


# What is Geothermal?

## An Idealized Geothermal System

Essential components for a good resource are:

- 1) heat
- 2) permeability
- 3) fluid



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# What is Geothermal?

## Types of Geothermal Energy Sources

- Moderate to High Temperature Hydrothermal
  - Volcanic areas (“Ring of Fire”), mid-oceanic ridge (Iceland), African rift, extensional environments (Basin and Range)
  - Mature technology
  - Power production
- Low to Moderate Temperature (the focus of our project)
  - Direct-use of a geothermal resource for any process that requires/rejects heat
  - Shallow to deep, low to moderate temperature sources can be used for Direct-use applications in a cascading system or stand-alone: spas, pools, heating, cooling/refrigeration, snow melting, beer brewing, greenhouses, produce drying, lumber drying, etc
  - Used for thousands of years by indigenous populations (for bathing, cooking, and sacred rituals)

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## What is Geothermal?

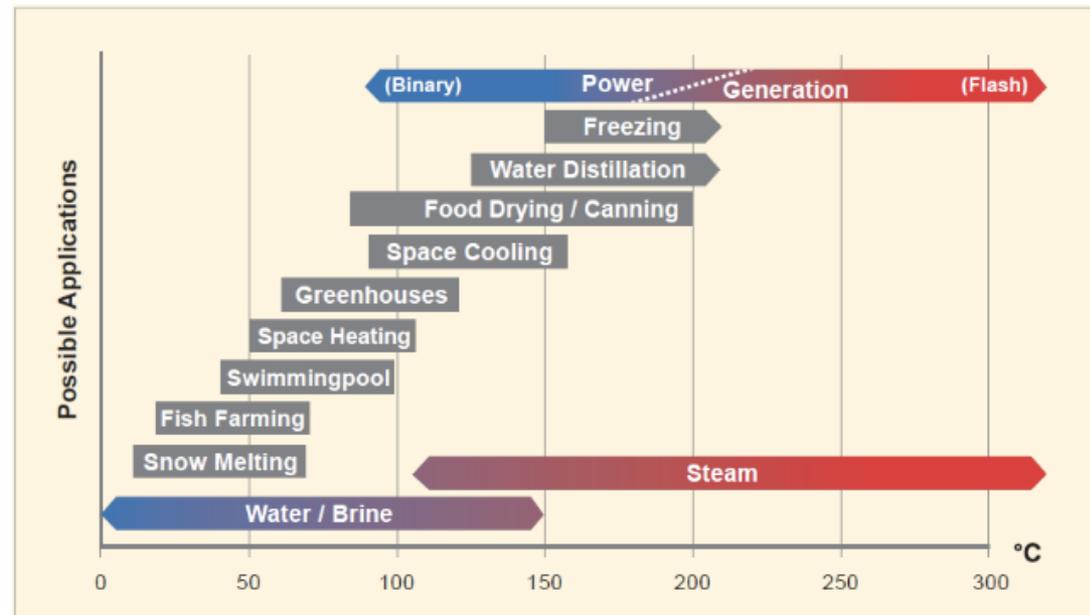
# Types of Geothermal Energy Sources

- Low temperature shallow geothermal (Geoexchange)
  - Shallow low temperature sources can be used for space conditioning (heating and cooling) and hot water: building space heating/cooling, pools, spas, greenhouses, wineries, breweries
  - See **Module 3** for additional info
- Others (in demonstration stage):
  - Geopressured
  - Hot Dry Rock (HDR)/ Enhanced or Engineered Geothermal Systems (EGS)
  - Hot Sedimentary Aquifers (HSA)
  - Co-produced fluids
  - Deep Direct-use (EGS for Heat rather than Power)

# What is Geothermal?

Geothermal resources are often classified by temperature

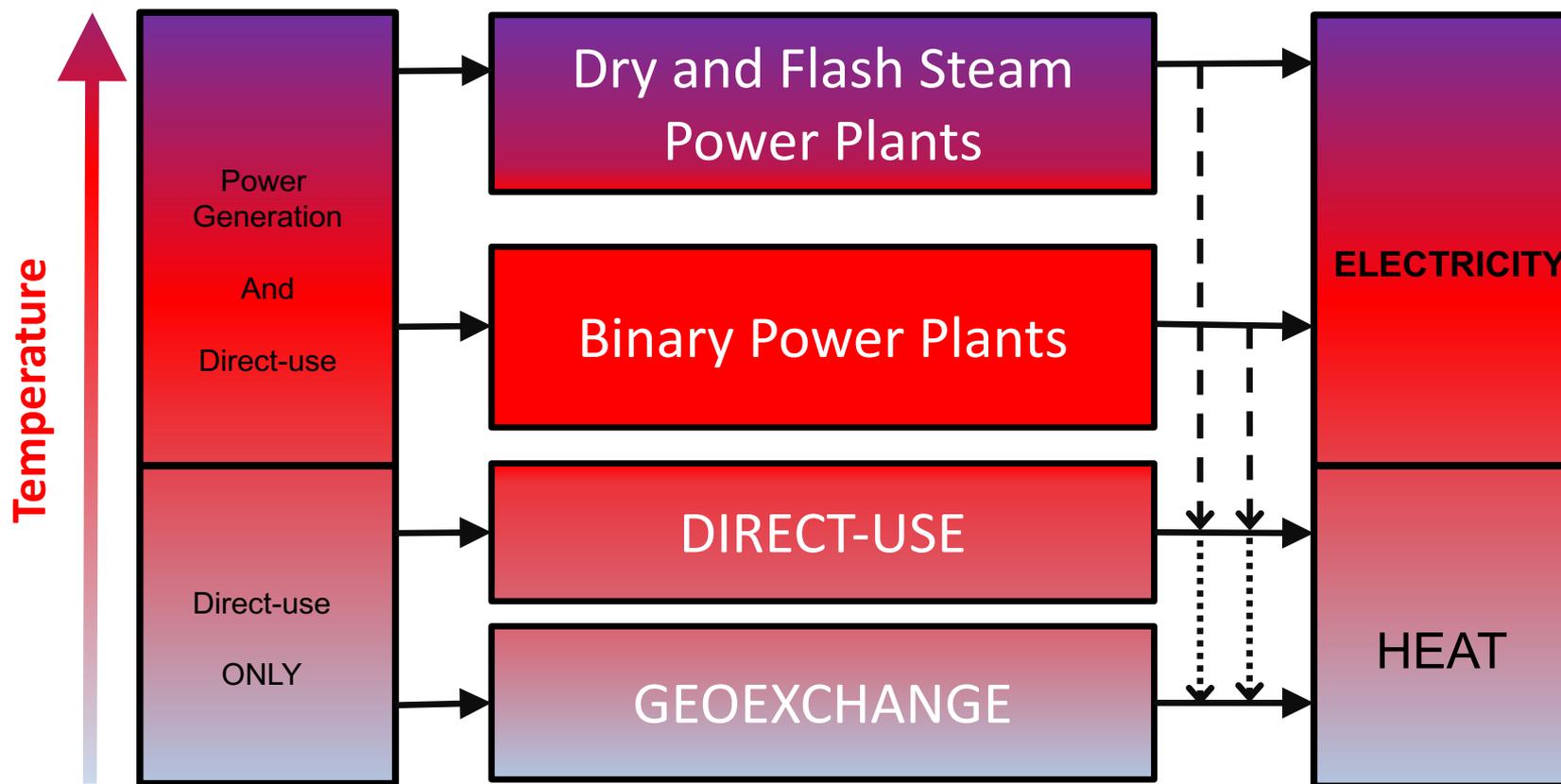
- Low Temperature (< 90° C or 194° F)
- Moderate Temperature (90-150° C or 194-302° F)
- High temperature (>150° C or 302° F)
- (Temperature ranges vary depending on the source of information)



Sources: Geo-Heat Center, Oregon Institute of Technology, ESMAP.org

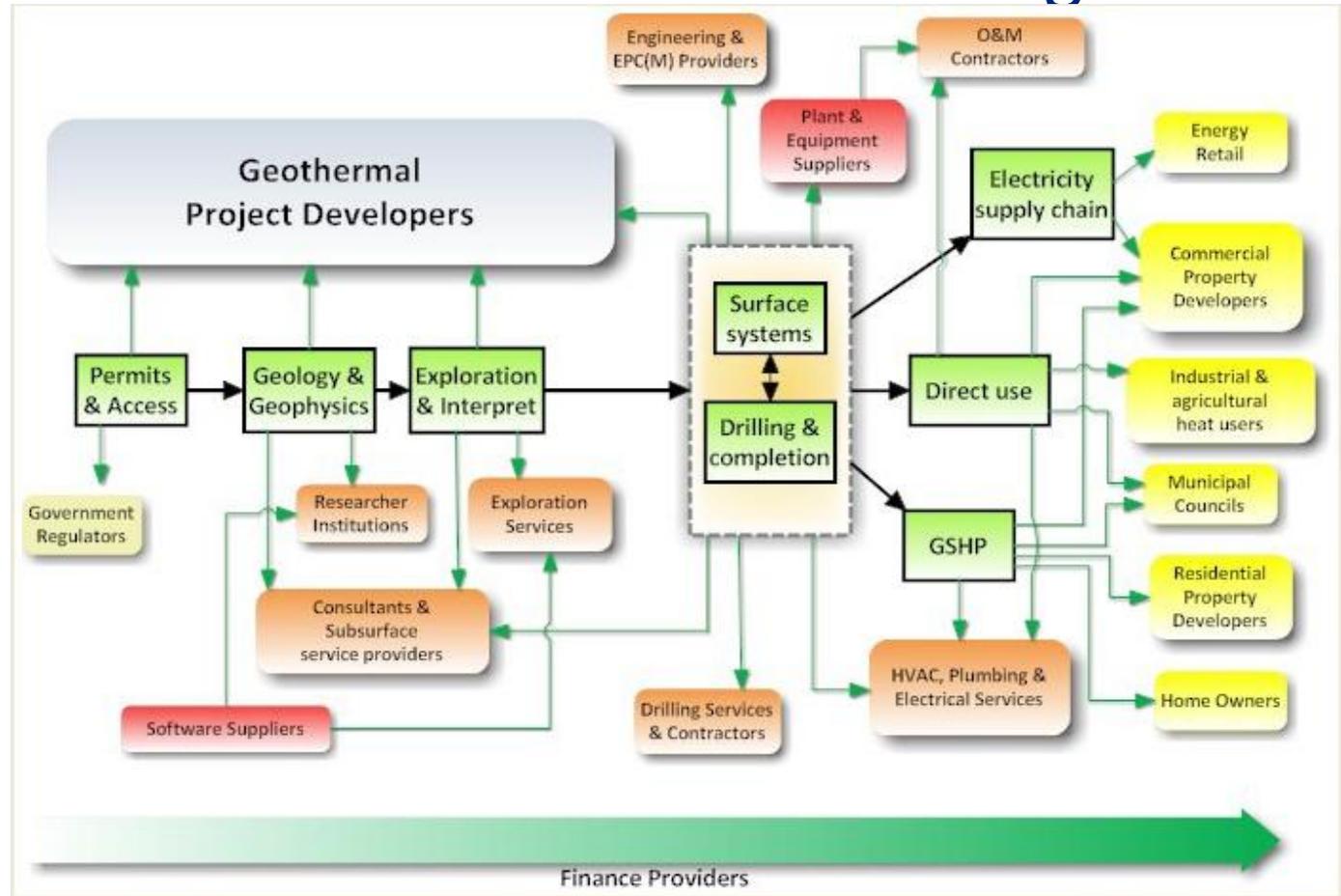
# The Geothermal "Spectrum"

