

Geothermal Energy: Emerging Technologies and Oil & Gas Synergies

Jim Hollis



**GEOHERMAL
TECHNOLOGIES**



Geothermal Facts:

- The center of the earth is hotter than the surface of the Sun
- The heat source is from the radioactive decay of elements and the leftover energy from the formation of the planet
- The Earth is cooling at a rate of 1° Celsius/Million years



GEOHERMAL ENERGY: TERMINOLOGY



1 Watt (W)

Nightlight

...



~750 homes

...

1 Megawatt (MW)



1 Kilowatt (KW)

Coffee Maker



~750,000 homes (2 Denvers)

1 Gigawatt (GW)



NEARLY-PERFECT POWER

Produces valuable stream of entirely clean baseload power, with economics comparable to solar and wind, and it requires only a fraction of the acreage

THE PROBLEM

...but most population centers aren't close enough to conventional geothermal sites, usually near tectonic plate boundaries

So, conventional geothermal is proven, but isolated, and has lagged solar and wind, despite substantial advantages

93

Geothermal power plants
operating in the US today

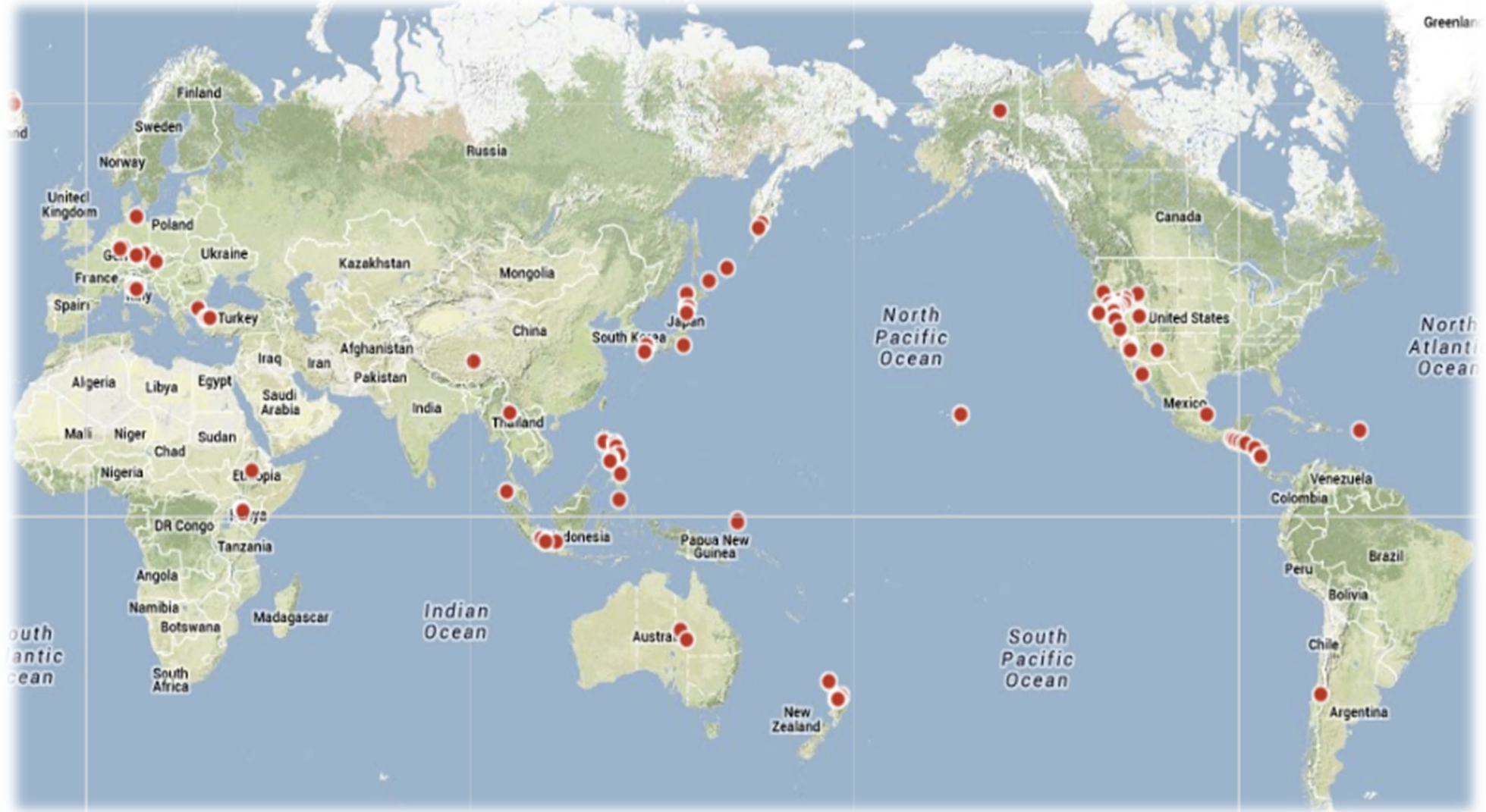
**3,794
MW**

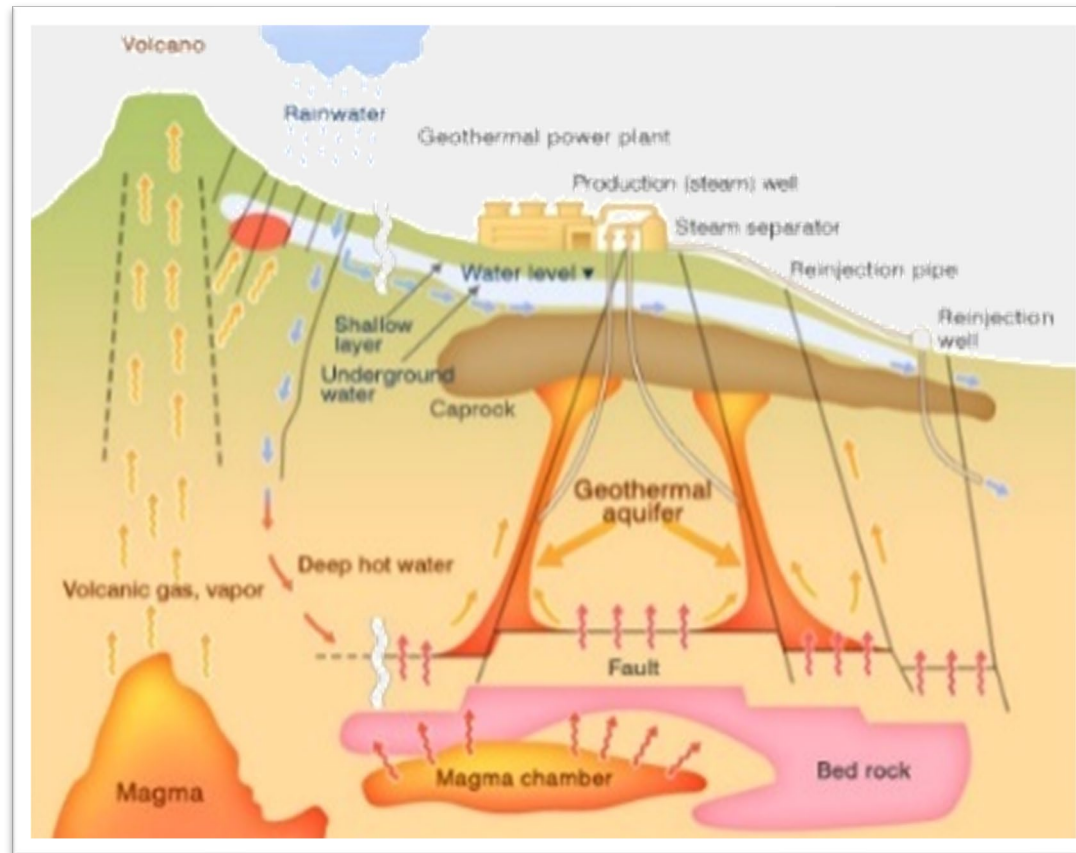
Geothermal energy capacity
in the US

2%

of renewable energy
production in the US

GEOHERMAL ENERGY PRODUCTION LIMITATIONS

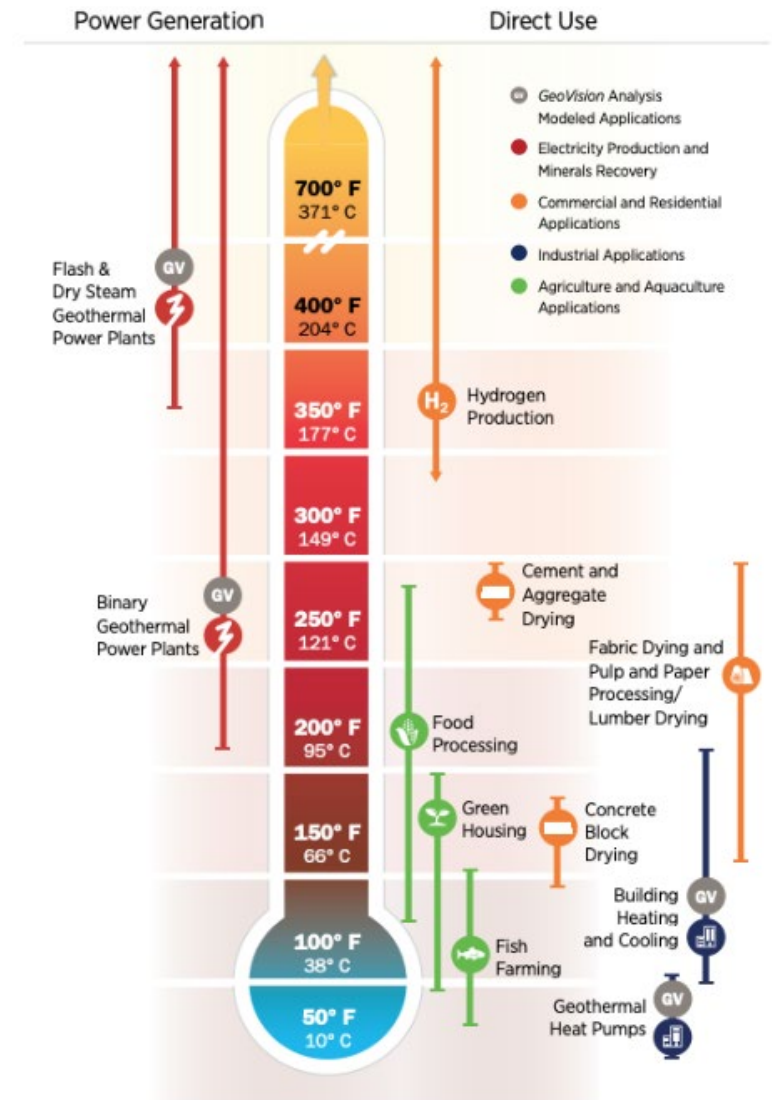
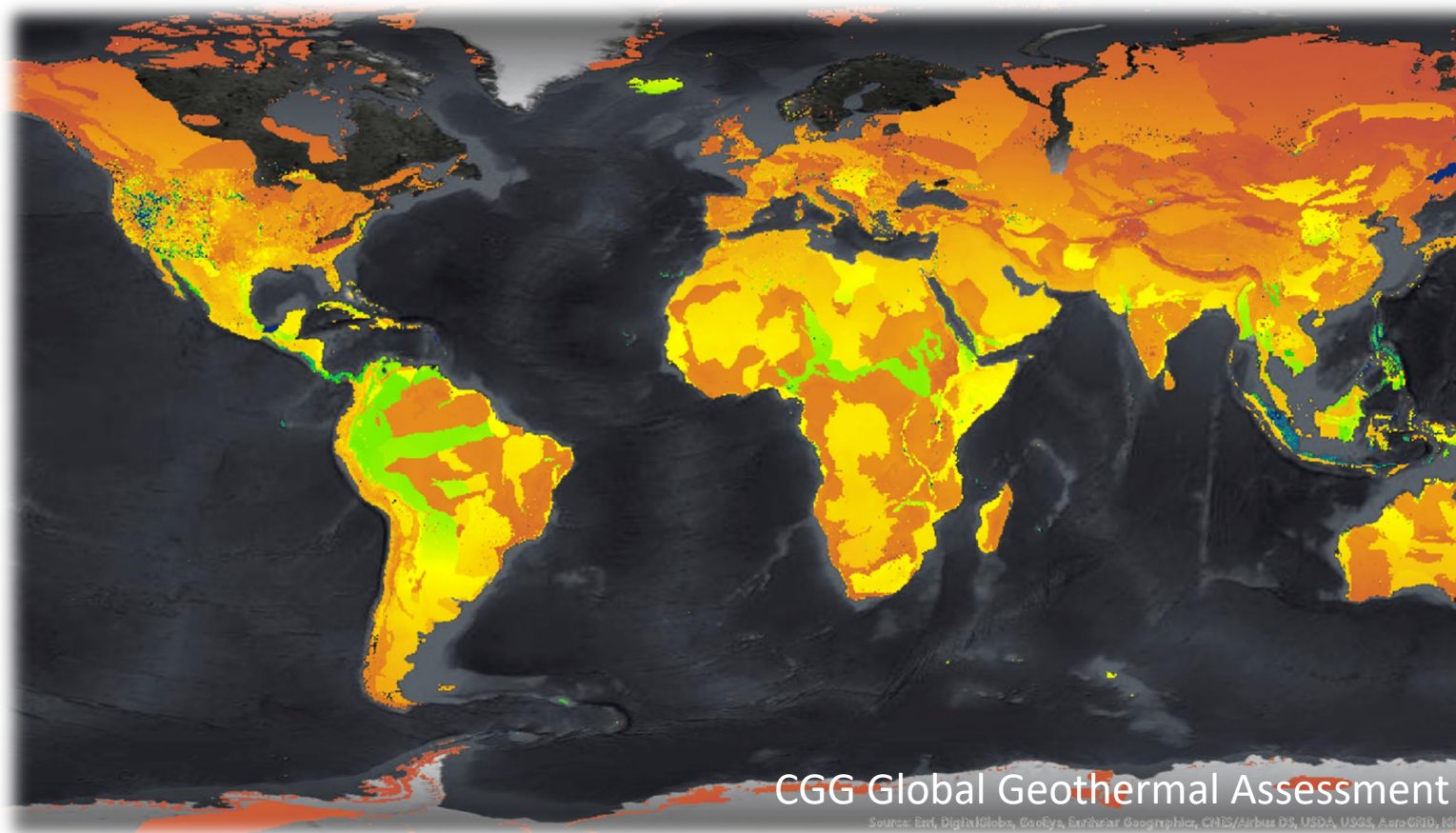




