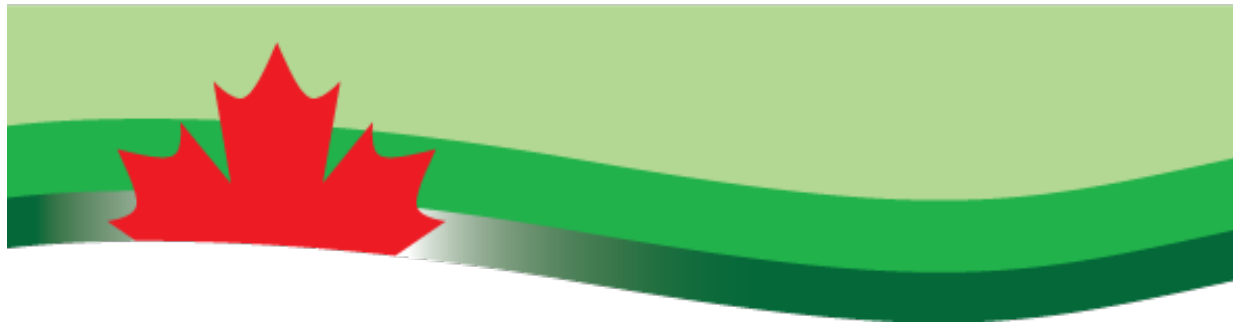


CanGEA

CANADIAN GEOTHERMAL ENERGY ASSOCIATION



GEOHERMAL 101

SCOTT ANDREWS, MSC.

CANGEA OPERATIONS MANAGER

WHO IS CanGEA?

Canadian Geothermal Energy Association



Industry Association

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



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

ROLE OF AN INDUSTRY ASSOCIATION



Increase “Investor/Stakeholder” Confidence

Government Relations

- The leading participant in discussions on geothermal power policy

Research

- Policy studies: Establishing a foundation for the geothermal industry within the larger energy community
- Technical research: Working collaboratively with Universities and other research centers

Networking and Events

- Facilitating business development opportunities in the geothermal industry

Outreach

- Hosting educational seminars in communities with geothermal power potential
- Developing informative digital and print material to cultivate wider public awareness of geothermal power



GEOHERMAL 101

OUTLINE

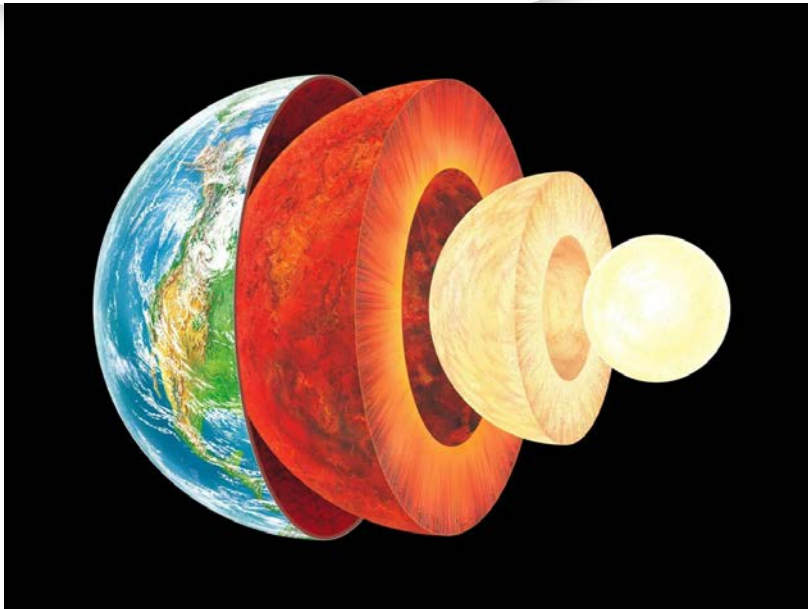
- What is it?
- Types of Geothermal
- World Resources
- Canada's Resources
- Geothermal Power & Direct Use
- Fit with Oil and Gas & Mining
- Member Projects
- Bring the Heat, Canada!



GEOHERMAL = EARTH HEAT

Primordial Heat

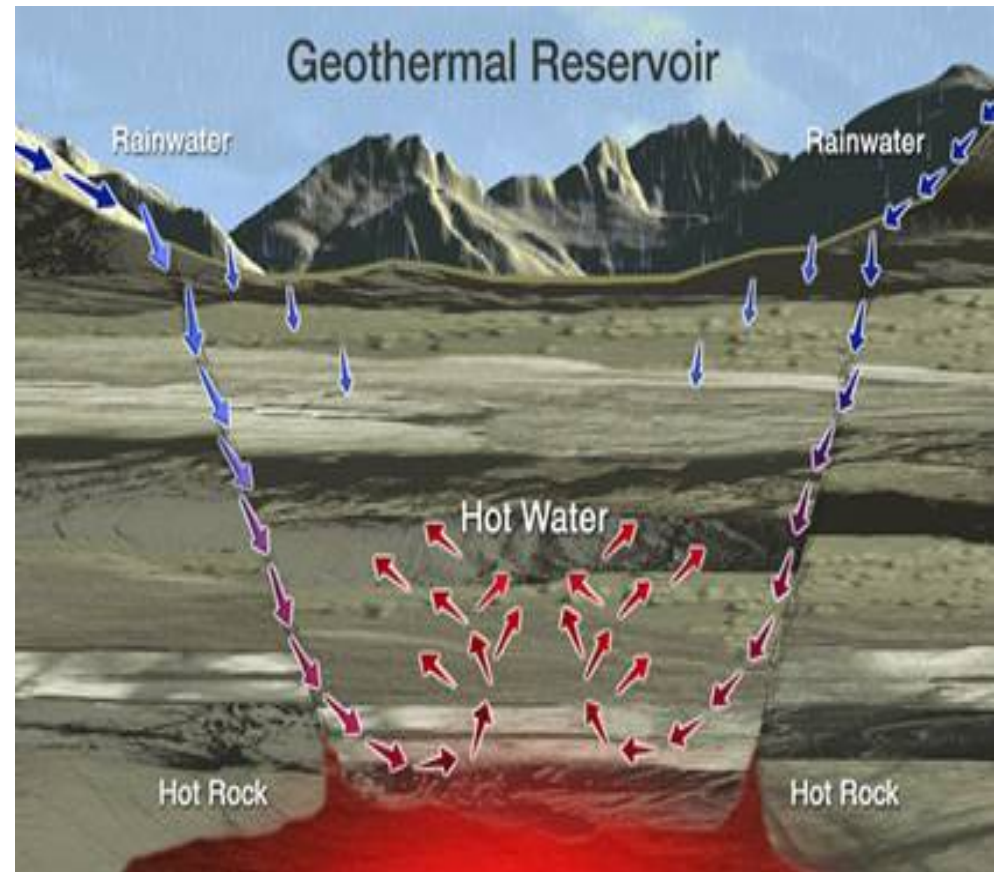
From the Initial Formation of the Earth, 4.6Ga



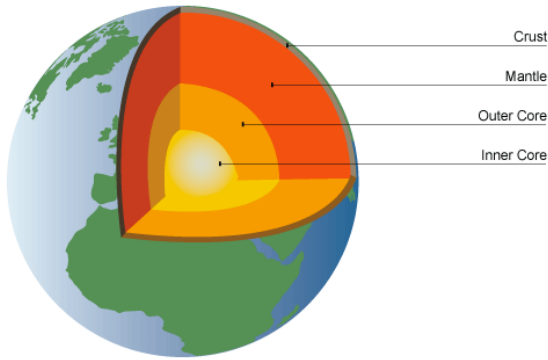
Why is the Earth hot?