Power Production → Direct-use → GeoExchange (Geothermal Heat Pumps)



# Power → Direct-use → GeoExchange

Ground source heat pump, direct use and geothermal power industry value chain map

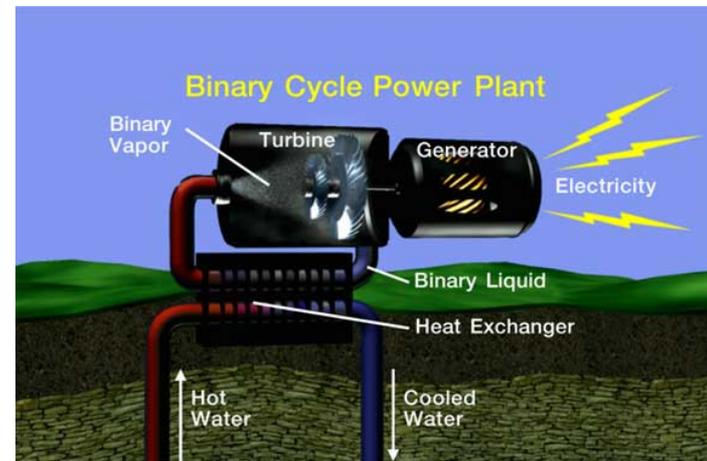
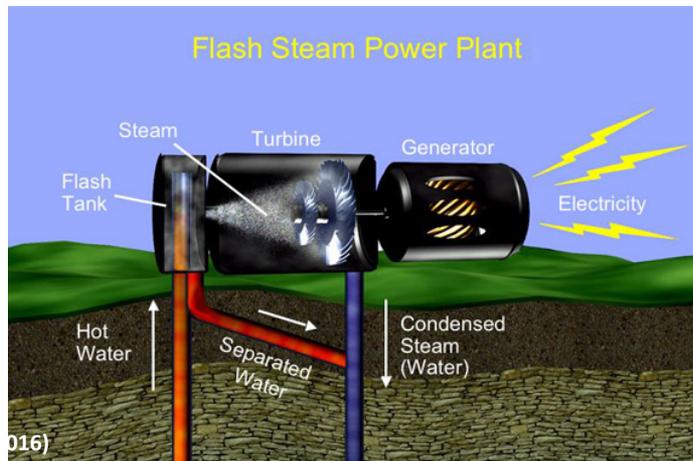
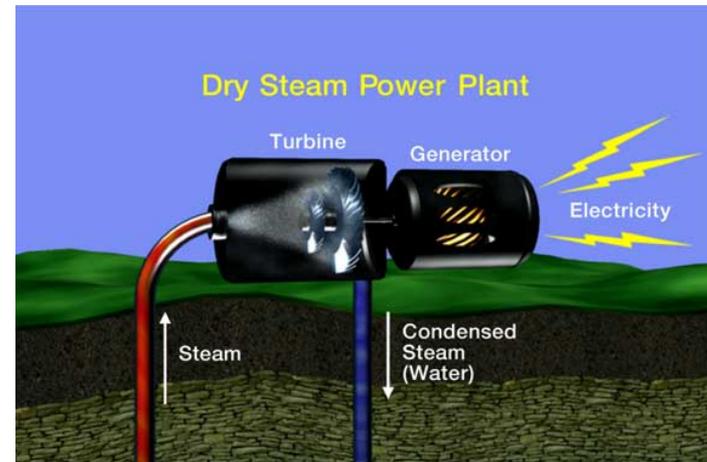


Source: <http://www.ausicom.com/news-419-opportunities-to-exploit-geothermal-energy-begin-to-heat-up>

# What is Geothermal?

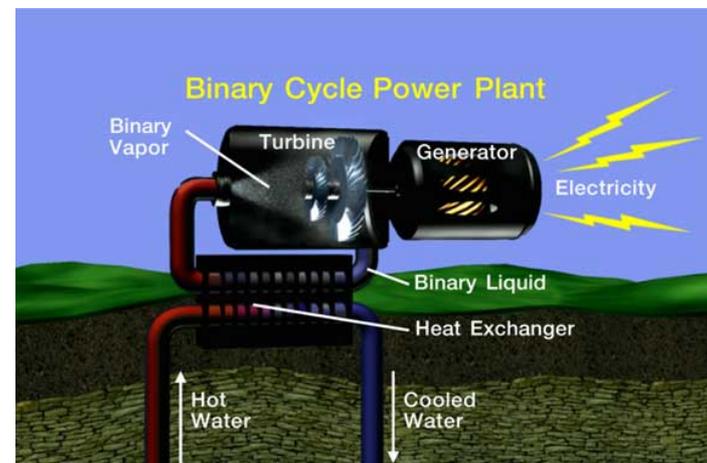
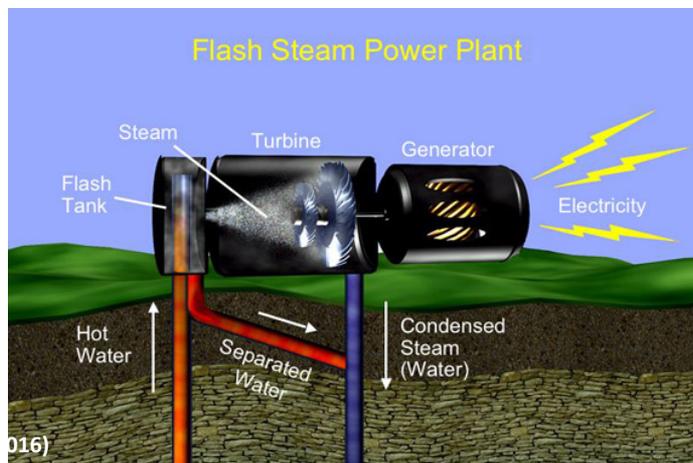
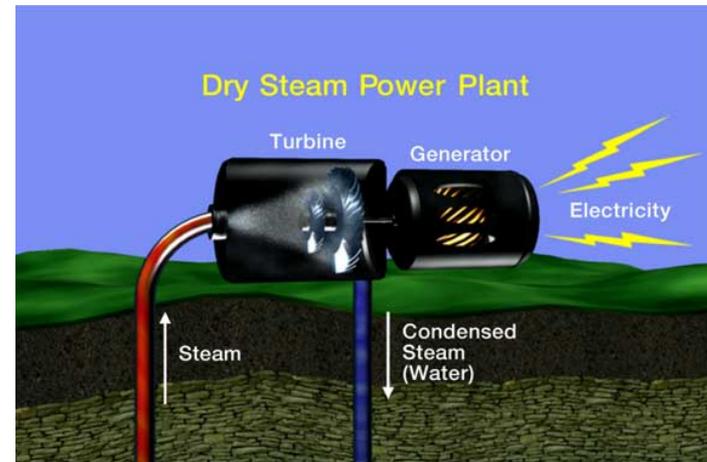
## Types of Geothermal Power Plants

- High to lower temperature options
  - Dry steam power plants are rare
  - Flash steam: hot water produces steam as pressure decreases
  - Binary: “working fluid” with a lower boiling point produces vapor