Conventional Geothermal:

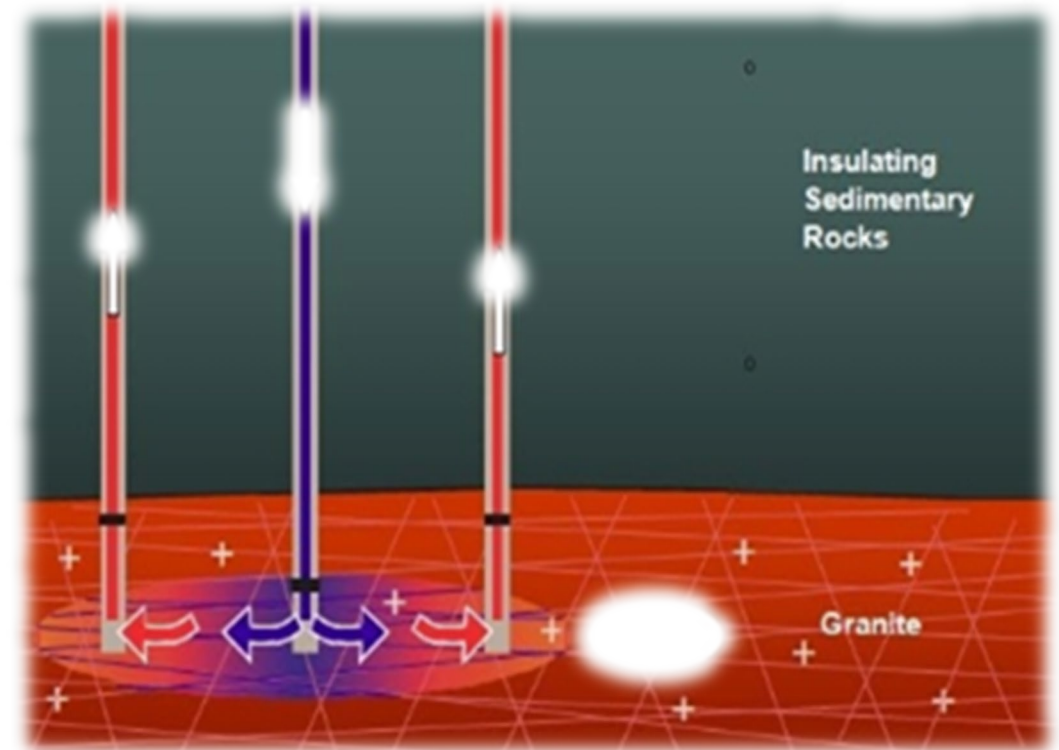
- Geologically complex and rare
- Needs natural water source, heat source, reservoir and plumbing system
- Providing ~16 GWe globally

