Geothermal Energy Sources, Applications and Benefits

Presented by:
Vladimir Agatonovic, P. Geol.
Ecoterra Solutions Inc.

OUTLINE

- The Earth Thermal Engine
- Basic Geothermics
- Geothermal Applications
- Benefits
- Western Canada Geothermal Potential
- Considerations and Project Examples

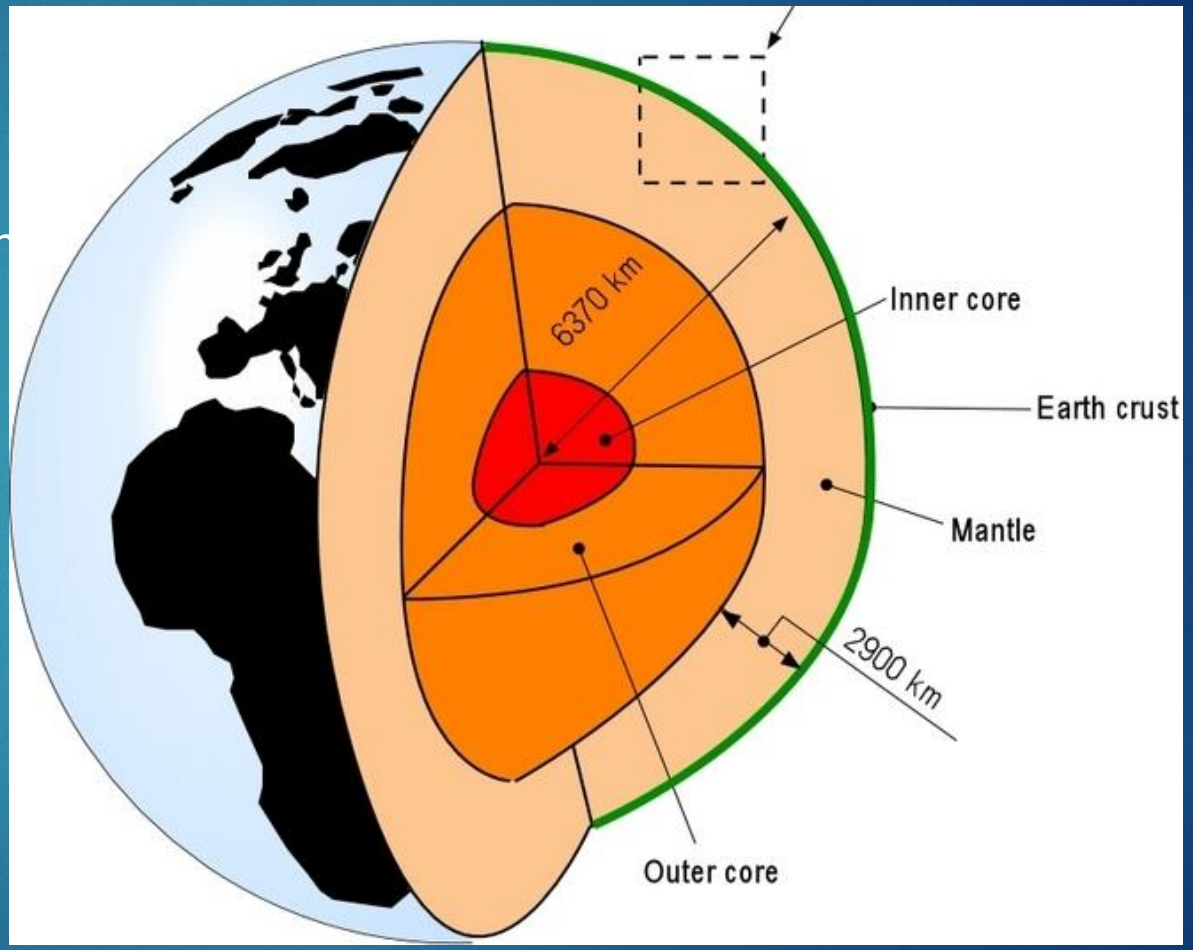
THE EARTH THERMAL ENGINE

THE EARTH

Crust – 20 – 65 km (min 5 km

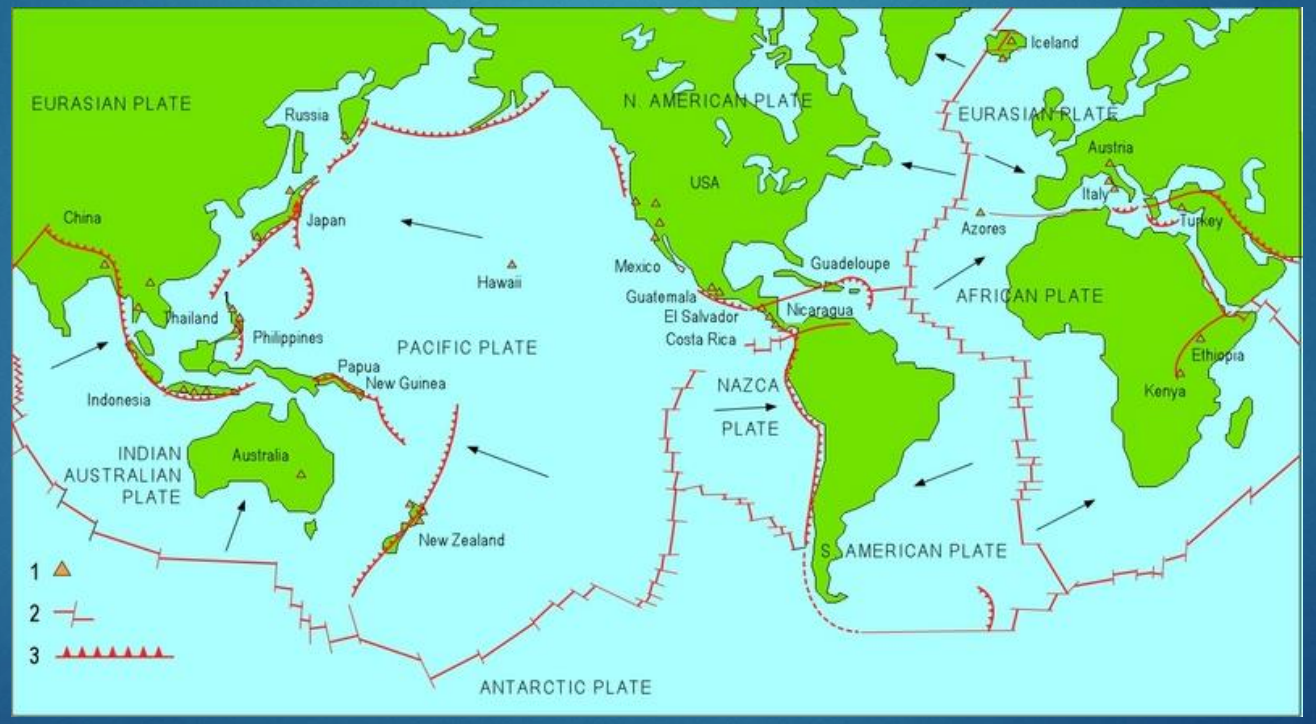
Mantle – 2900 km thick

Core – 3470 km in radius



EARTH'S PATTERN OF PLATES

(1) ***Geothermal fields producing electricity;***
(2) ***Mid-oceanic ridges crossed by transform faults (long transversal fractures);***
(3) ***Subduction zones, where the subducting plate bends downwards and melts in the asthenosphere.***



HEAT FROM THE EARTH

- The heat balance by Stacey and Loper (1988), estimated that the total flow of heat from the Earth to the atmosphere is estimated at 42×10^{12} W (conduction, convection and radiation)
- 8×10^{12} W, comes from the crust which presents 2% of the volume of the Earth

HEAT FROM THE EARTH (Cont'd)