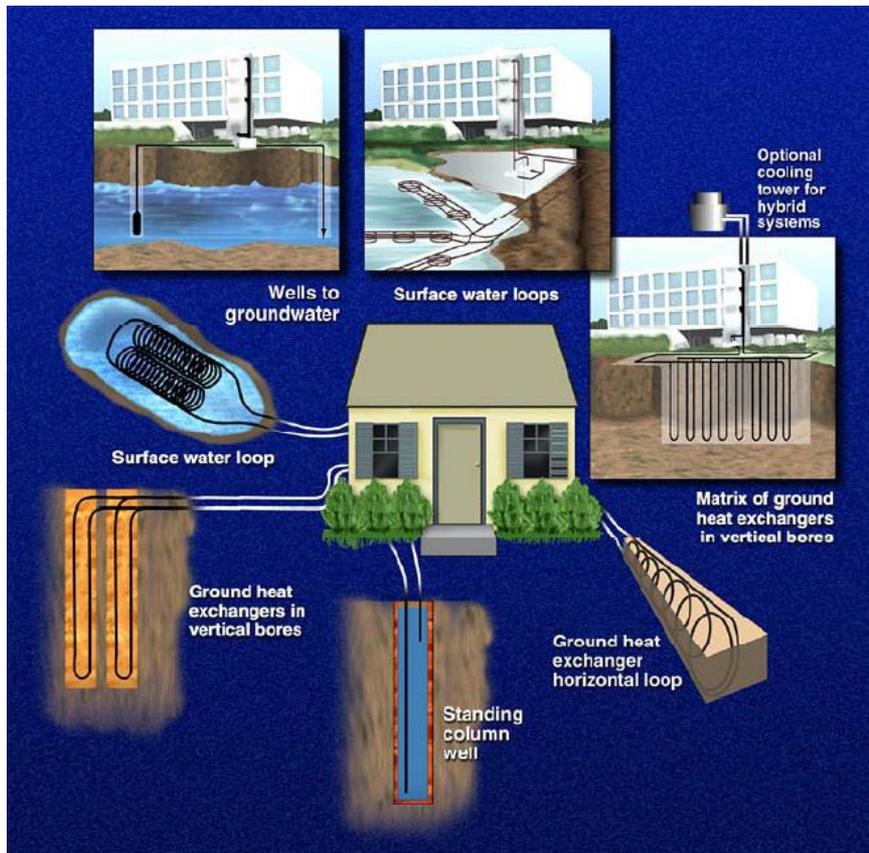


# What is Geothermal?

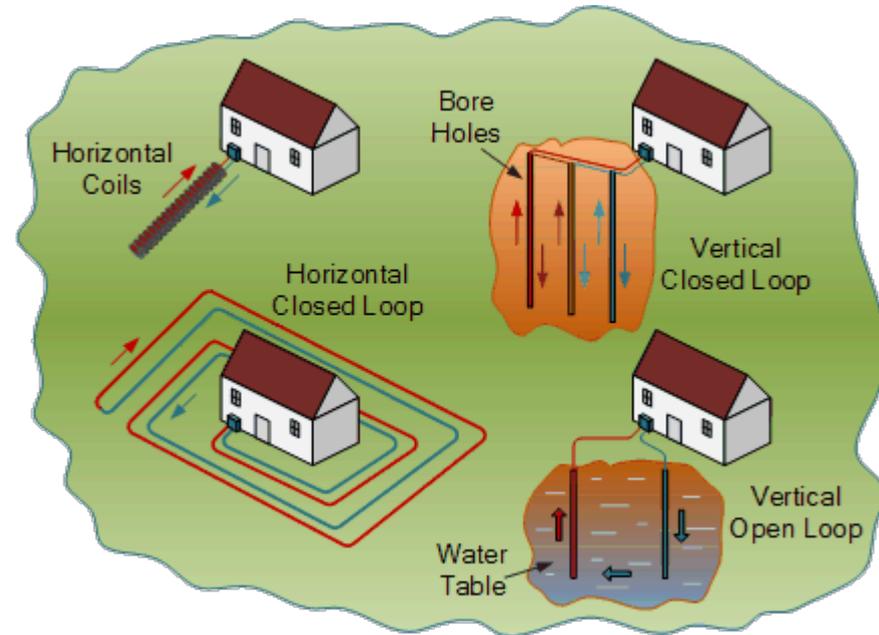
**VIDEO: Geothermal Energy 101**



# Direct-use vs. GeoExchange

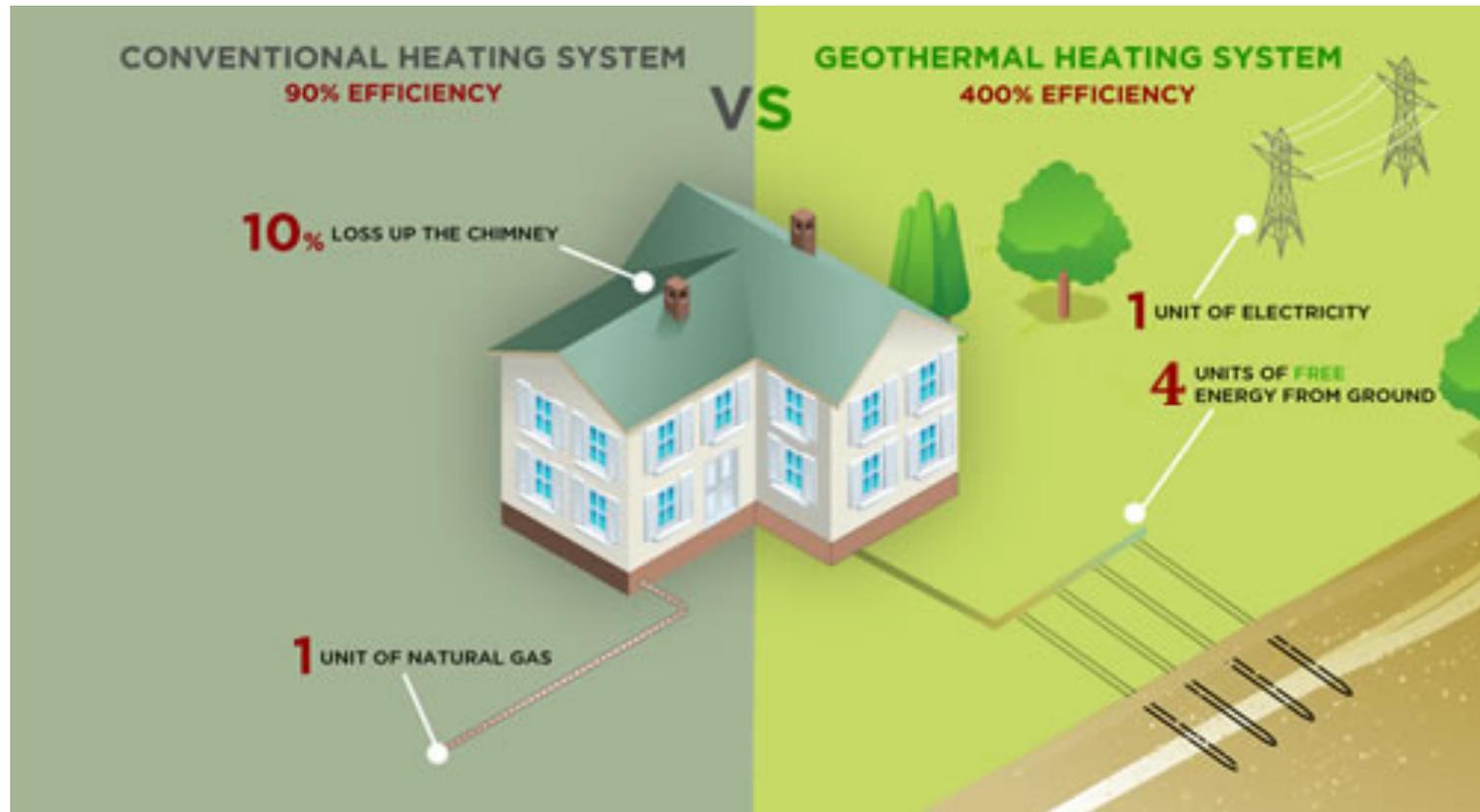


Source: <http://teeic.indianaffairs.gov/er/geothermal/restech/scale/index.htm>



<http://www.alternative-energy-tutorials.com/geothermal-energy/geothermal-energy.html>

# Direct-use vs. GeoExchange



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# GeoExchange vs. Direct-use

## END USE

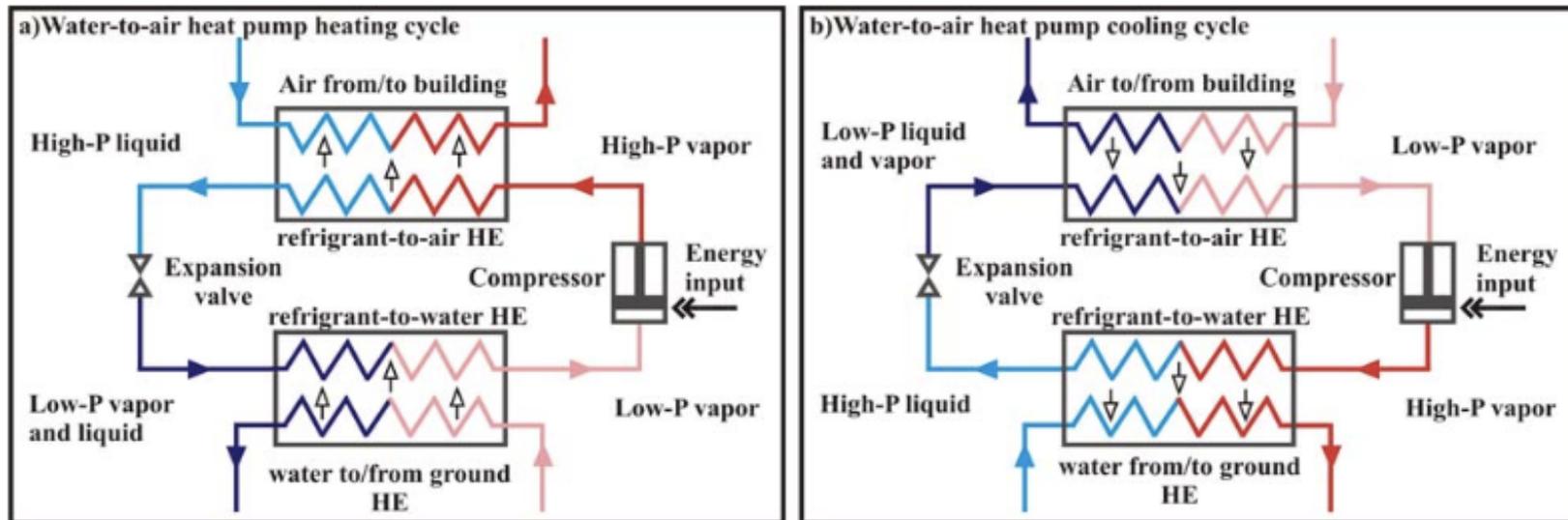
- A temperature spectrum
- Geothermal heat pumps can increase efficiency of a geothermal fluid if the temperature of the fluids is not hot enough ( $\sim <35\text{C}$ ) for the end use
- Direct use applications in the United States have been growing at a rate of about six percent per year and are abundant throughout the western states.
- A hybrid system of both direct-use and heat pumps can be used
  - Similar to a binary power plant, but the working fluid is run through a heat pump instead of a turbine