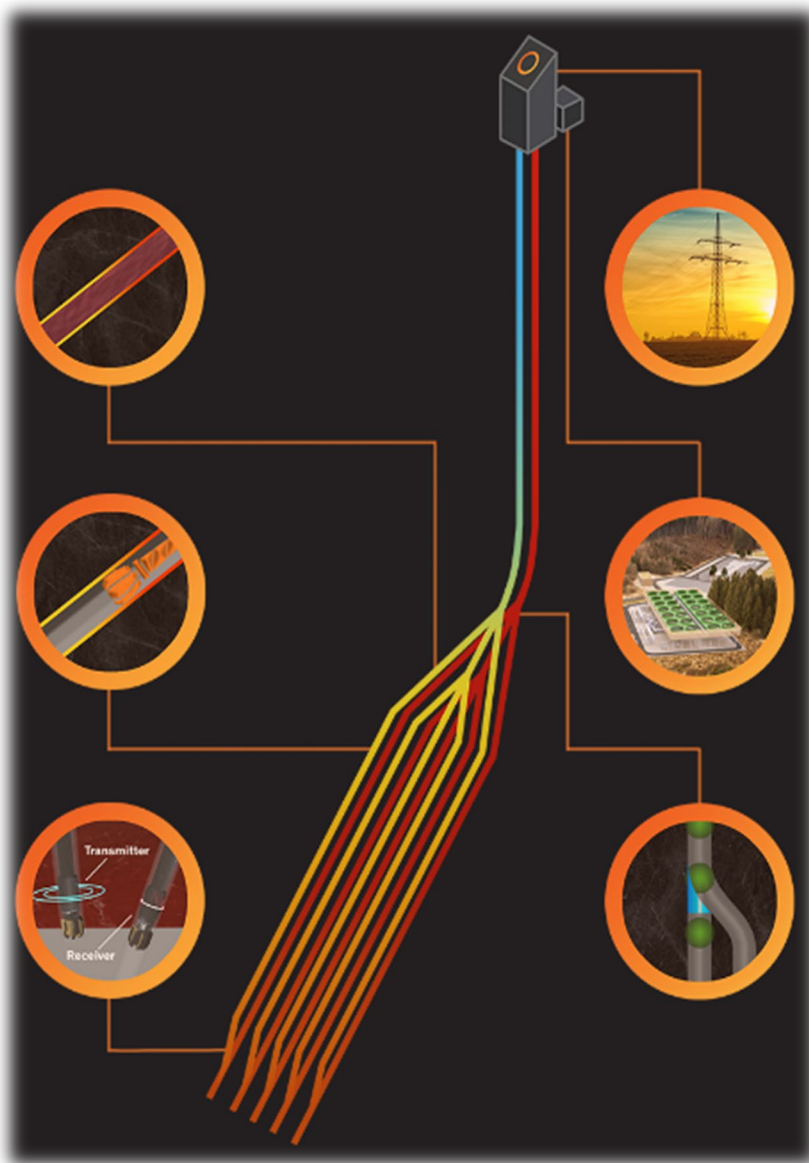
GEOHERMAL ENERGY: UNCONVENTIONAL GEOHERMAL





- \$1B++ investment over decades
- Drill into hot basement rock (granites), create an artificial reservoir (fracking) and introduce water
- Benefits: Globally available
- Challenges to overcome:
 - Imaging basement rock
 - Reservoir creation
 - Water loss
 - Induced seismicity (earthquakes)
 - Thermal decline/economics
- Who: DOE (FORGE), Fervo Energy, etc.