- 32.3×10^{12} W come from the mantle, which represents 82% of the total volume of the Earth
- 1.7×10^{12} W come from the core, which accounts for 16%
- The Earth cooling rate is 10.3×10^{12} W

BASIC GEOTHERMICS

BASIC GEOTHERMICS

- The presence of volcanoes, hot springs and other thermal phenomena led to conclusion that the interior of the Earth is hot
- In 16th and 17th century the first holes were dug
- The temperature of the Earth increases with depth
- The first temperature measurement was conducted in 1740 by De Gunsanne, in the mine near Belfort, France

GEOTHERMAL GRADIENT

- An average geothermal gradient (GG) is ~ 2.5 – 3°C/100m
- At 2000 m depth 65°C – 75°C
- At 3000 m depth 90°C – 105°C
- There are areas with lower GG 1°C/100 m - heat sinks, and
- Areas with 30°C/100 m GG – hot reservoirs

GEOTHERMAL SYSTEMS ELEMENTS

- Source – zone with hot temperature, magmatic intrusion
- Reservoir – volume of hot permeable rocks
- Fluid – meteoric water, gases

GEOTHERMAL RESERVOIR TYPES

- Liquid Dominated - Hydrothermal
- Vapour Dominated - Hydrothermal
- Hot Dry Rock
- Geo-pressurized (sediments under compaction)