## LOCATION

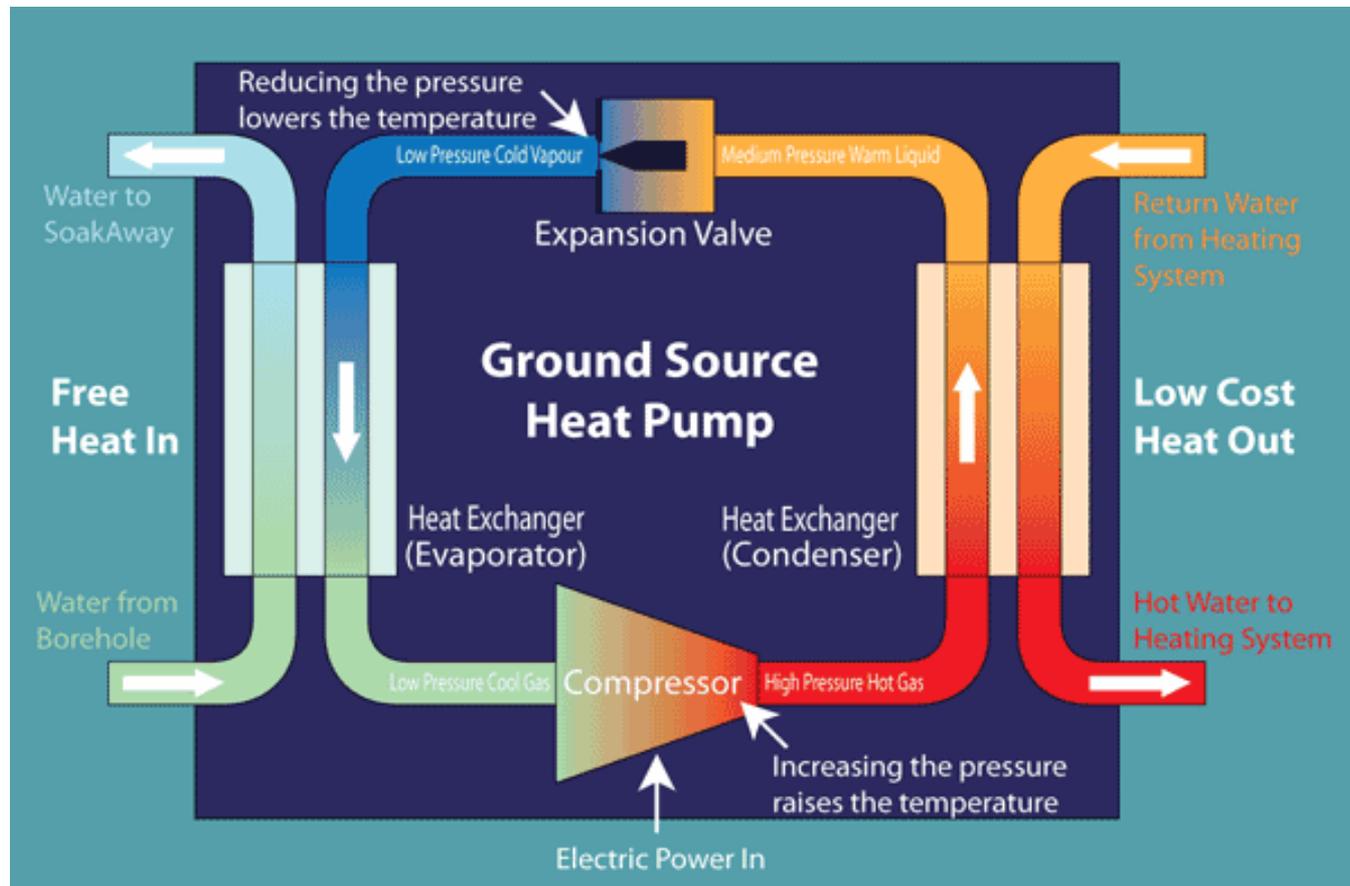
- Geothermal heat pumps can be used essentially anywhere
- Direct-use applications are economically favourable in areas of known higher heat flow/geothermal gradient

# Geothermal Heat Pump – how does it work?

- Transfer of heat from building to ground heat exchanger or vice versa (works for heating or cooling); Heating example below
- Water from ground heat exchanger circulates in heat exchanger where heat from water is transferred to low-pressure refrigerant (mixture of vapor and liquid)
- Refrigerant evaporates in heat exchanger and continues to a compressor where energy input (electricity) is required to increase pressure of the refrigerant, resulting in temperature increase
- High-pressure refrigerant vapor moves towards heat exchanger where refrigerant heat is transferred to air and distributed to building
- Refrigerant condenses in heat exchanges, goes to expansion valve where temperature reduced through pressure decrease
- Low-pressure refrigerant returned to refrigerant-to-water heat exchanger and cycle continues



# Geothermal Heat Pump – how does it work?

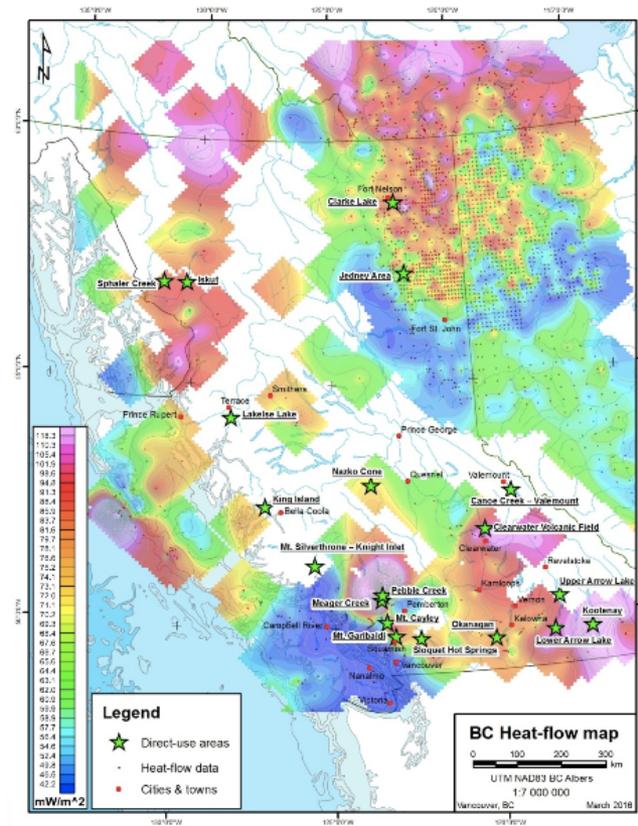


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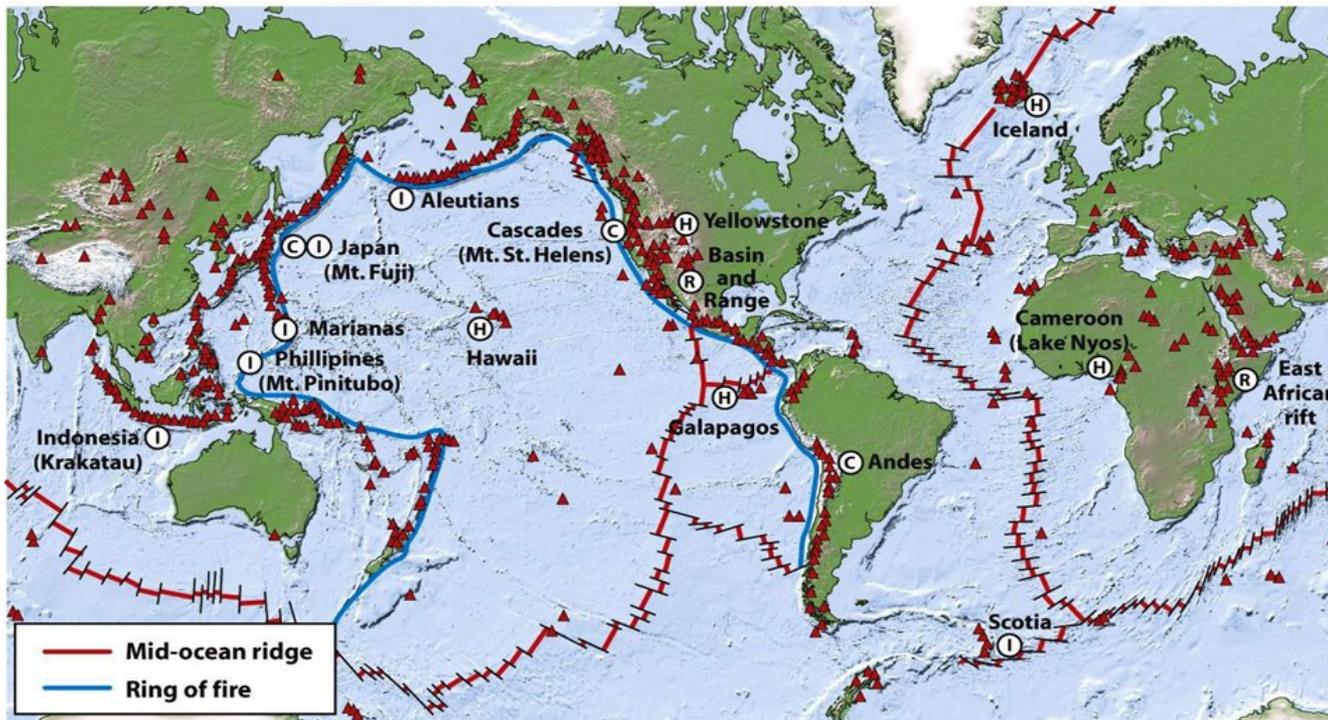
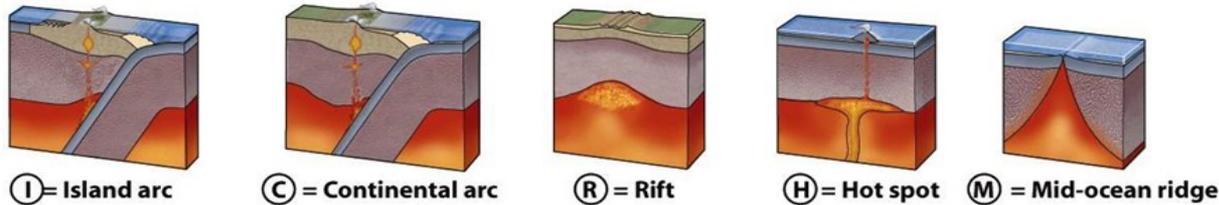
# Geothermal Heat Pump – how does it work?