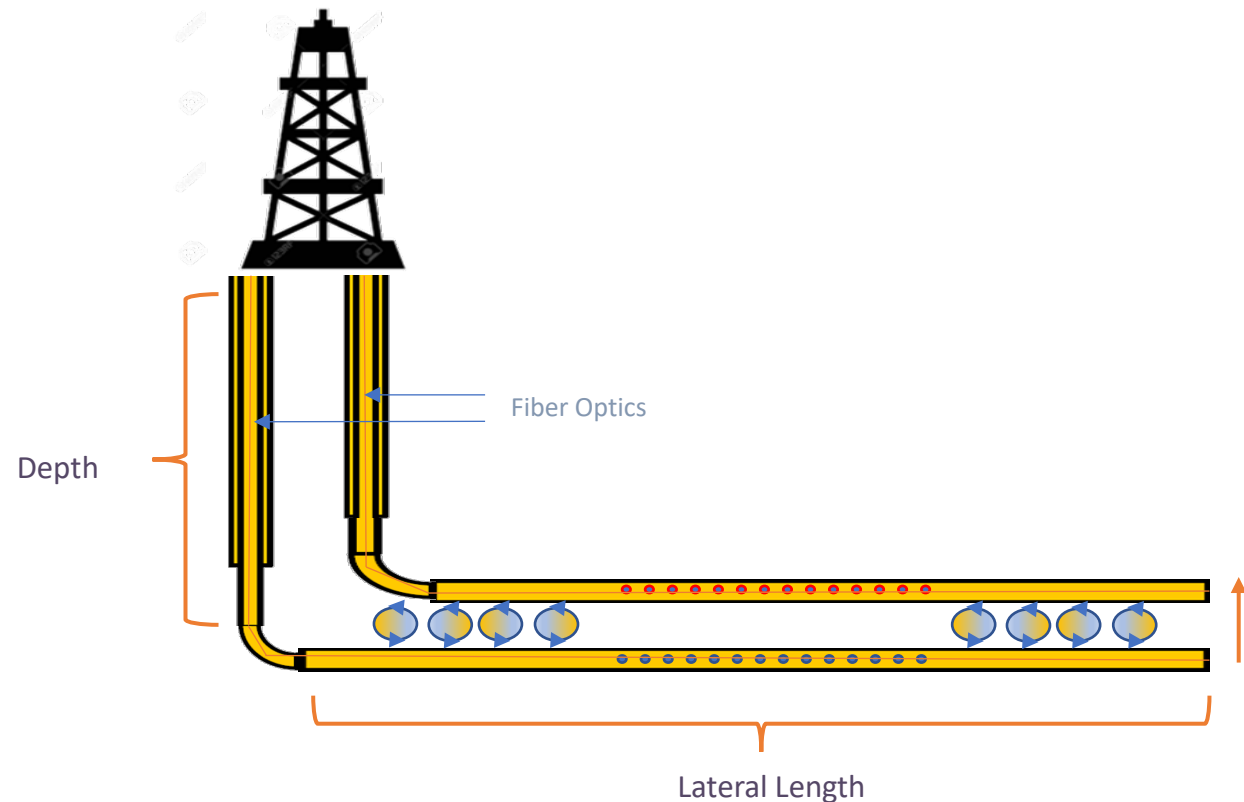


- Circulate a fluid in a closed loop or multi-closed loop system
- U-loop and Pipe-in-Pipe Variations
- Benefits: Solves water loss, reservoir, imaging and induced seismicity issues
- Challenges to overcome:
 - Thermal decline/economics
- Who: Eavor, GreenFire Energy, others