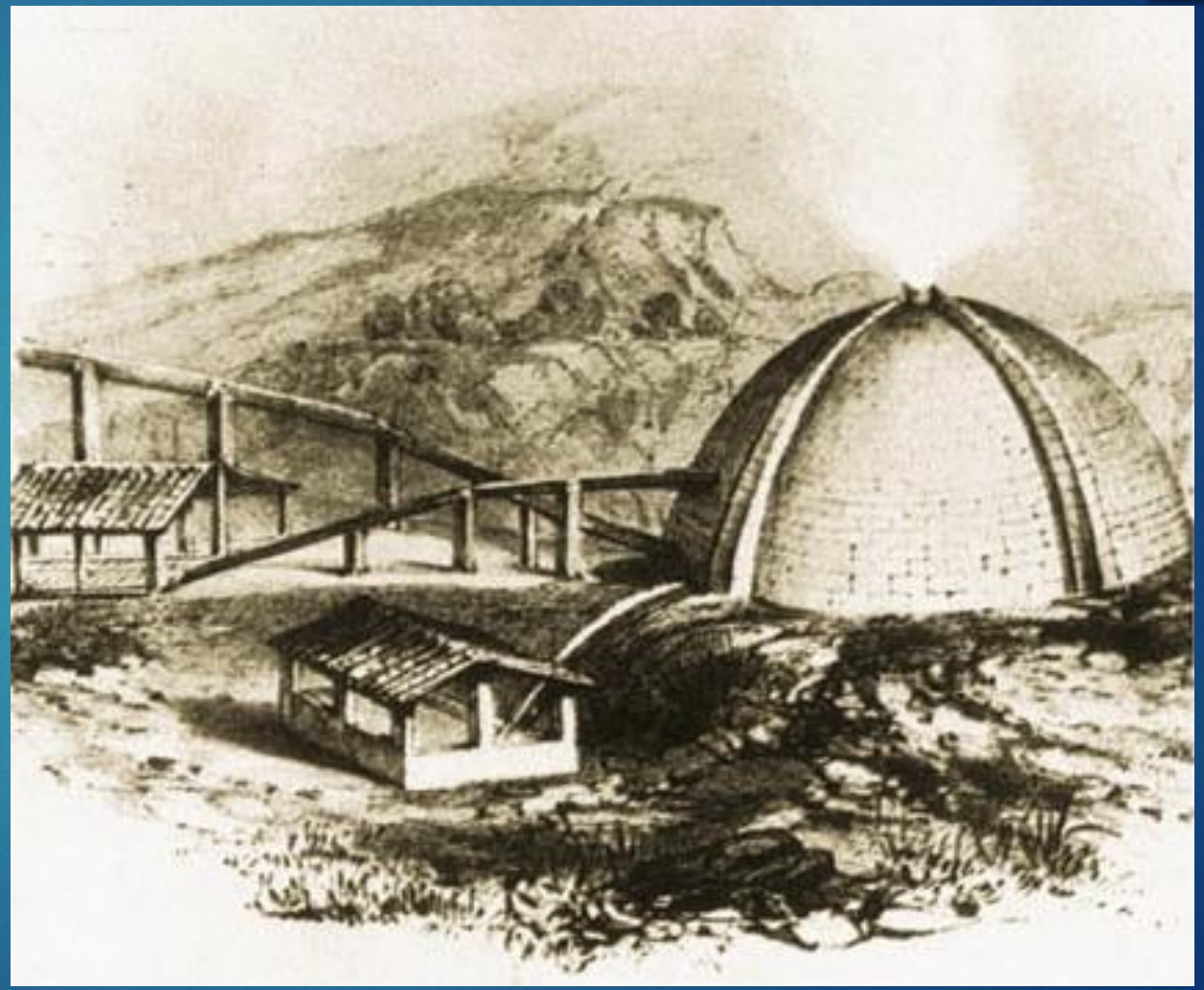
GEOTHERMAL APPLICATIONS

GEOTHERMAL APPLICATIONS

- Electric Power Generation
- Direct Use
- District Heating

HISTORY

- In 1827 Francesco Larderel, founder of this industry, developed a system for utilising the heat of the boric fluids in the evaporation process, rather than burning wood from the rapidly depleting forests



HISTORY (Cont'd)

- By 1904 the first attempt was made at generating electricity from geothermal steam; again, it took place at Larderello; *along with its inventor, Prince Piero Ginori Conti*

HISTORY (Cont'd)

- Electricity generation at Larderello was a commercial success. By 1942 the installed geo-thermoelectric capacity had reached 127,650 kWe
- In 1919 the first geothermal wells were drilled in Japan
- 1921 wells drilled at The Geysers, California, USA

HISTORY (Cont'd)

- 1958 a small geothermal power plant began operating in New Zealand
- 1959 another began in Mexico
- 1960 in the USA, followed by many other countries in the years to come

ELECTRIC POWER GENERATION (Cont'd)

DIRECT USES

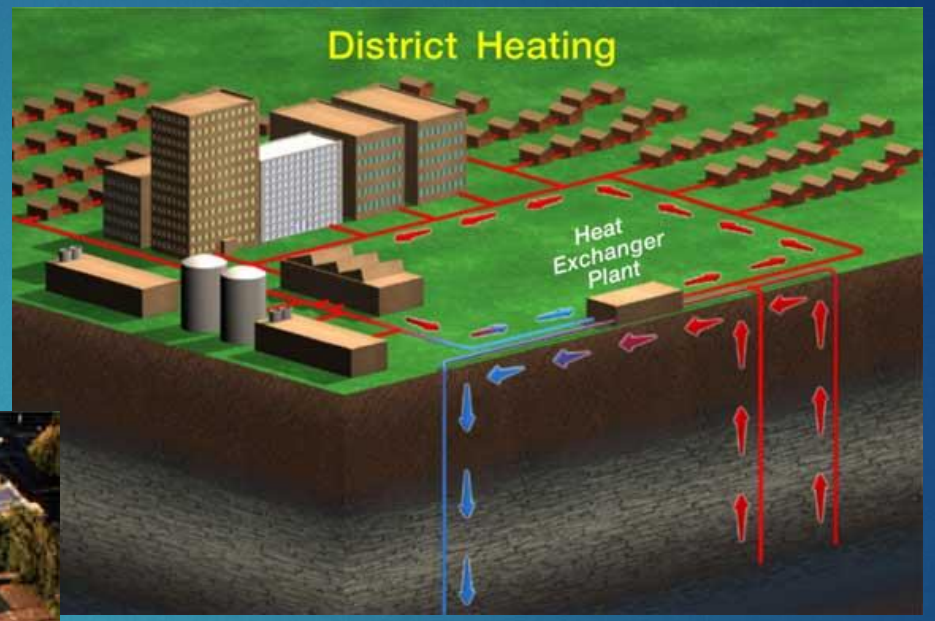
- Balneology (hot springs, spas)
- Agriculture (greenhouse, soil warming)
- Aquaculture (fish, prawn, etc. farming)
- Industrial use (material treatment, drying)
- Residential and District Heating