**VIDEO**

# Where is Geothermal?



# Where is Geothermal?



- distribution of near-surface geothermal (hydrothermal) resources
- Particularly concentrated along the circum-Pacific “Ring of Fire” and other active global plate boundaries
- Western Americas
- Caribbean
- Philippines, Indonesia
- New Zealand
- Iceland
- African Rift Valley

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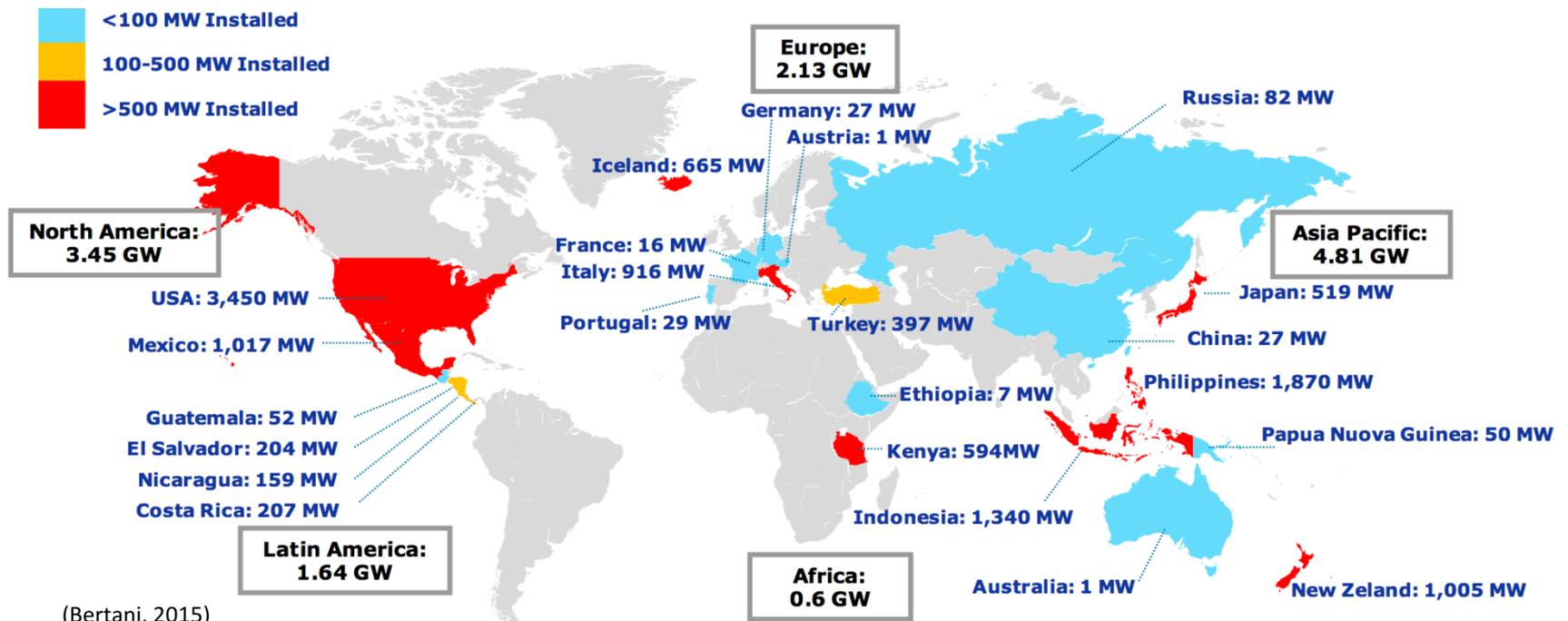
# Where is Geothermal?

## Geothermal Power Worldwide (2015)

- Geothermal power generation is a mature technology
  - History of over 100 years of geothermal utilization
  - Large scale plants operating for 50+ years
- World wide over 12.6 GW of installed generation capacity
- Worldwide growth rate ~ 10%
  - Much higher in some countries
- In several countries, geothermal generation is competitive on cost with other sources (coal, hydro) without subsidies
  - Generation cost commonly in range 7-10 c US/kWh
  - New projects going ahead in NZ at ~ 5 c US/kWh

# Where is Geothermal?

- 12.6 GW installed capacity worldwide (as of 2015)
- Projected 21.5 GW by 2020

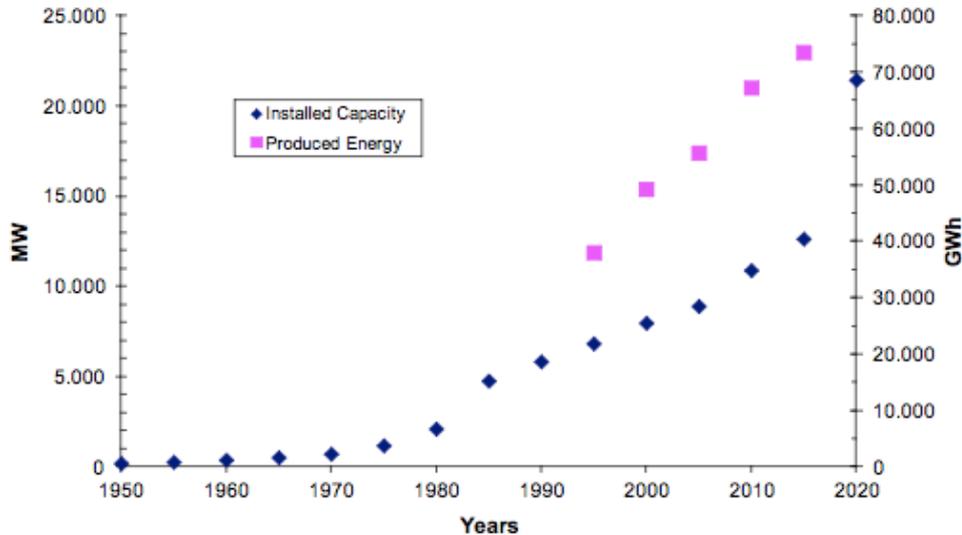


(Bertani, 2015)  
<https://pangea.stanford.edu/ERE/db/WGC/papers/WGC/2015/01001.pdf>

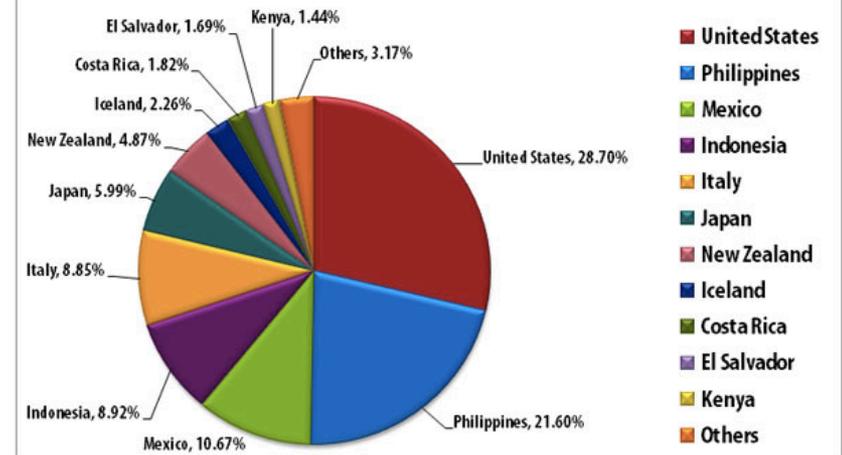
# Where is Geothermal?

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- Projected 21.5 GW by 2020

World Geothermal Electricity



Breakdown of Geothermal Electricity Production



(Bertani, 2015)

(<https://pangea.stanford.edu/ERE/db/WGC/papers/WGC/2015/01001.pdf>)

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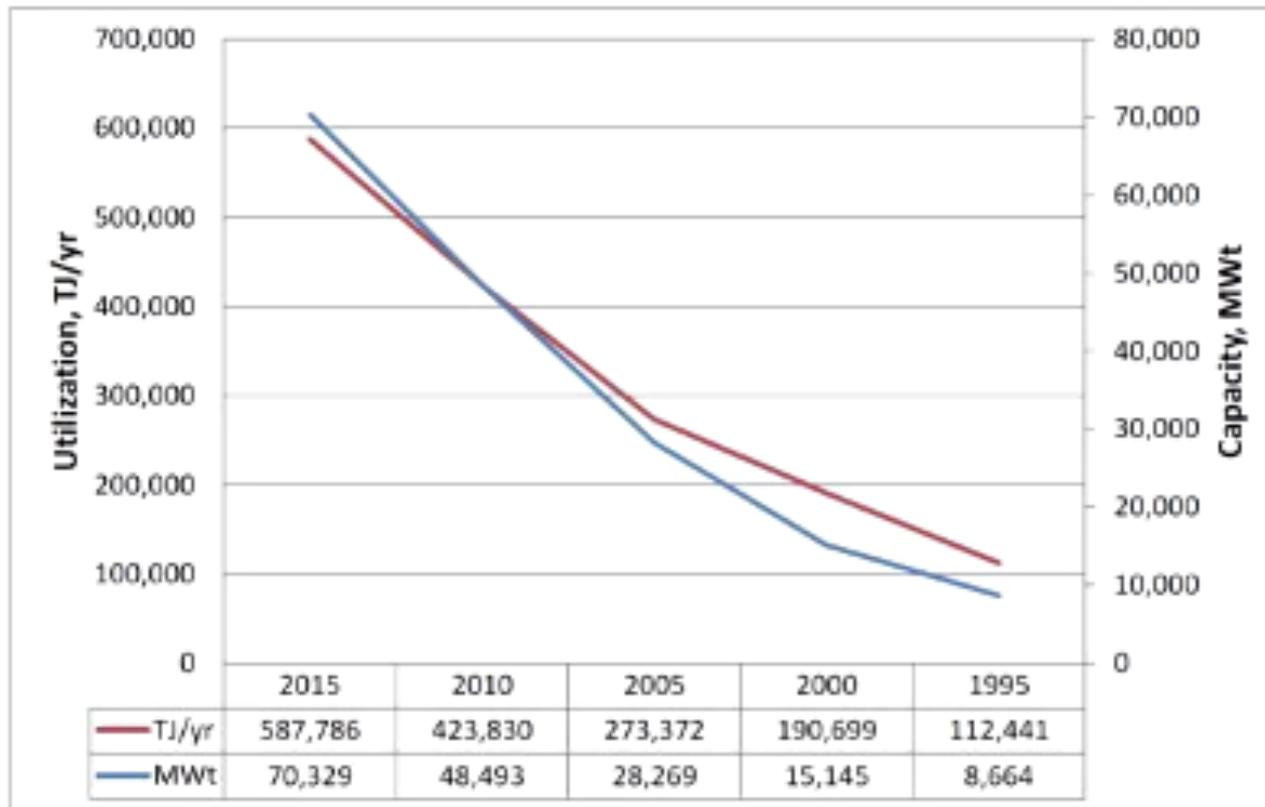
## Where is Geothermal?