Radiogenic Heat

Heat resulting from the decay of naturally occurring radioactive elements in the

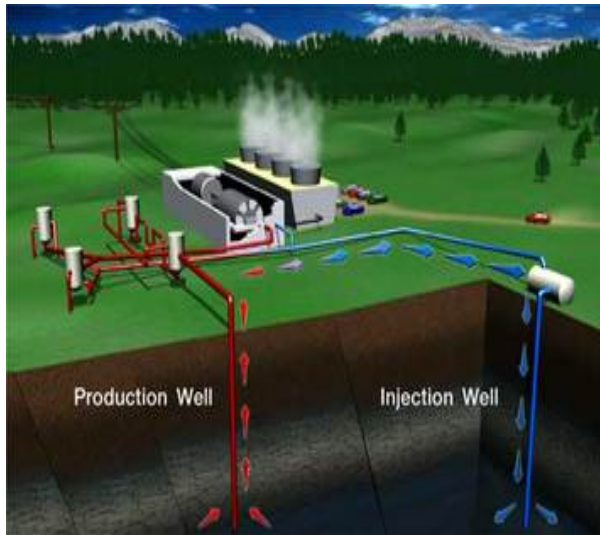


GEO THERMAL



Earth

A Geothermal Power Plant

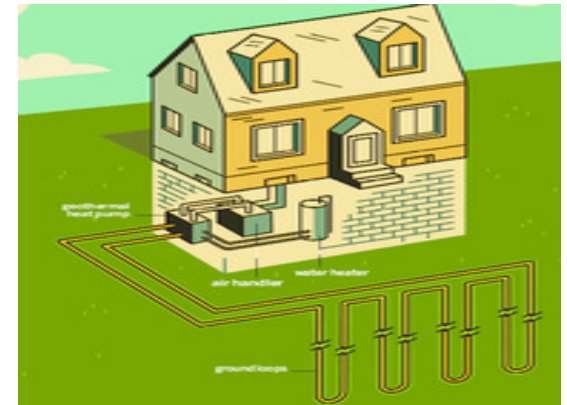


GEO EXCHANGE



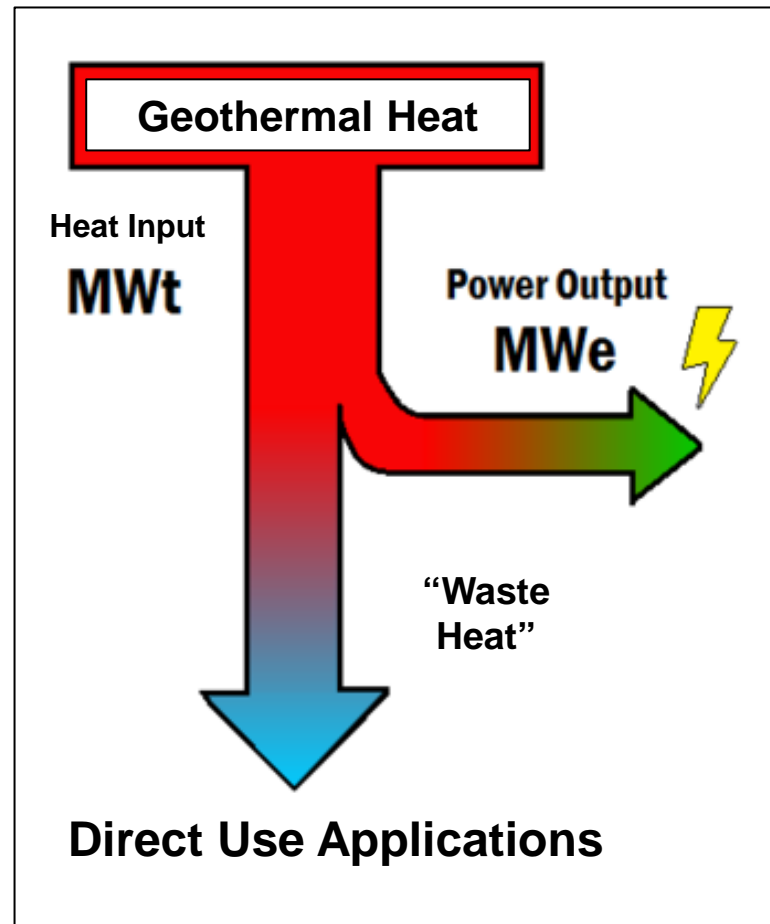
Sun

A Geo-Exchange Heating/Cooling Unit

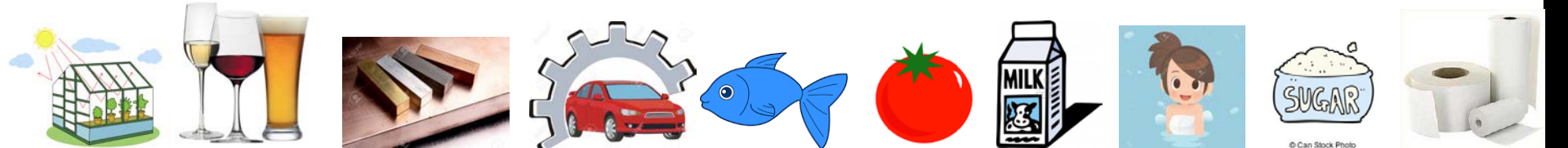


The difference is temperature moderator (geo-exchange) vs. a positive thermal source (geothermal)

GEO THERMAL IS A HEAT RESOURCE



*Conversion
Efficiency 5-
20%*



HOW GEOTHERMAL SYSTEMS WORK

..... Natural Geothermal Systems

To generate power from natural geothermal systems you need:



Abundant heat
found in rocks at
depth

+



Fluid to carry heat
from the rocks

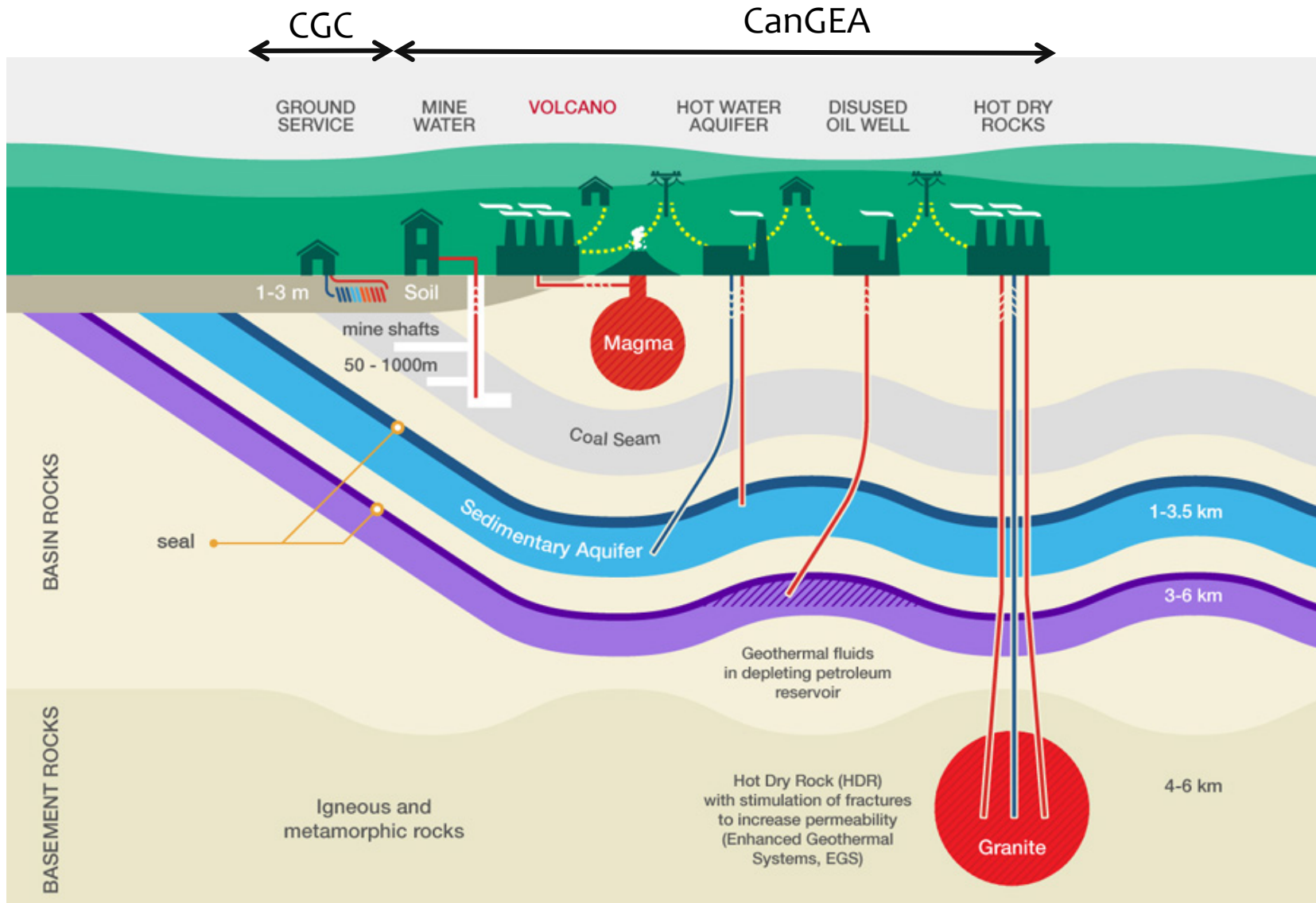
+



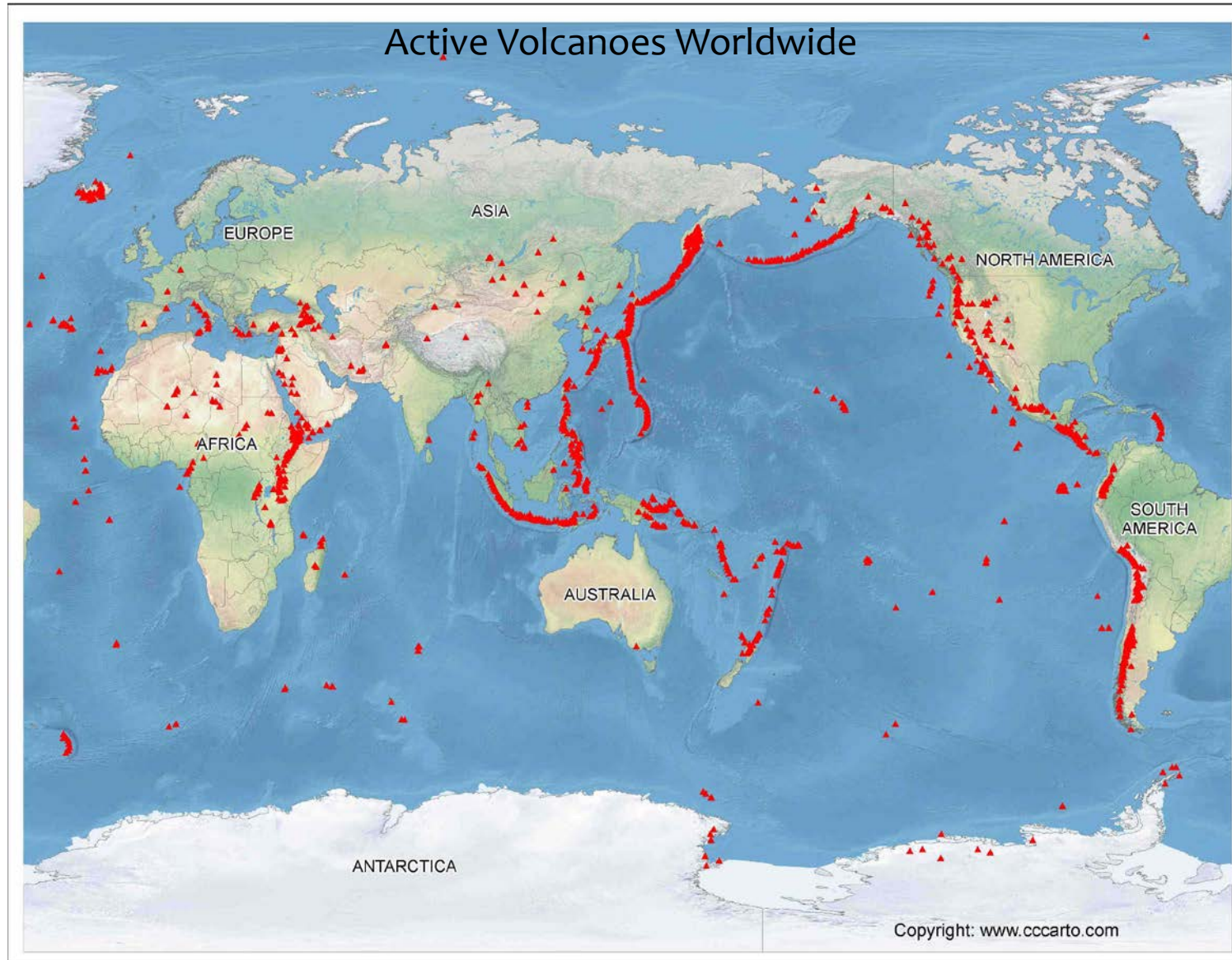
Small pathways to
conduct fluid through
the hot rocks

US DOE, 2015

TYPES OF GEOTHERMAL



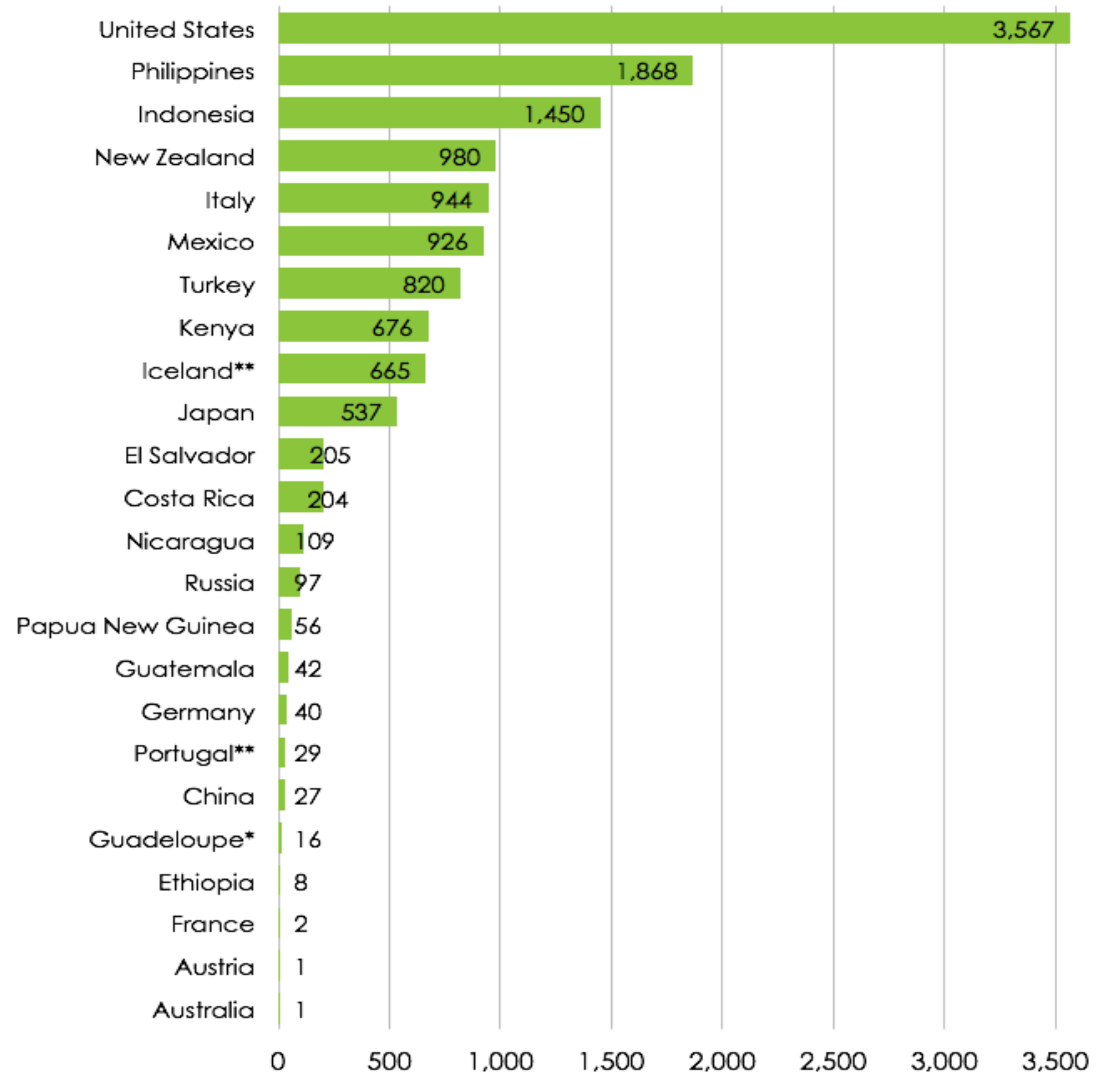
WHERE IS THE EARTH HOTTEST?



WORLDWIDE GEOTHERMAL POWER PRODUCTION

GEOTHERMAL COUNTRIES

Installed power generation capacity (Jan 2017)