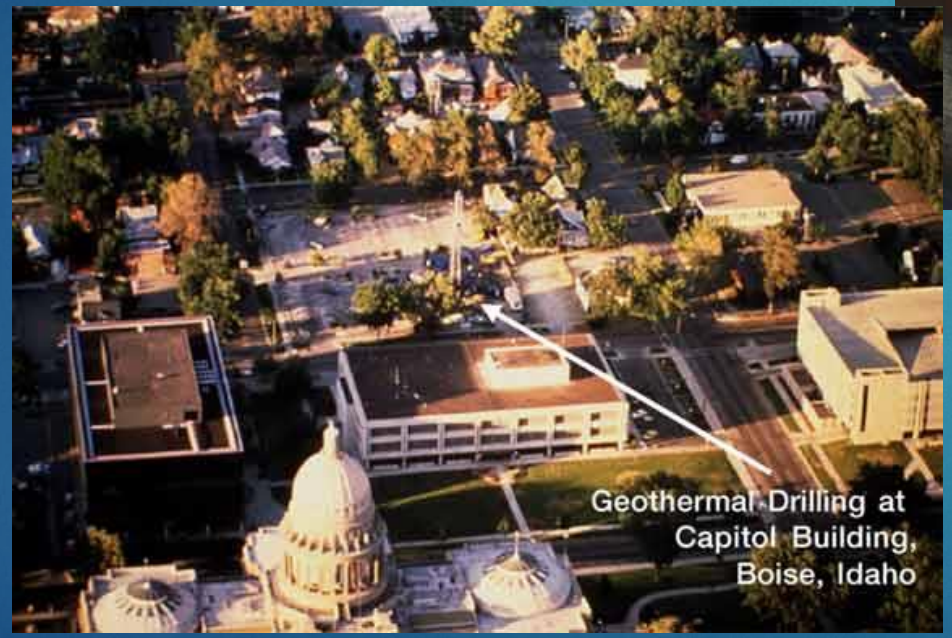
AGRICULTURE USE

Applications

DISTRICT HEATING

Hot water from one or more geothermal wells is piped through a heat exchanger.





The first district heating system in the USA was built in Boise, Idaho.

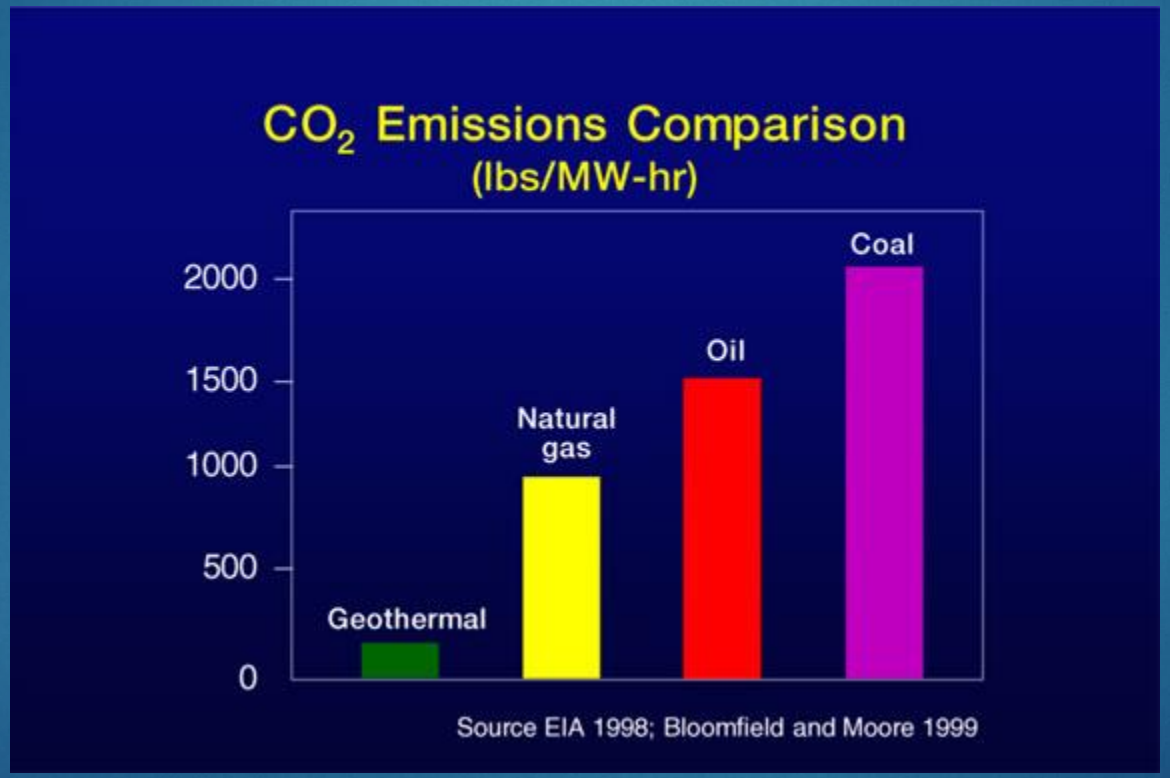
AN EXAMPLE (FORMER YUGOSLAVIA)

Junakovic Health and Recreation Facility

- Production Well
  750 m deep, 52^{o}C
  at the well head,
  21 L/sec.
-
- Injection well - 750 m deep, 1.5 km N.
- Two heat pumps are used to heat: Hotel with 124 rooms, 6 of 12 swimming pools, and two restaurants, spa, etc.