### Global Growth of Direct-use Geothermal (2015)

- Canada is 5<sup>th</sup> in direct utilization of geothermal by energy used (TJ/year)
- **45%** global growth since 2010
- Installed capacity 70,330 MWth across 82 countries
  - Up from 48,500 MWth 5 years ago
- Has helped offset 148 million tonnes of CO<sub>2</sub> annually
- Slightly more than ½ of Direct-use geothermal applications globally comes from GeoExchange systems
  - please refer to Module 3 for additional information on **GeoExchange**

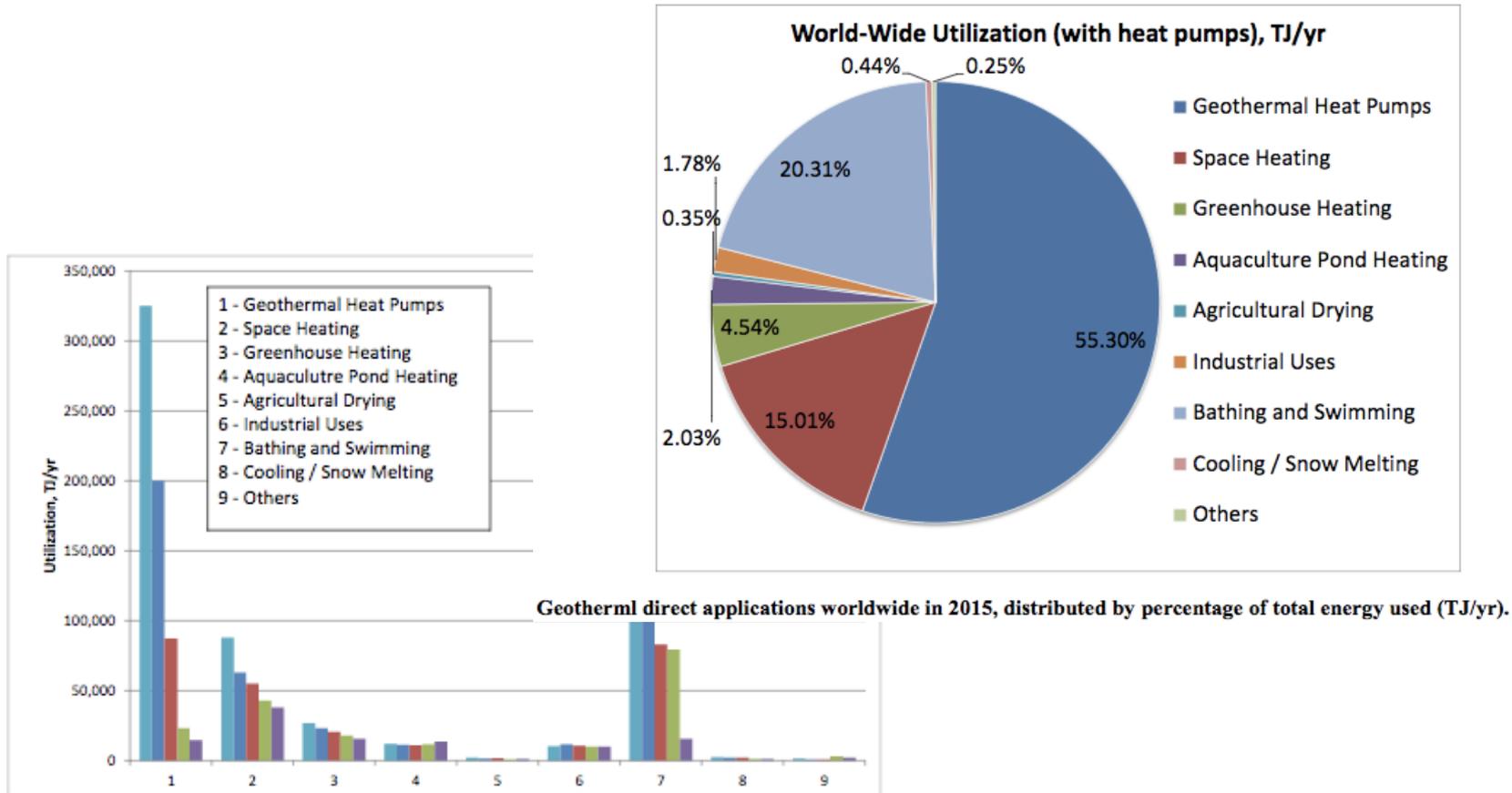
# Where is Geothermal?

## DIRECT-USE GEOTHERMAL GLOBAL GROWTH OVER PAST 10 YEARS



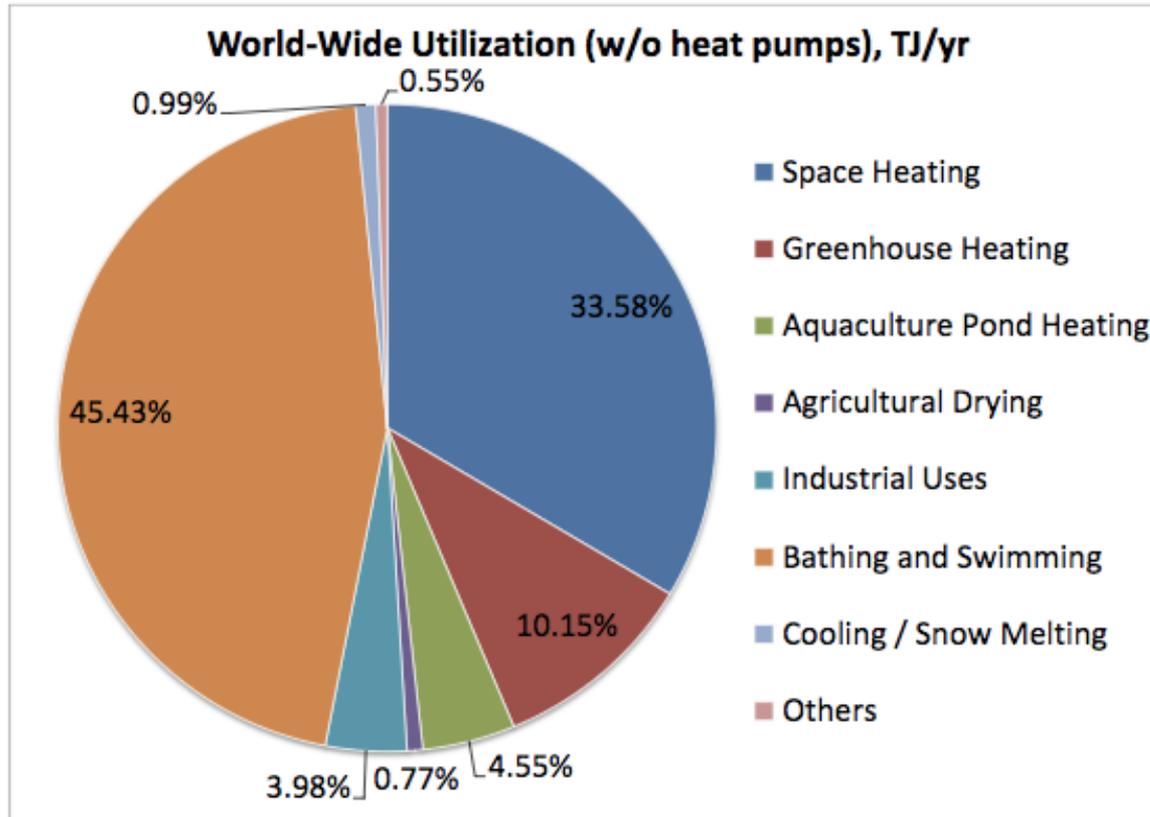
Lund & Boyd, 2015

# Where is Geothermal?



Comparison of worldwide direct-use geothermal energy in TJ/yr from 1995, 2000, 2005, 2010 and 2015.