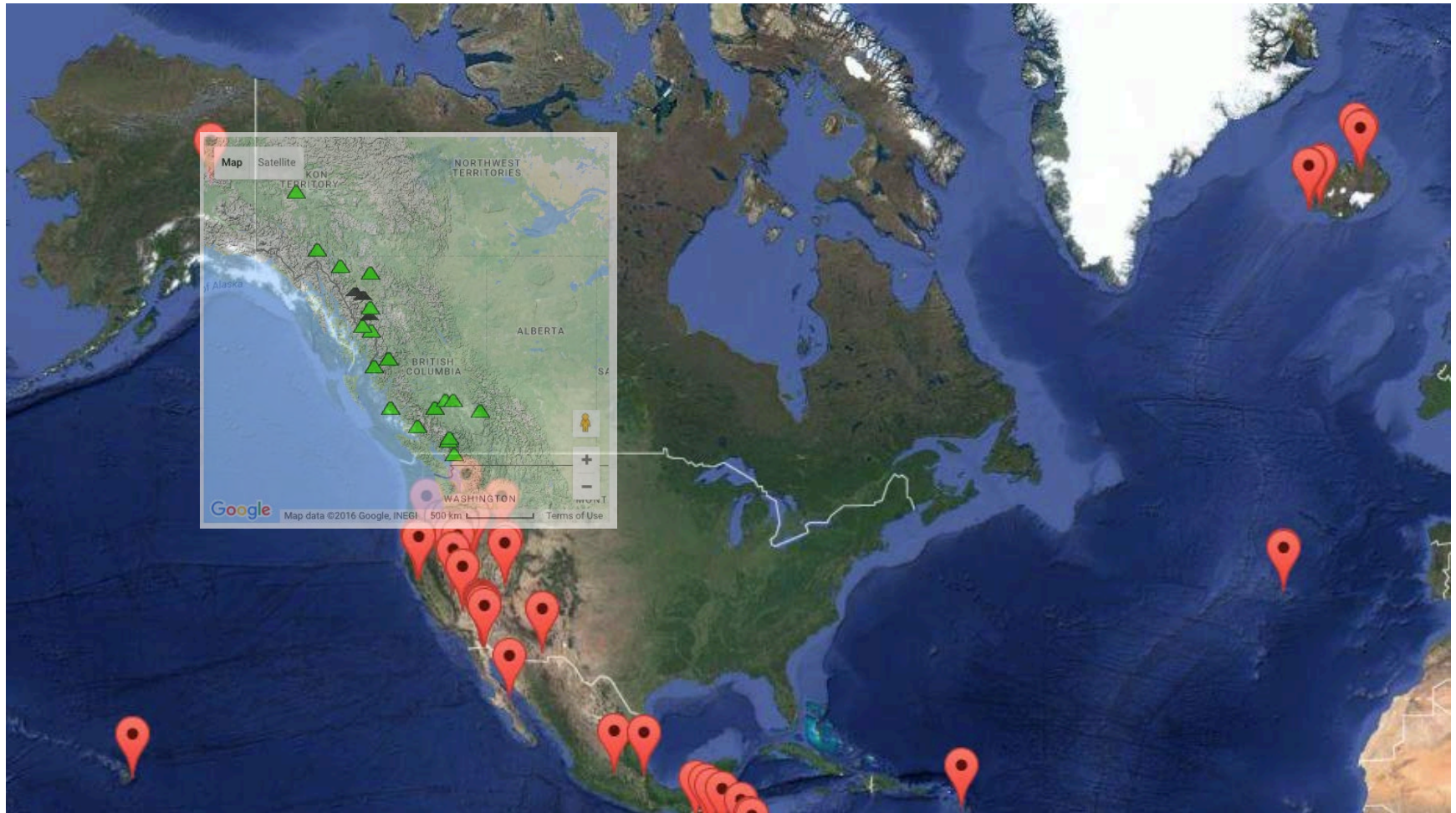


Source: TGE Research (2017), GEA (2016), IGA (2015), Enerji Atlası (2017)

ZERO MW IN CANADA

CANADA'S RESOURCE ESTIMATE: 5,000+ MWe (CanGEA)

Worldwide Geothermal Power Plants



www.thinkgeoenergy.com,
volcanodiscovery.com

CANADIAN GEOTHERMAL RESOURCES

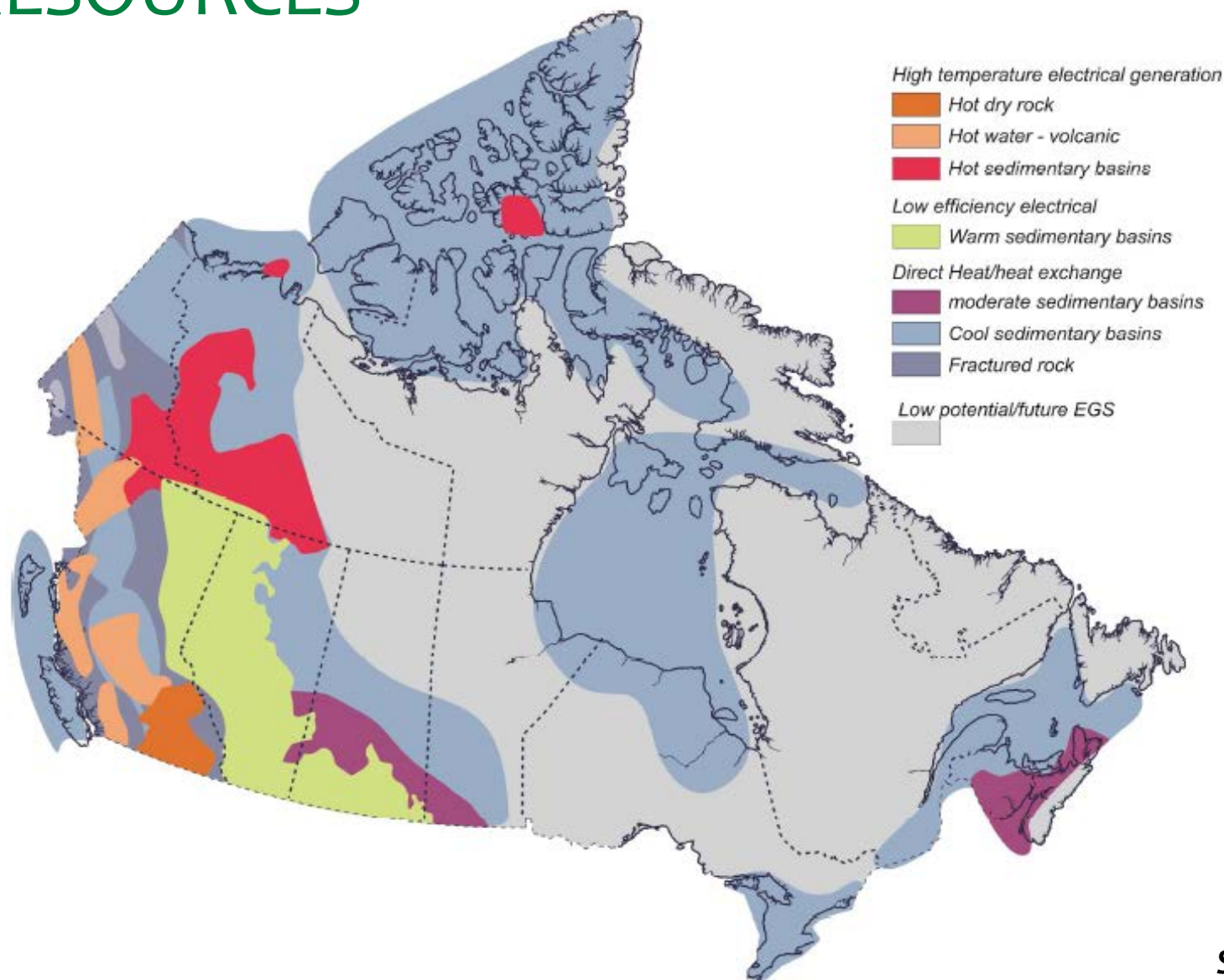
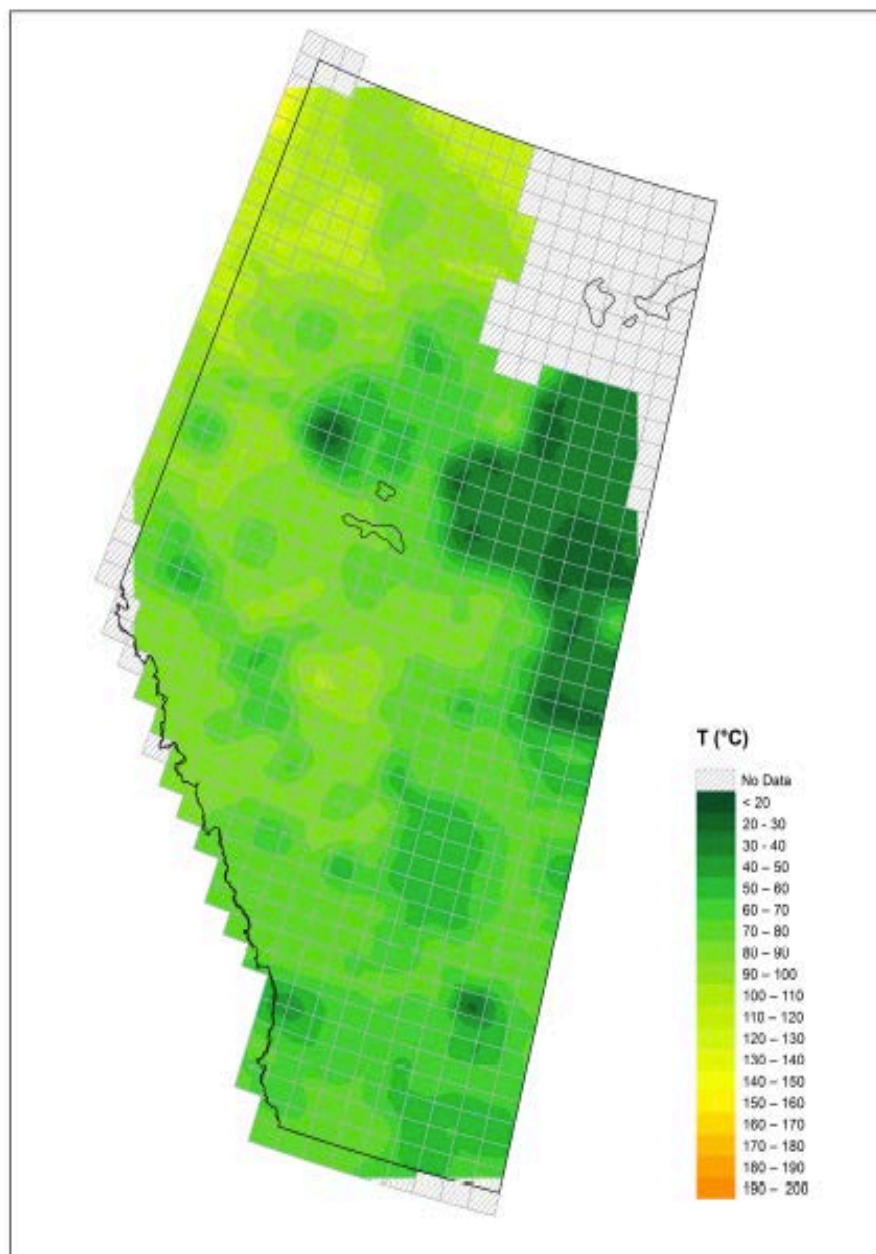


Figure 2. Map showing distribution of geothermal potential in Canada based on end use.