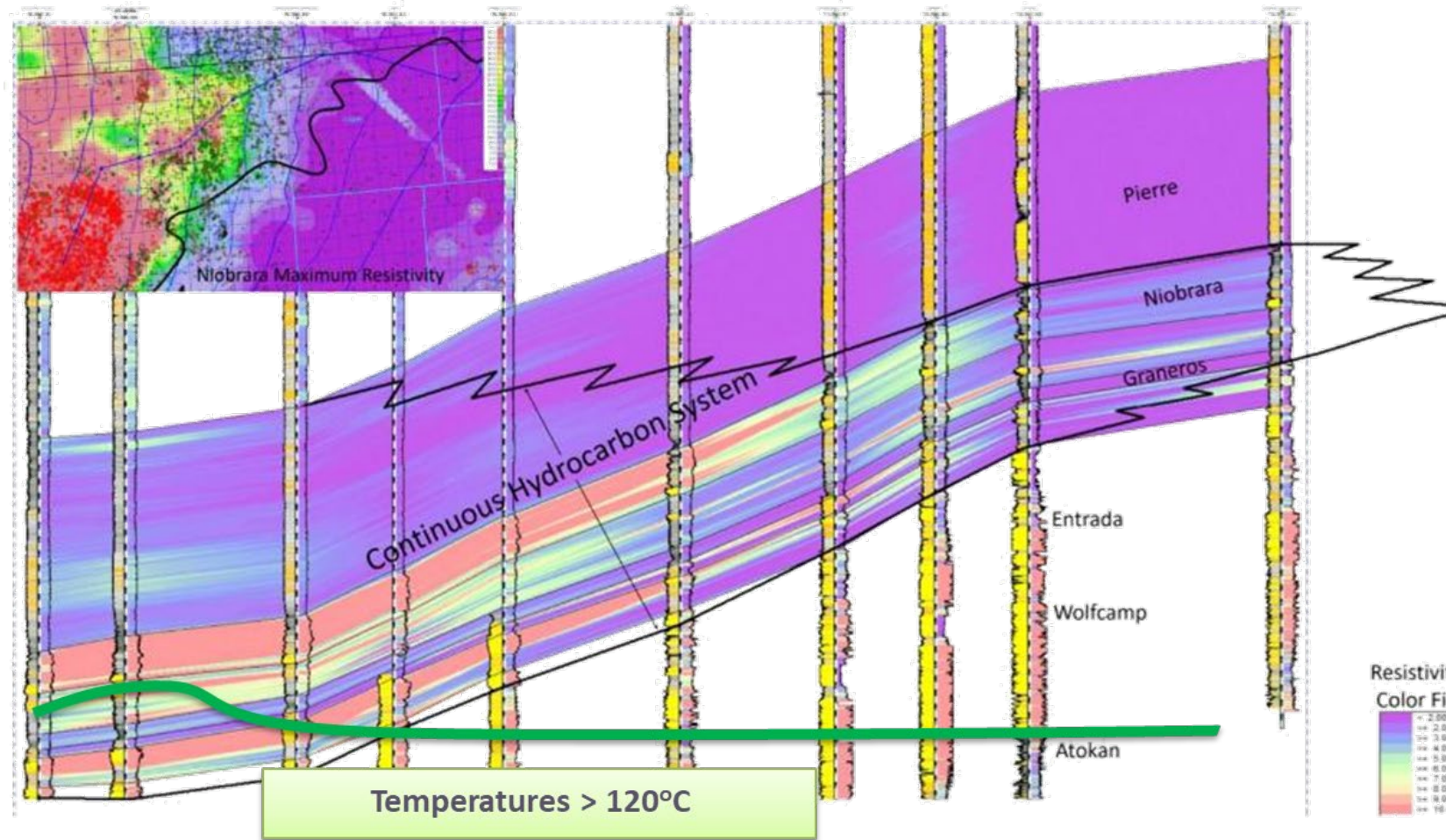
GEOHERMAL ENERGY: HOT SEDIMENTARY AQUIFERS