BENEFITS

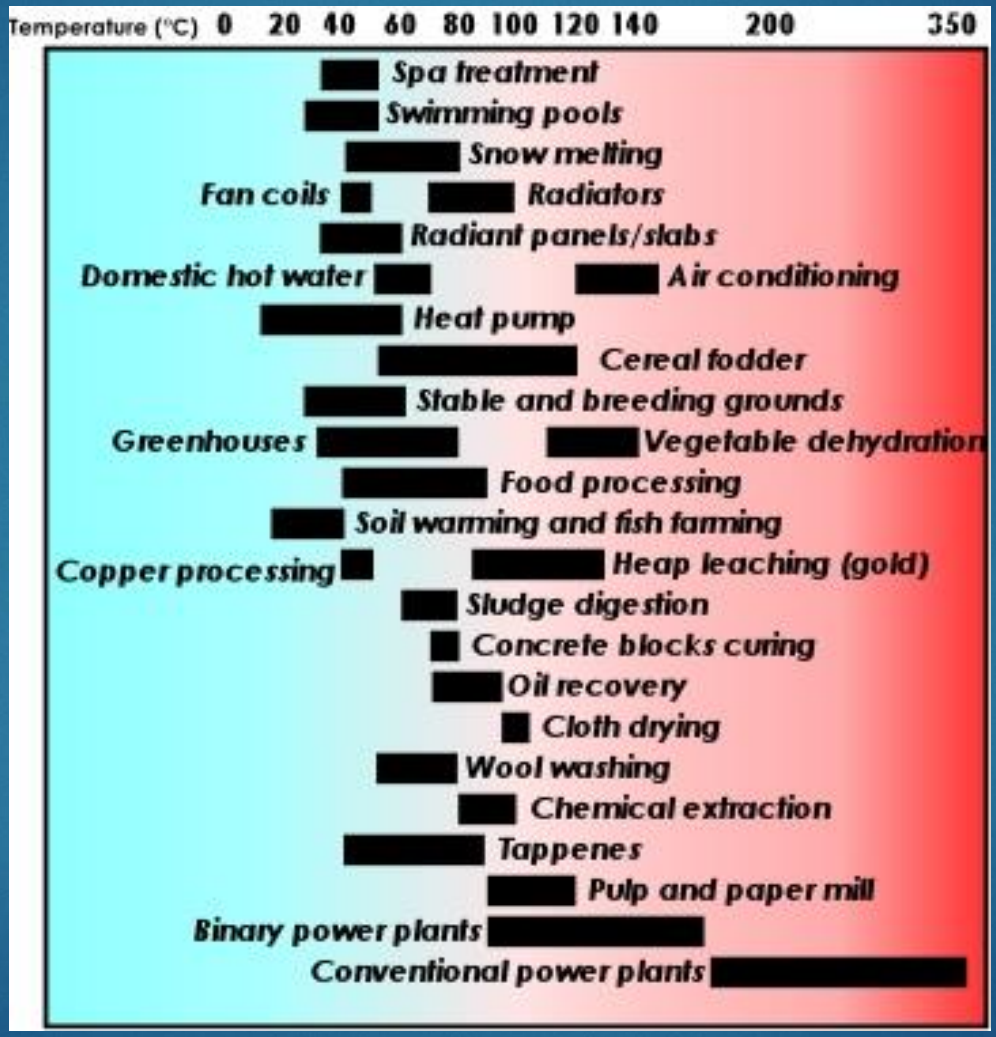
BENEFITS - CO_2 EMISSION REDUCTIONS



BENEFITS OF GEOTHERMAL POWER

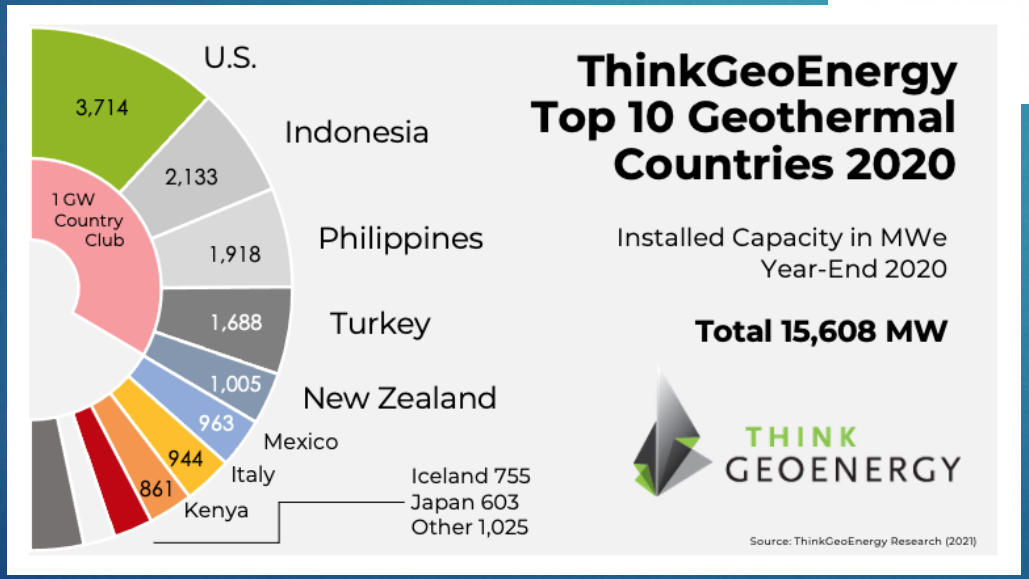
- Provide clean and safe energy using little land
- It is renewable and sustainable
- Generates continuous, reliable ‘base-load’ power
- Conserves fossil fuels and contributed to diversity in energy sources
- Benefits local economy
- Offers modular, incremental development and local power source to remote sites