Temperature (°C) at 3500m



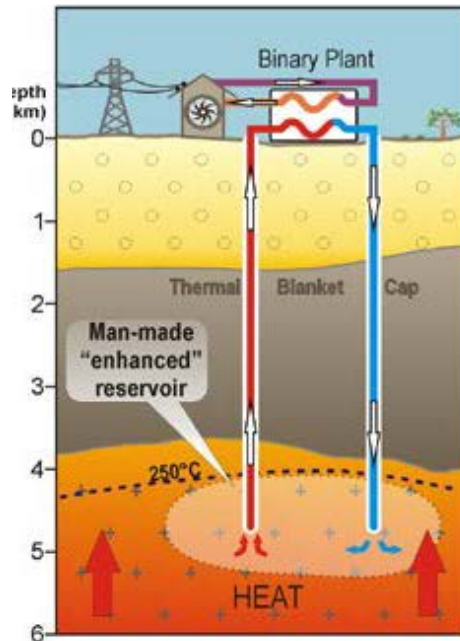
DEEP GEOTHERMAL PLAY TYPES

Anywhere

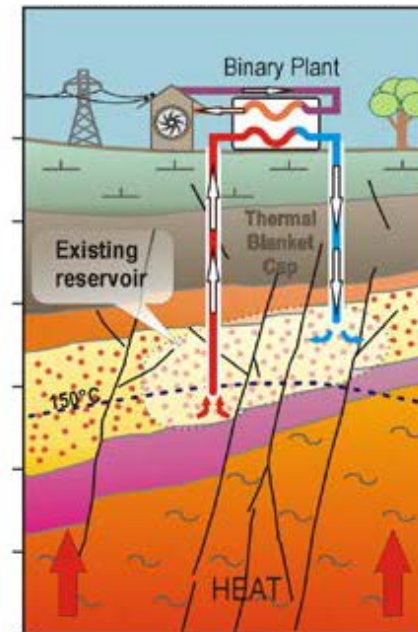
AB, SK, NEBC, YK

BC

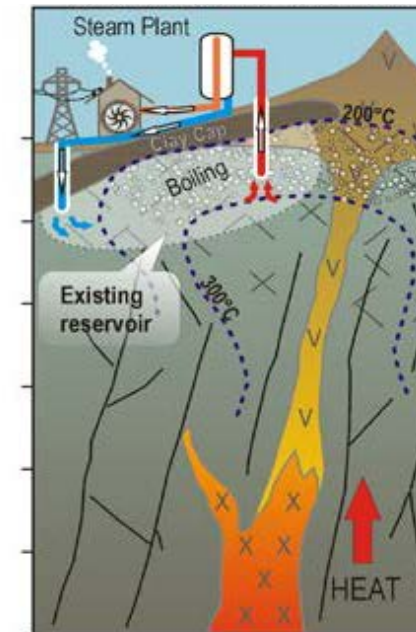
Enhanced Geothermal Systems



Hot Sedimentary Aquifers



Volcanic



CanGEA Cost Estimates

>\$7 MM/MWe

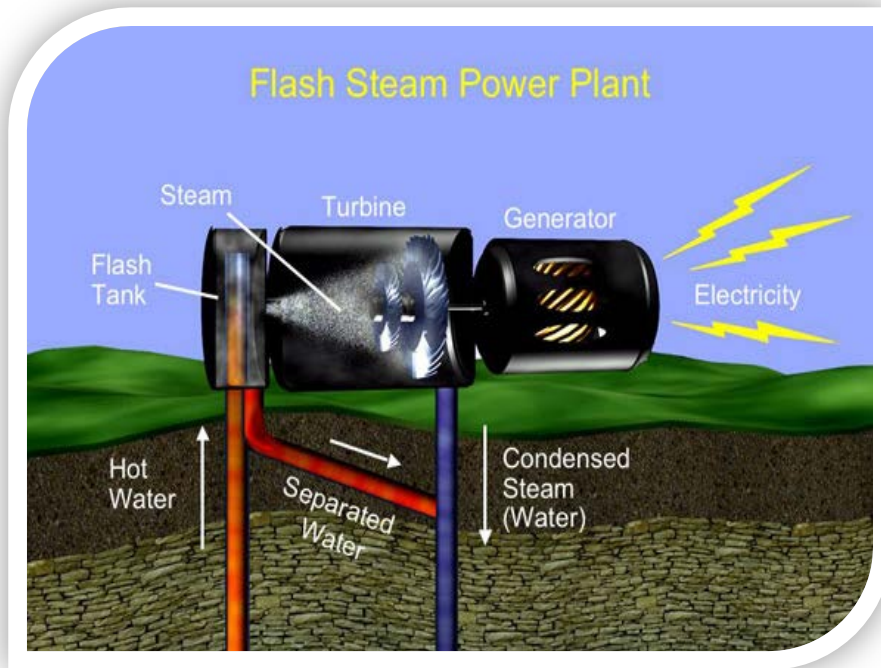
\$1.6-2.2 MM/MWe

>\$3-5 MM/MWe

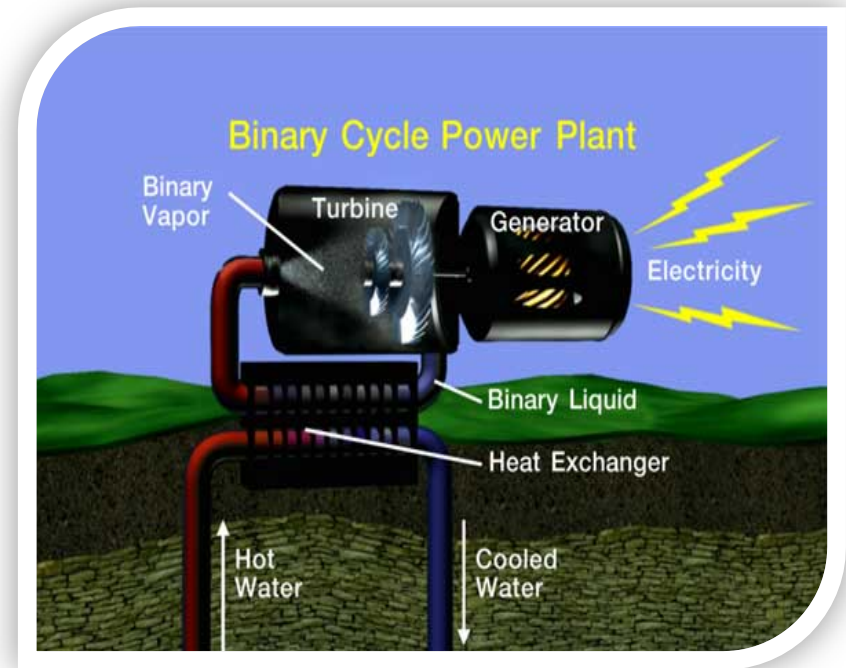
Hot Dry Rocks, Pty

MAKING POWER FROM HEAT

FLASH STEAM VS BINARY CYCLE



>150 °C