# Where is Geothermal?



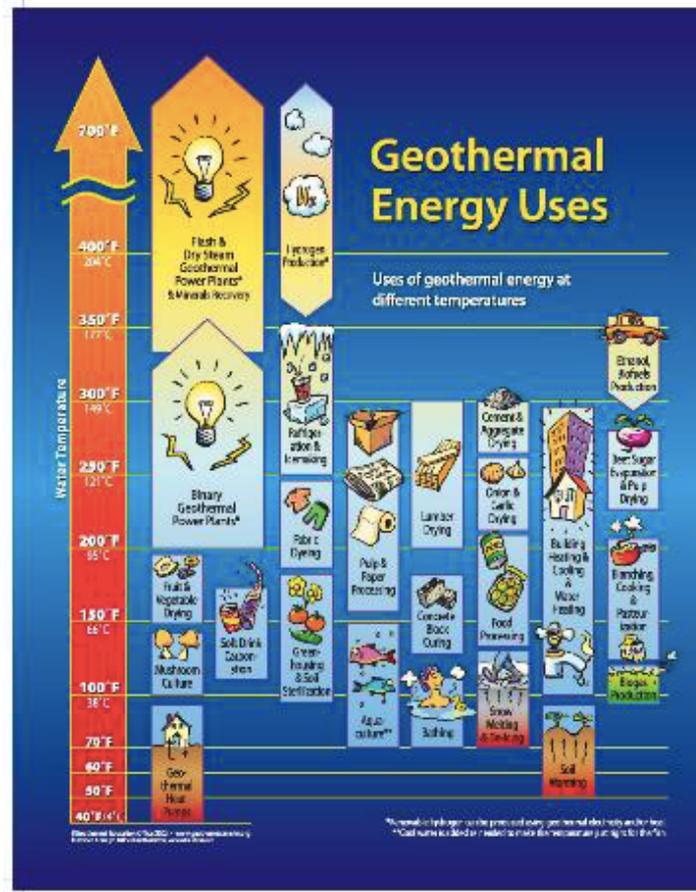
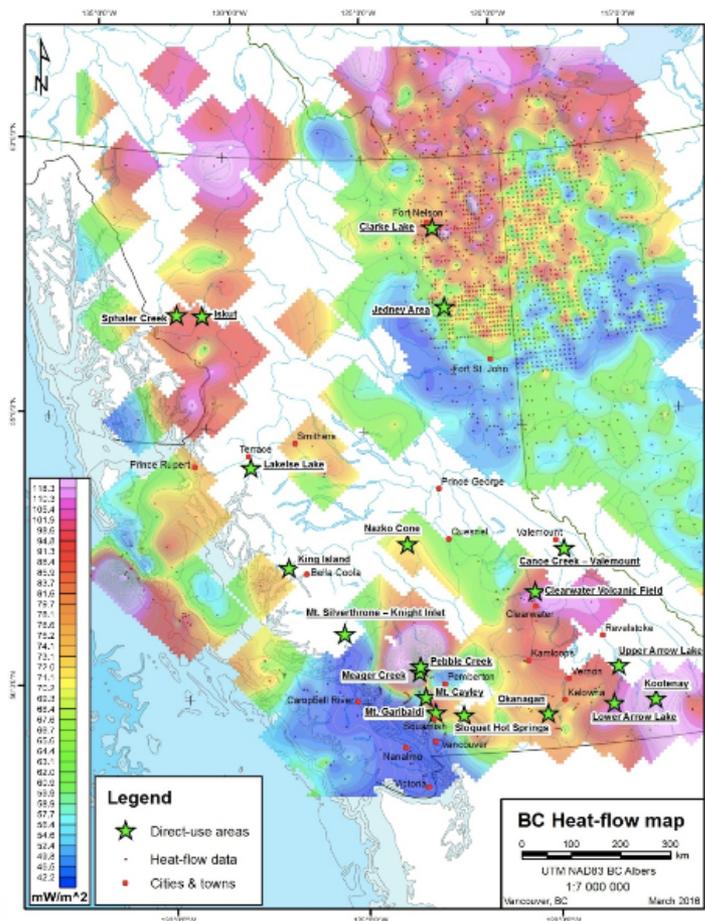
**Geothermal direct applications worldwide in 2015 without geothermal heat pumps, distributed by percentage of total energy used (TJ/yr)**

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## Where is Geothermal? Canadian Direct-use

- Canada is 5<sup>th</sup> in direct utilization of geothermal by energy used (TJ/year)
- more than 140 thermal springs >10C identified in Western Canadian Cordillera
- First Nations were first to use these resources for traditional, sacred uses
- Banff National Park (1<sup>st</sup> national park in Canada) was created in 1885 as result of dispute about right to develop hot springs
- 13 commercial hot springs: Alberta (2), British Columbia (9), Yukon (1), Saskatchewan (1: from a deep hot aquifer)
- Exploitation of shallow geothermal for GeoExchange is concentrated in Ontario and Quebec but installations across the country (avg unit is 14 kW, COP 3.5)
  - 60% residential
- District Energy GeoExchange Systems (Richmond, UBC Okanagan, Gibsons BC)

# Where is Geothermal in BC?

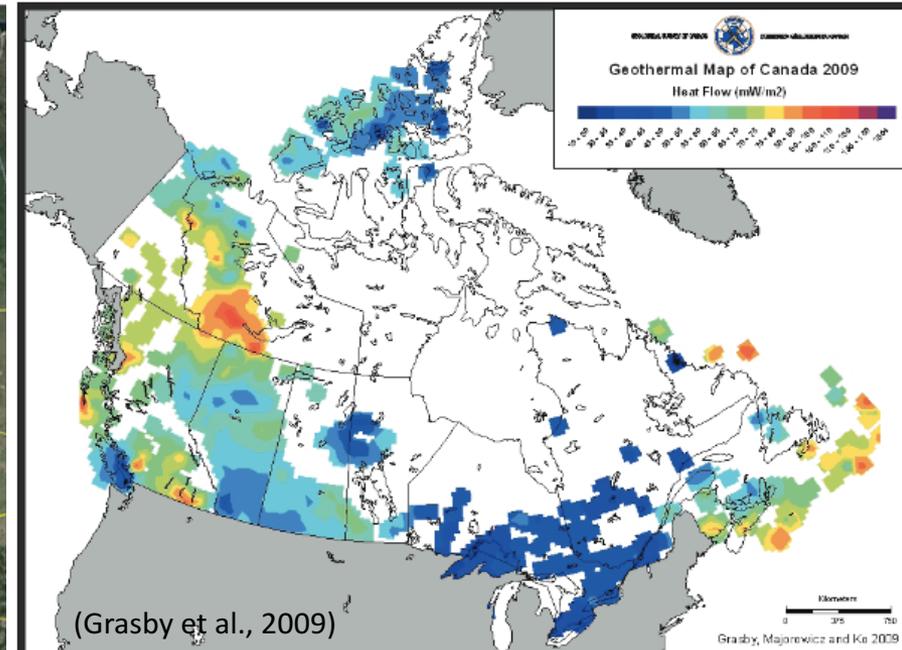
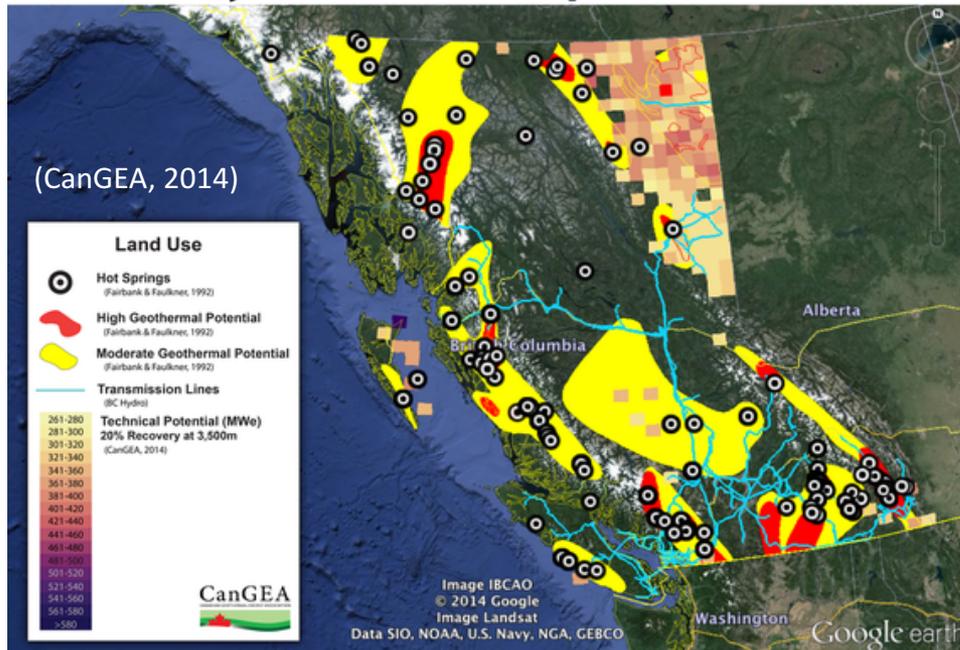


- Many areas in BC have potential
- Electricity and Direct-use (heat)
- Heat flow map updated in 2016
- GeoExchange can be deployed BC wide on an individual unit scale or as district energy system

# Where is Geothermal in BC?

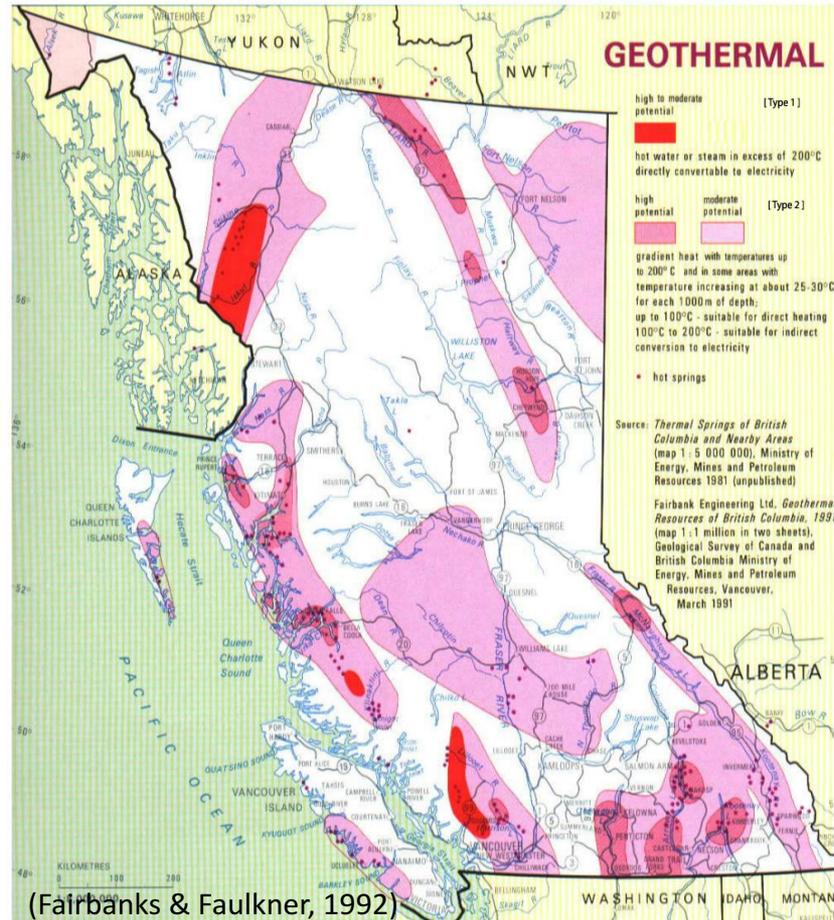
## Previous studies

### Priority Geothermal Exploration Areas



# Where is Geothermal in BC?

Previous studies  
(continued)



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## Why Geothermal?