GEOTHERMAL WATER USE



Geothermal Installed Capacity

Source: IGA 2020

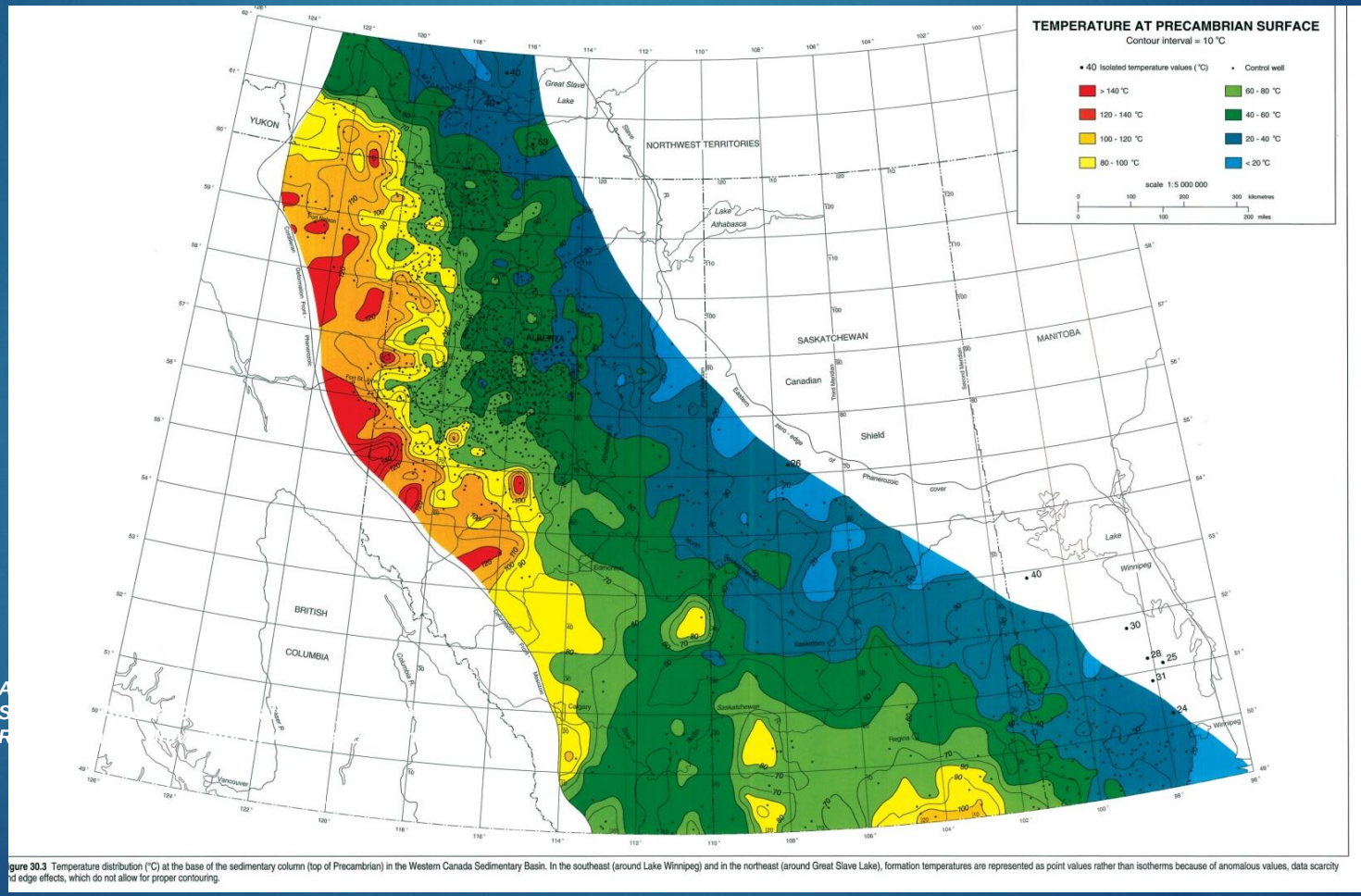


WESTERN CANADA GEOTHERMAL POTENTIAL

GEOTHERMAL SOURCES

- Hot Springs (Alberta & BC)
- Produced Formation Water (Oil and Gas)
- Geothermal Geological Formations (BC)

WESTERN CANADA POTENTIAL



igure 30.3 Temperature distribution (°C) at the base of the sedimentary column (top of Precambrian) in the Western Canada Sedimentary Basin. In the southeast (around Lake Winnipeg) and in the northeast (around Great Slave Lake), formation temperatures are represented as point values rather than isotherms because of anomalous values, data scarcity nd edge effects, which do not allow for proper contouring.

GEOTHERMAL SOURCES

- Oilfield produced water use would be a geothermal application, with installation of a heat exchanger at the water-flood plant (i.e. Eckville, Alberta. with 78°C)
- Orphan and negative oil and gas wells which are not suitable for the oil or gas production
- Geothermal Reservoirs such as South Meager, BC. With several 2 to 3 km long horizontal wells, temperature 255°C; by2007 project should generate 100 MW, and later 200MW (2010).

CONSIDERATIONS

- Preliminary Reconnaissance: Data Review
- Geological/Geophysical Settings
- Geothermal Gradient
- Hydro-chemical data – springs, well data; geo-thermometers (indicators of geothermal reservoir temperature), indication of mixing zones (fresh and meteoric water)
- Potential Users and Applications

- 20 MW Binary Plant (by Ormat or Mitsubishi) requires 75°C (numerous single-well examples in Nevada, USA)

CONSIDERATIONS

- In Selecting a Geothermal Well Location:
- Distance to The Potential Users or Power Grid
- Drinking Water Source Protection: DUA
- Aquifer/Reservoir: hydraulic and thermal conductivity, yield and water quality
- On January 25, 2022, AER issued ‘Mineral Rights Information Bulletin 2022-02, wrt. Geothermal leases

PROJECT EXAMPLES

PROJECT EXAMPLES

- Winfield, BC – Retirement Lodge Heat Source
- Reko Diq Gold Mine, Balochistan, Pakistan
- St. Leon Hot Springs near Nakusp, BC

- Winfield – one (1) geothermal well: 80m deep with 24°C at the well head. The building heating has a set of heat pumps, further expansions are possible.
- Reko Diq– hot dry rock reservoir, with minor hot water occurrences – fumaroles (vents) on the surface (82°C) –water highly mineralized.