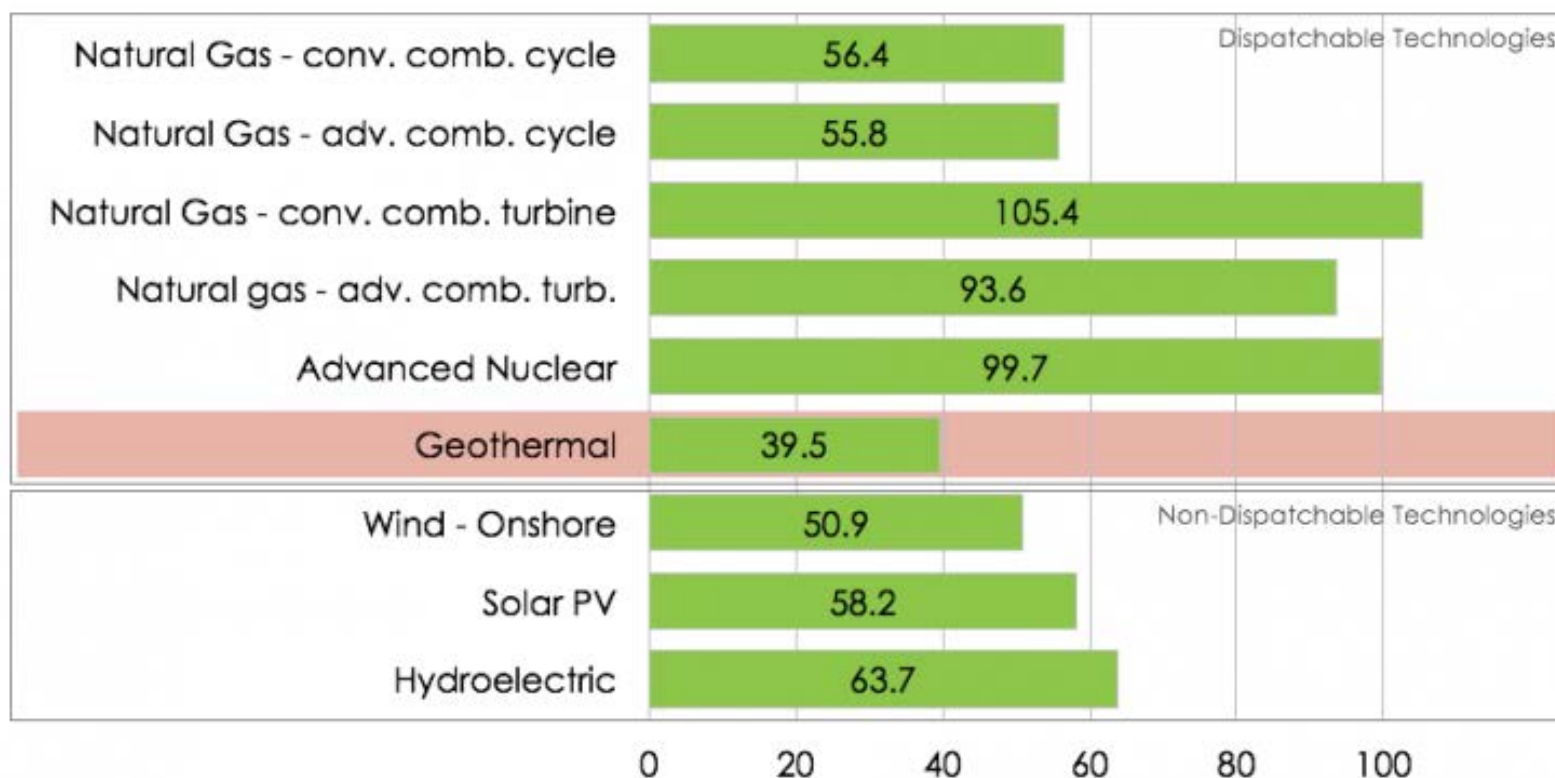


74-150 °C

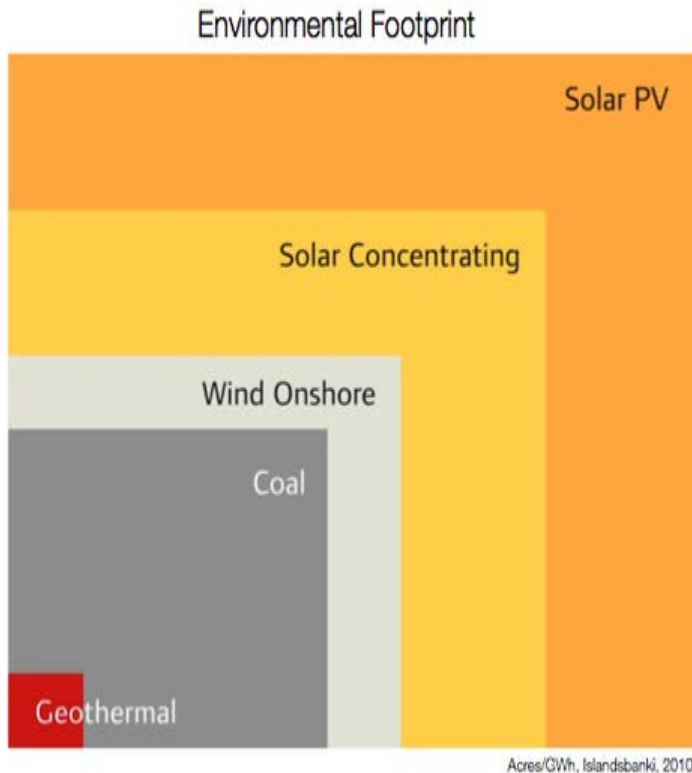
LEVELIZED COST OF ENERGY (LCOE)

ESTIMATED LEVELIZED COST OF ELECTRICITY GENERATION

U.S. WEIGHTED AVERAGE LCOE (2015 \$/ MWH) For plants entering service in 2022



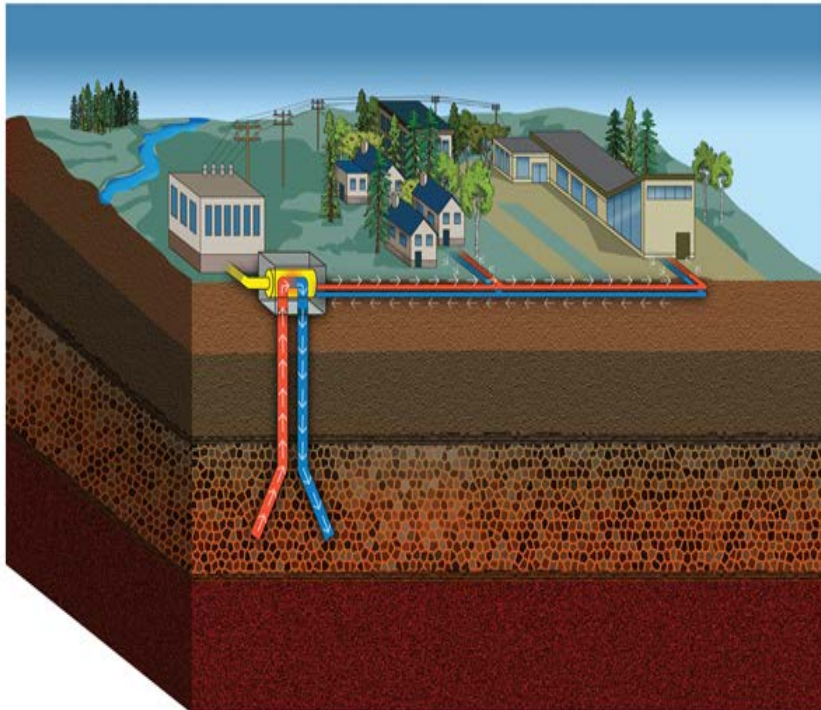
Geothermal Energy And The Environment Footprint



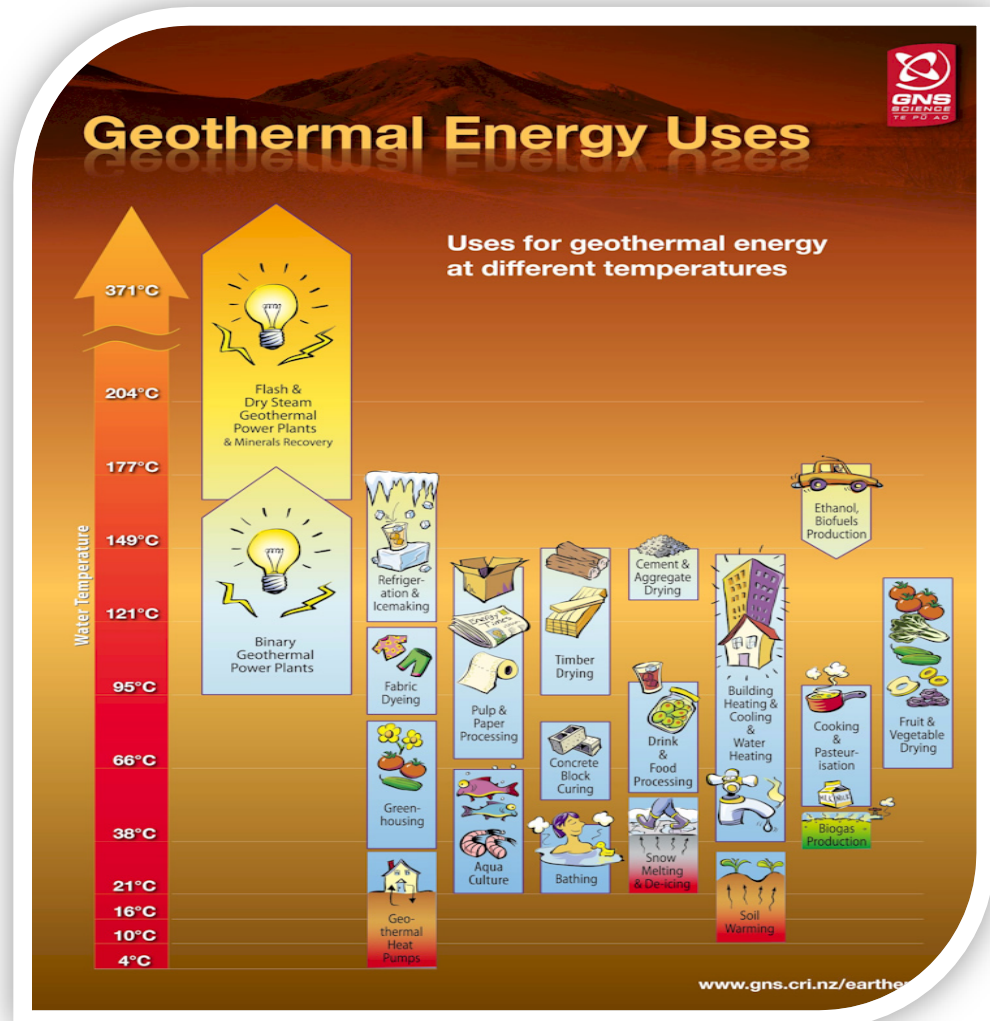
Geothermal energy is a clean source of reliable electricity and large scale direct use of the hot water derived from the earth