### **WHY ISN'T GEOTHERMAL ENERGY MORE WIDELY KNOWN & USED?**

- Lack of awareness of the resource and how it can be used
- Lack of incentives and government policies to make it competitive with alternatives
- Relative inexpensive use of natural gas and biomass for heating (and hydro for electricity)
- Current levelized cost of energy (LCOE) does not take into consideration social and environmental impacts

### **WHY SHOULD WE CARE ABOUT USING GEOTHERMAL?**

- Local jobs, local economic development
- Entrepreneurship “gold mine” – bring green, sustainable marketing ideas to life
- Cascading uses: power, industrial drying, hot spring resort, heat greenhouses, brewery, pavement-melting, etc
- Ecotourism: nature conservation and sustainable tourism in geothermal areas

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# Why Geothermal?

## **BENEFITS OF DIRECT-USE GEOTHERMAL**

- Generally the most efficient use of a geothermal resource as no energy is lost in energy conversion
- Heat from ground is used as heat in the application
- Caveat: typically needs to be used close to source unless there is large flow and high temperature
- Low-cost heat for business and communities
- Minimize or eliminate greenhouse gas emissions
- Local food security
- **Reliable, proven technology**
- **Clean, green and sustainable**
- **Cost-competitive**

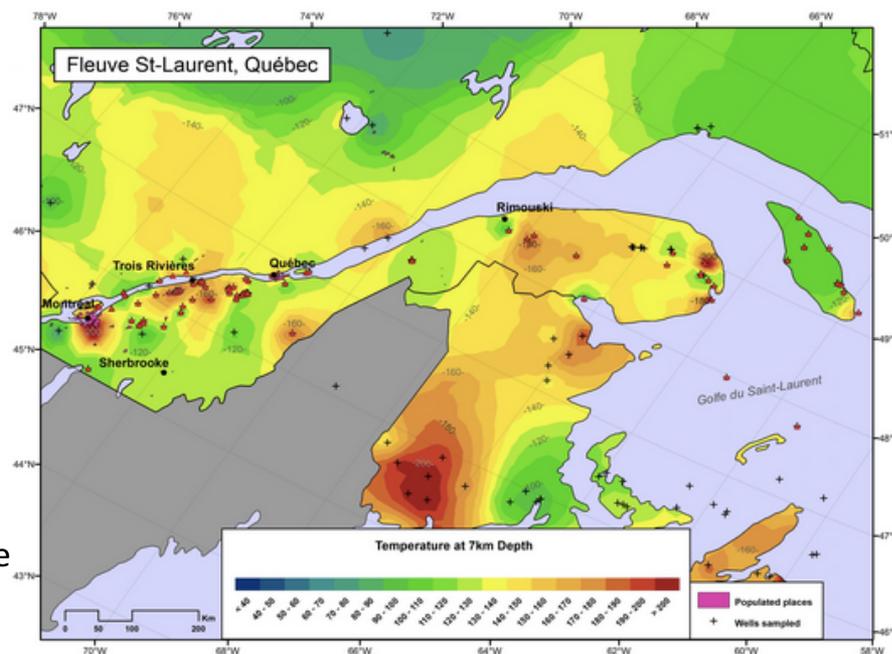
# Why Geothermal?

## GEOTHERMAL ENERGY IN THE NEWS IN CANADA

- Canada is the #5 largest producer of geothermal DIRECT-use in the world
  - Hot spring resorts in Yukon, BC, Alberta and Saskatchewan (!)
  - Fish farms in Yukon and BC
  - Tar manufacturing using geothermal cooling in Alberta
  - Solar-hybrid community storing solar heat in summer to heat homes in winter using geothermal heat pumps (Drake Landing, Alberta)
  - Manitoba, Ontario and Quebec – largest deployment of geothermal heat pumps
  - Using geothermal waters in an abandoned mine to heat a community (Springhill, Nova Scotia)
- “Alberta Government Eyes Geothermal Fix to Abandoned Well Crisis” , Alberta Oil Magazine, published October 5, 2016
  - <http://www.albertaoilmagazine.com/2016/10/alberta-government-eyes-geothermal-fix-abandoned-well-crisis/>
- “Canada Has Enormous Geothermal Potential. Why Aren’t We Using it?”, DeSmog Canada, published April 27, 2016
  - <http://www.desmog.ca/2016/04/27/canada-has-enormous-geothermal-potential-why-aren-t-we-using-it>

# Geothermal Funding in Canada (Quebec)

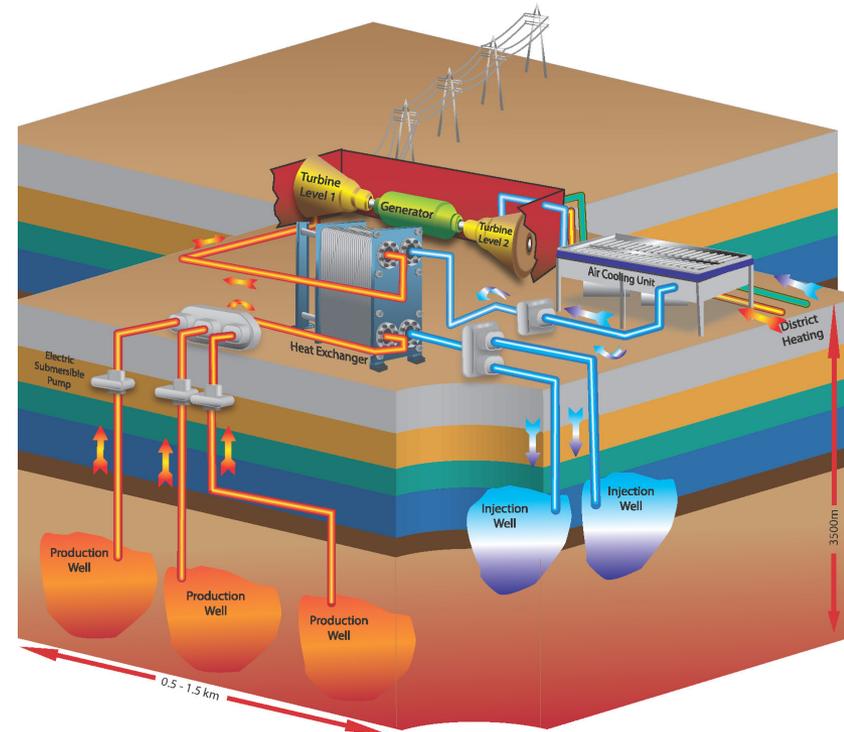
- Integration of deep geothermal energy in Canada's energy portfolio, Quebec
- <http://www.nrcan.gc.ca/energy/funding/current-funding-programs/eij/17114>
- **Lead Proponent:** Institut de recherche d'Hydro-Québec (IREQ)
- **Project Total:** \$ 2,910,000
- **Objective:** study the potential for deep geothermal (EGS – Enhanced Geothermal System) for electricity production in Québec and Atlantic Canada
- **Benefit:** will make it possible to characterize an emerging technology of interest and to provide the foundations necessary for its development
- **Status:** Project currently in progress



Map of temperatures at a 7 km depth along the St. Lawrence River valley (note: average temperatures are identified based on the colour scale as well as values indicated directly on the map).

# Geothermal Funding in Canada (Saskatchewan)

- **Front End Engineering Design (FEED) Study: Williston Basin Low Temperature Geothermal Demonstration, Saskatchewan**
- <http://www.nrcan.gc.ca/energy/funding/current-funding-programs/eii/16150>
- **Lead Proponent:** Deep Earth Energy Production Corp.
- **Project Total:** \$ 2,084,485
- **Objective:** the design of a 10 MW gross geothermal power plant with an expected net output of 5 MW
- **Benefit:** A greater understanding of the technical and financial viability of producing power from low temperature geothermal reservoirs across Canada.
- **Status:** Demonstration project is financially viable and that potential environmental effects could be mitigated with best practice measures.
- **Next step:** drill and test a proof of concept production well and an injection well to verify the reservoir characteristics



DEEP Geothermal Process

## Geothermal Funding in Canada (Alberta)

- Conversion of an abandoned oil & gas well to geothermal – a 1<sup>st</sup> for Canada
- Leduc #1 – Living Energy Project
- Demonstration project showcasing geothermal, wind, solar
- More than 77,000 wells in Alberta listed as inactive, over 180,000 are abandoned
- Converting them to geothermal systems would put drilling and service companies back to work
- Can provide heat and power on a micro-generation or distributed grid system
- Off-the-shelf geothermal generators can be skid-mounted and costs US \$250,000 to \$350,000
- <http://www.albertaoilmagazine.com/2016/10/alberta-government-eyes-geothermal-fix-abandoned-well-crisis/>
- <http://www.desmog.ca/2016/08/25/geothermal-picks-up-steam-alberta-proposal-retrofit-abandoned-oil-wells>



## Geothermal Funding in Canada (BC)

- **Optimized geothermal exploration, BC (Lakelse area), awarded 2013**
- [https://www.sdtc.ca/uploads/2015/releases2011-2013\\_EN.pdf](https://www.sdtc.ca/uploads/2015/releases2011-2013_EN.pdf)
- **Lead Proponent:** Borealis Geopower
- **Project Total:** \$ 2.4 Million
- **Objective:** A significant barrier to exploiting geothermal energy is financing exploration (current approach often fails to provide feasible return on investment). Optimized geothermal exploration methodology – a carefully ordered set of processes and technologies to provide an accurate picture of a geothermal resource, allowing the drilling of production wells precisely where they have the highest probability of hitting commercially-viable amounts of hot water.
- **Benefit:** By 2020, this technology should enable 310 MW of cumulative generation capacity.



# The Geothermal “Spectrum”

Power Production → Direct-use → GeoExchange (Geothermal Heat Pumps)