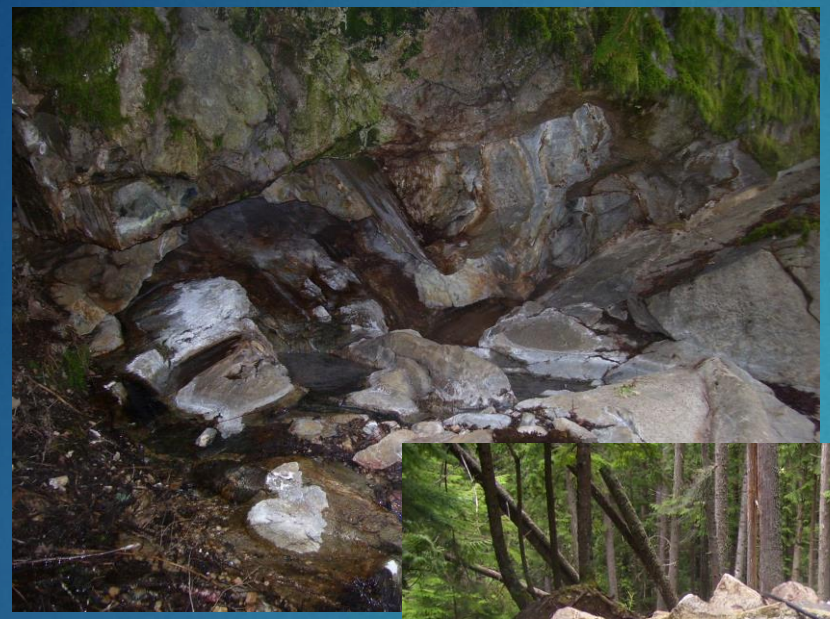
Reko Diq – Gold Prospect

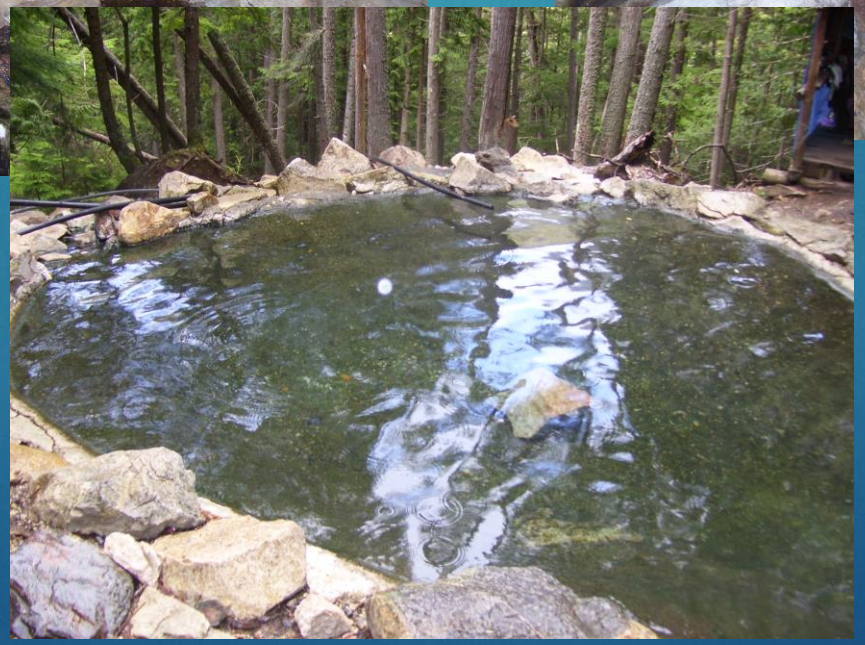
- Challenges – the closest marine port 700 km, no roads nor railroads to the port, unpopulated, very limited surface water available.
- Perfect case for the geothermal power generation.