GEOTHERMAL DIRECT USE

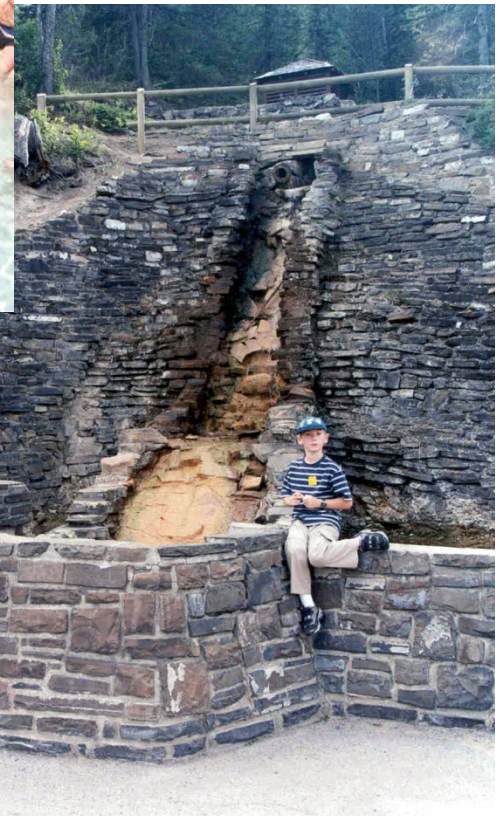
MARKET/APPLICATION NEAR GEOTHERMAL RESOURCE



Geothermal Well Pair

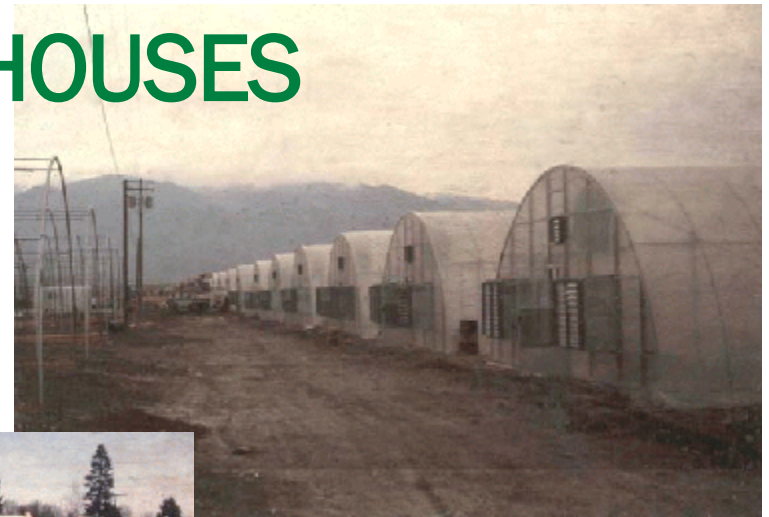
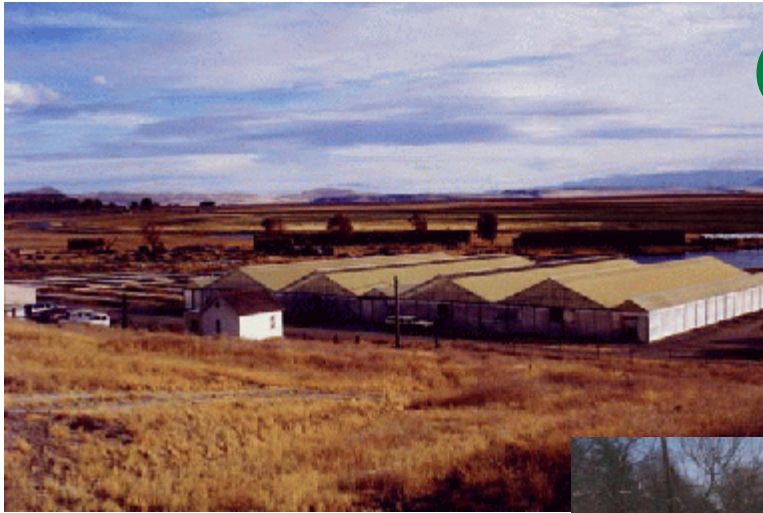


Banff Upper Hot Springs and Pool



Spring at 47°C and pool at 40°C. Used by local Blackfoot Indians and 1st visited by Europeans in 1884 – run by Canadian government since 1932 – half million visitors/year

GREENHOUSES



**Greenhouses shapes
and designs**



**USA, Iceland and
Hungary**

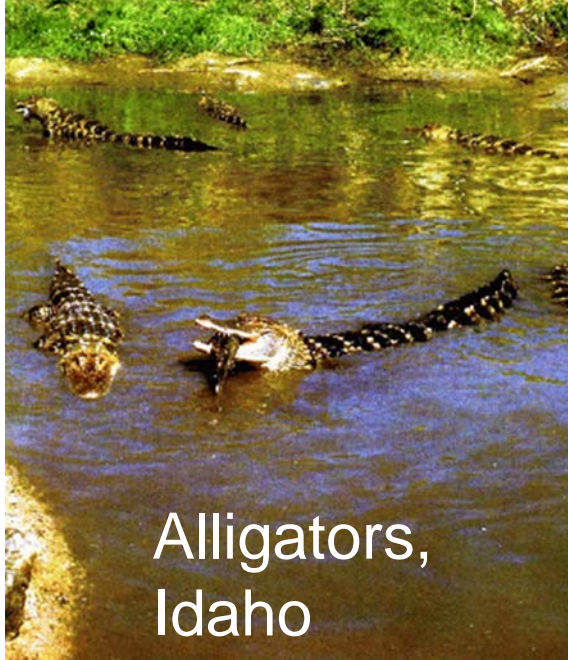




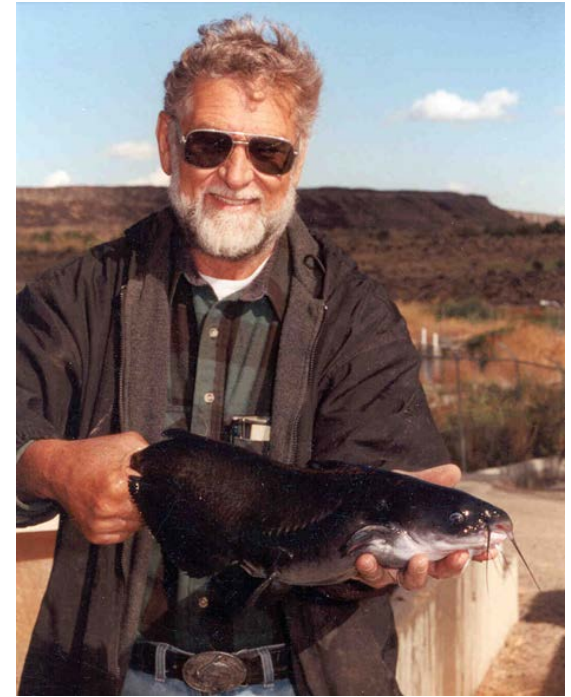
Osarian greenhouses, Kenya – 1,000,000 roses/day shipped overseas



AQUACULTURE



Alligators,
Idaho



Tilapia and cat fish



Eels,
Slovakia



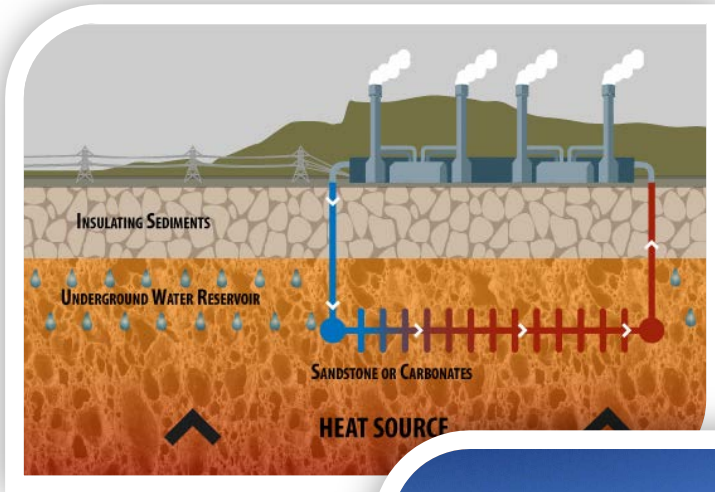
INDUSTRIAL – DISTRICT HEATING



Klamath Falls snow melting system



GIANT GEOTHERMAL OPPORTUNITY 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

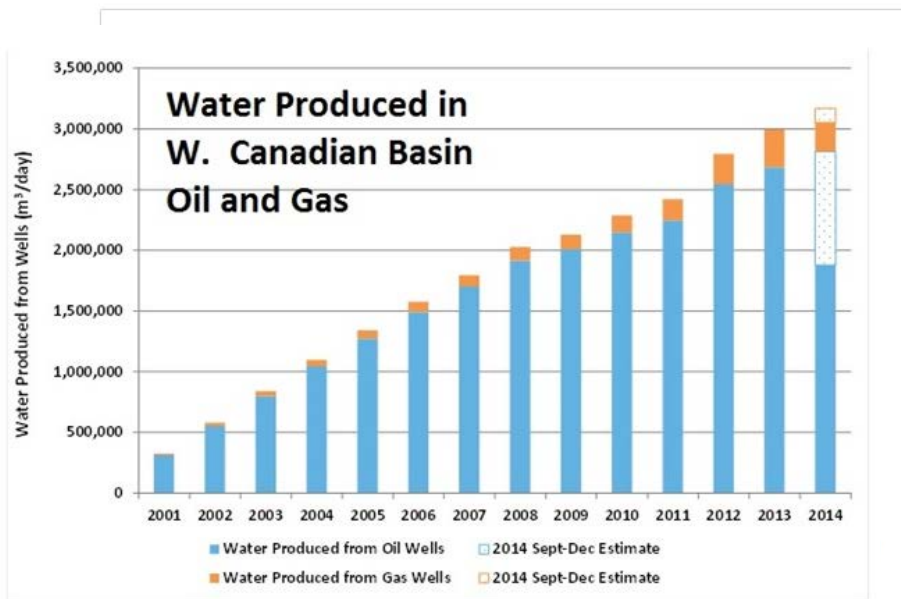


- Delineated Resource
- World-class resource extraction talent
- Recycle old oil and gas wells
- Orphan Well Opportunity

REPURPOSING INACTIVE WELLS

Rebranding Liabilities as Assets

- Standing, Inactive Wells
- Co-Produced Fluids
 - High-water cut wells
 - Enhanced Oil Recovery
 - Install insulated gathering systems to collect heat



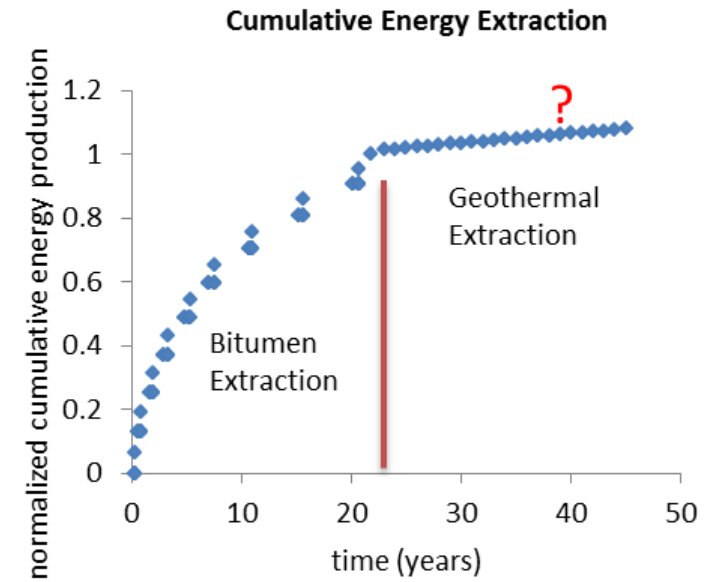
Oil and Gas Investments Bulletin, 2014

Geothermal Greenhouse in Germany



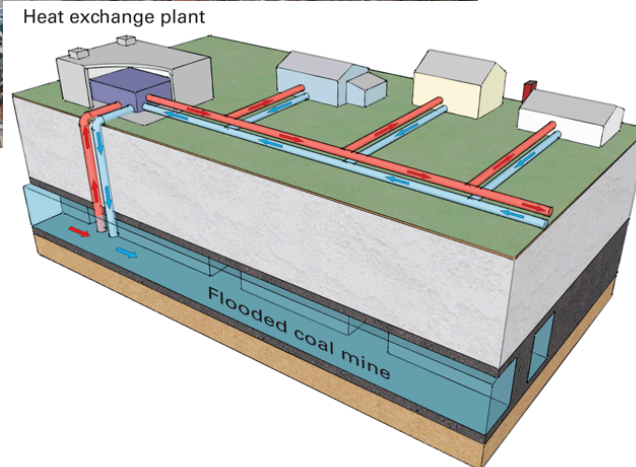
GEOHERMAL IN THE IN-SITU OIL SANDS

- Use of Processing/Boiler Blow Down Heat
- End-of-life strategy for mature/swept pads



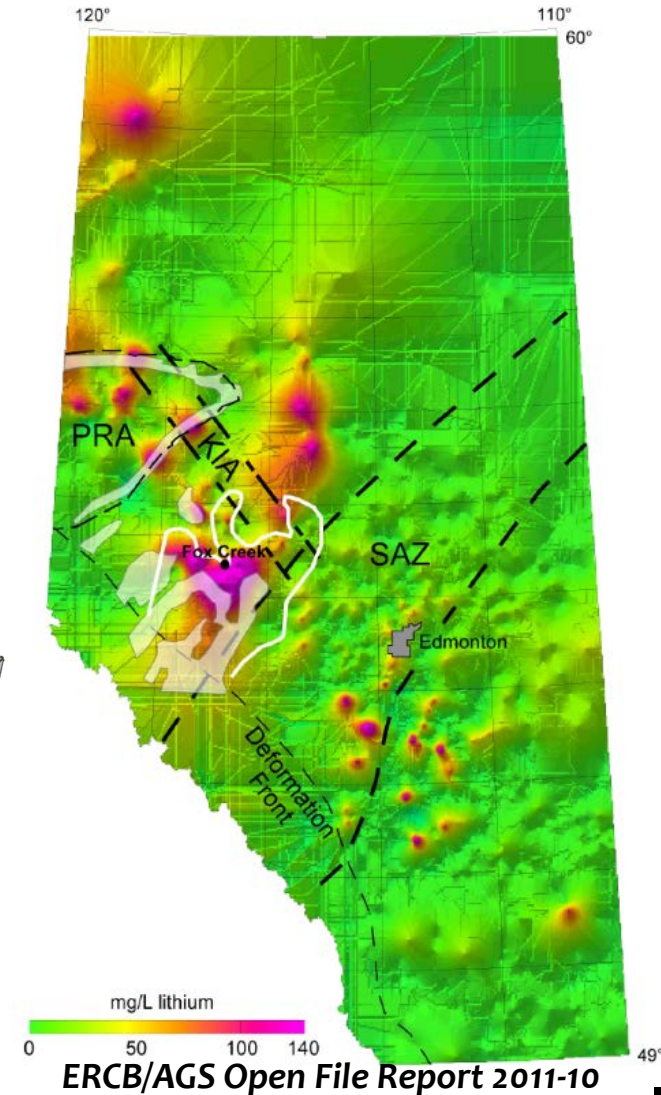
MINING SECTOR OPPORTUNITIES

From Gold to Geothermal? Con Mine, NWT



Ohio Geological Survey

Alberta's Lithium Potential



WHY AREN'T THERE ANY PROJECTS DEVELOPED YET?

There are fiscal, non-fiscal, technical, and non-technical reasons why Canada doesn't have any operating fields:



- Too remote
- Transmission access
- New to Canadians
- Other energy sources have been historically less expensive
- High front end cost
- ...
- **Policy doesn't exist or isn't effective**

CANADIAN PROJECTS



DEEP | EARTH | ENERGY | PRODUCTION

Deep Earth Energy Production Corp. (DEEP)

- Hot Sedimentary Aquifer, SK
- 5 MW net power (10 MW gross)
- Feasibility Study Complete/Proof of Concept in Progress



Borealis GeoPower

- Valemount Geopark, BC
- Construction starts late 2016
- 15MWe
- hotsprings, greenhouses, brewery, aquaculture



Takhini Hot Springs

- Yukon Territory
- Two 35C hot spring pools enriched in Calcium, Magnesium and Iron



Epoch Energy Development

- Partnership with Town of Hinton announced
- Aim to heat Public Buildings using geothermal energy

GEOHERMAL: A REVIEW

- **Huge Resource Potential in Canada**
 - Mountain regions
 - Sedimentary basins
- **Baseload Power and Heat**
- **Direct Use**
 - Centralized Heating, Hot Springs, Greenhouses
- **Mature industry worldwide**
- **Develop with Oil and Gas**
 - Orphan well repurposing
 - Produce heat and hydrocarbons together (co-produced fluids)



ARE YOU AS EXCITED ABOUT GEOTHERMAL AS WE ARE?

- **Join CanGEA!** www.cangea.ca/join
- **Contact your MP!**
 - Sign the powearthful letter
- **Stay engaged**
 - Talk about the resource to your friends/family/network
- **Invest in geothermal**
 - Crowdfunding
 - Invest in Canadian projects
 - Volunteer
 - Start your own business



BURNING QUESTIONS?