St. LEON HOT SPRINGS GEOTHERMAL POTENTIAL

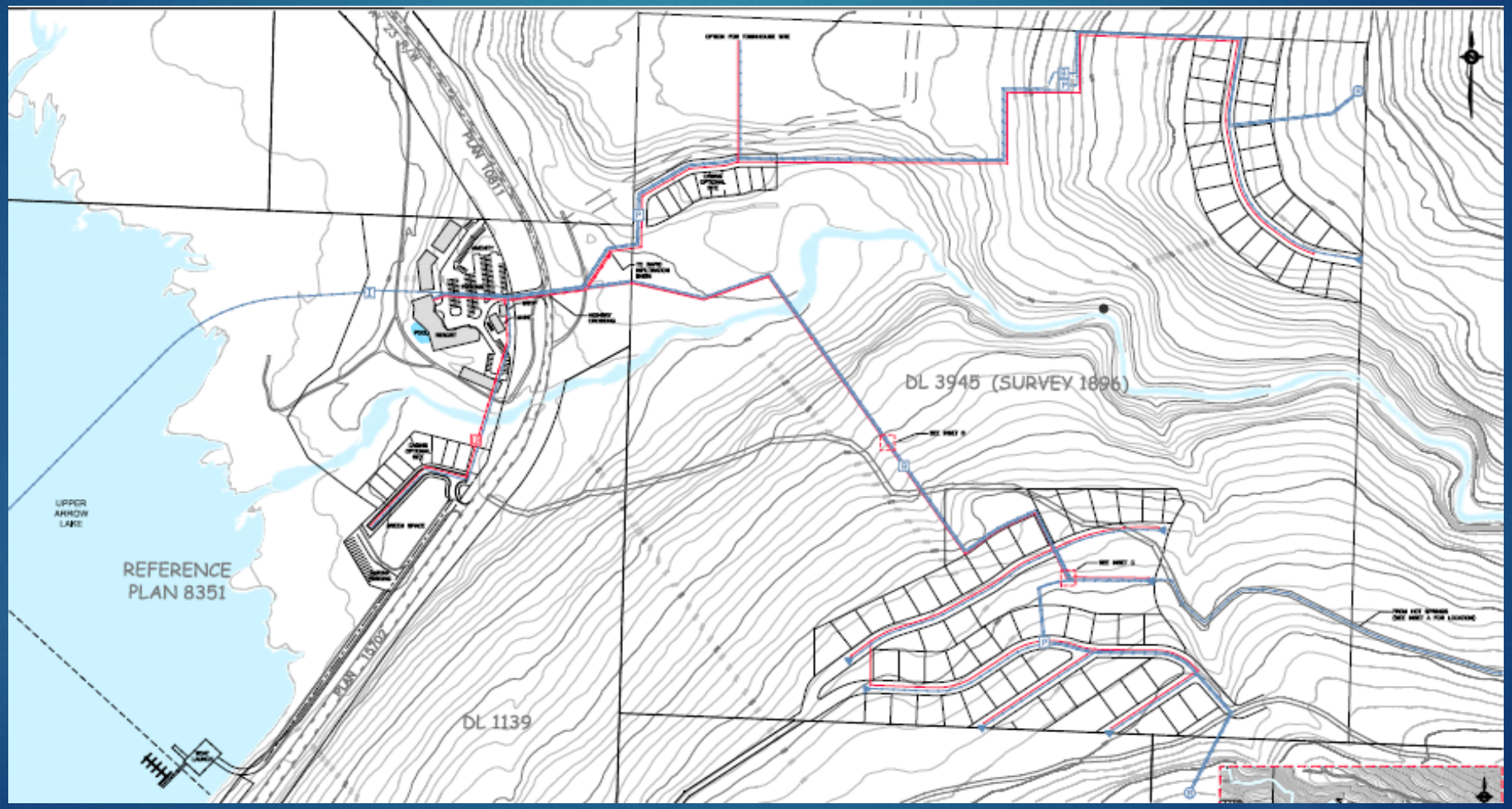
- Located at Upper Arrow Lake, 26 km north of Nakusp, BC
- Two hot springs have been used for recreational purposes since 1900s
- In 2009, South Korean Investors were interested in developing this property
- In 2015 property was purchased by a property developer from Edmonton

St. LEON HOT SPRINGS





St. LEON Conceptual Design (2010)



St. Leon Geothermal Potential

- There are two springs (hot water discharged from a fractured rock formation)
- In 2008 and 2009, both springs had 1.3 L/s (1120 m3/day), and 48°C temperature (November 2008)
- On May 14, 2009, Spring water pH=7.77 EC = 880 µS/cm^2 and temperature of 46.5°C, and;
- St. Leon Creek water pH=7.98 EC = 550 µS/cm^2 and temperature of 5.6°C
- Water samples collected from the hot spring and the creek

St. Leon Geothermal Potential cont…

- Using geo-thermometers and fresh water indicators it appears that:
  - Hot spring's water is mixture of fresh and formation water
  - Reservoir temperature in mixing zone using Fourier silica formula is estimated to be 82°C
  - Using sodium/potassium (Na/K) and sodium/lithium (Na/Li) ratio, reservoir temperature was calculated to range between 189°C and 239°C
  - Further drilling investigation is required to confirm the reservoir temperature and the flow rate

St. LEON WATER QUALITY

Report To	Vladimir Agatonovic, FOCUS CORPORATION	
ALS File No.	L765669	
Date Received	19-May-09	
RESULTS OF ANALYSIS		
Sample ID	ST. LEON'S HOT SPRING	ST. LEON'S CREEK
Date Sampled	15-MAY-09	15-MAY-09
ALS Sample ID	L765669-1	L765669-2
Matrix	Water	Water
Barium (Ba)-Dissolved	0.026	0.016
Beryllium (Be)-Dissolved	<0.0050	<0.0050
Bismuth (Bi)-Dissolved	<0.20	<0.20
Boron (B)-Dissolved	<0.10	<0.10
Cadmium (Cd)-Dissolved	<0.010	<0.010
Calcium (Ca)-Dissolved	142	5.72
Chromium (Cr)-Dissolved	<0.010	<0.010
Cobalt (Co)-Dissolved	<0.010	<0.010
Copper (Cu)-Dissolved	<0.010	<0.010
Iron (Fe)-Dissolved	<0.030	<0.030
Lead (Pb)-Dissolved	<0.050	<0.050
Lithium (Li)-Dissolved	0.226	<0.010
Magnesium (Mg)-Dissolved	<0.10	0.72
Manganese (Mn)-Dissolved	<0.0050	<0.0050
Potassium (K)-Dissolved	5.8	<2.0
Selenium (Se)-Dissolved	<0.20	<0.20
Silicon (Si)-Dissolved	29.5	4.55
Silver (Ag)-Dissolved	<0.010	<0.010
Sodium (Na)-Dissolved	121	<2.0
Strontium (Sr)-Dissolved	5.17	0.207

THANK-YOU!

QUESTIONS??