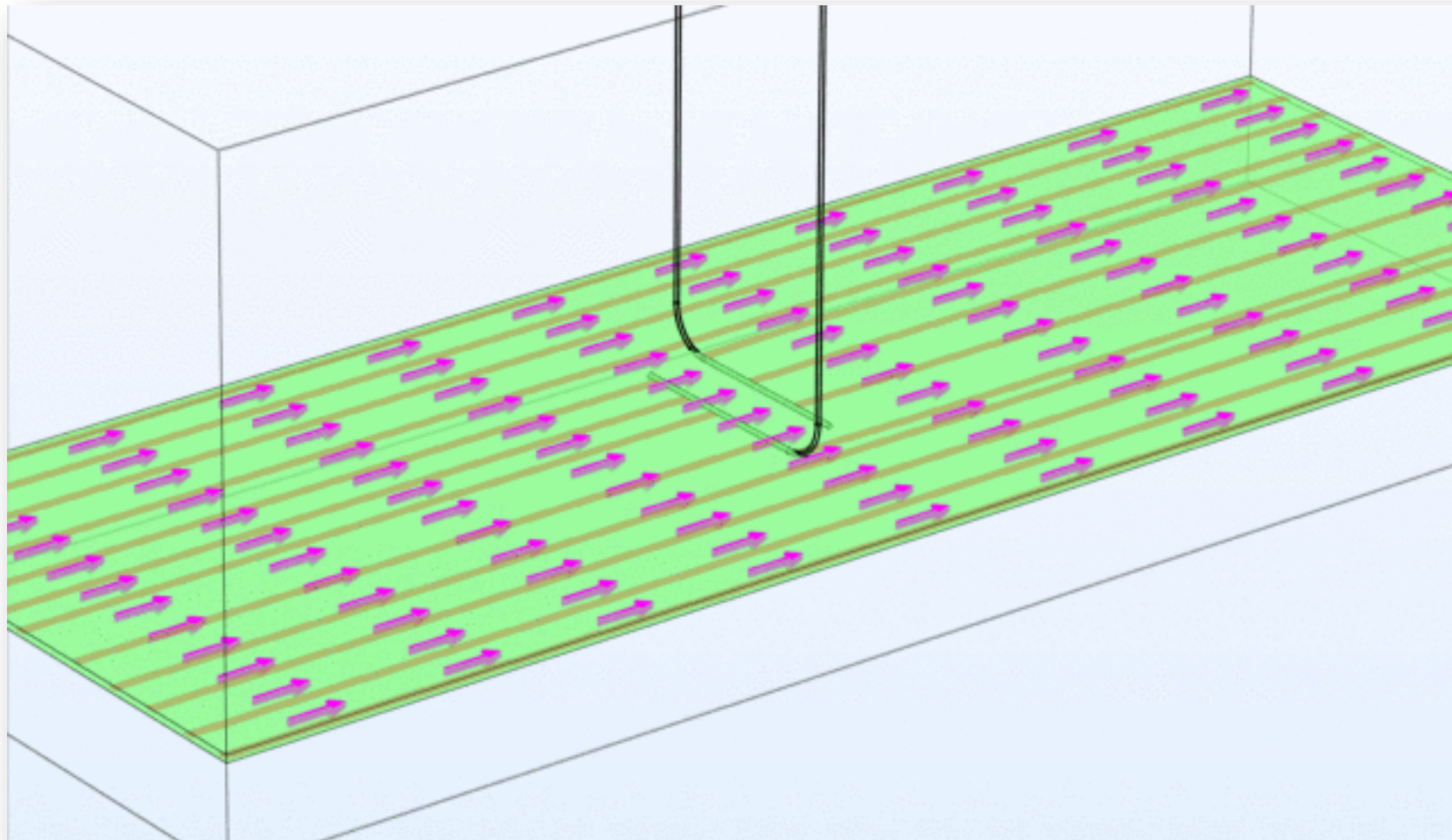
- Target hot brines that exist below most oil and gas basins.
- Build a production and injection system using lateral wells
- Create a convective recharge system optimized for longevity through well geometry and pumping
- Benefits:
 - Scalable – sedimentary basins are globally abundant
 - Reuse oil and gas data, technology and infrastructure
 - Economically attractive – depreciate system construction over decades and low OpEx (no fuel)
- Challenges to Overcome: Funding
- Who: GTI, DEEP, etc.



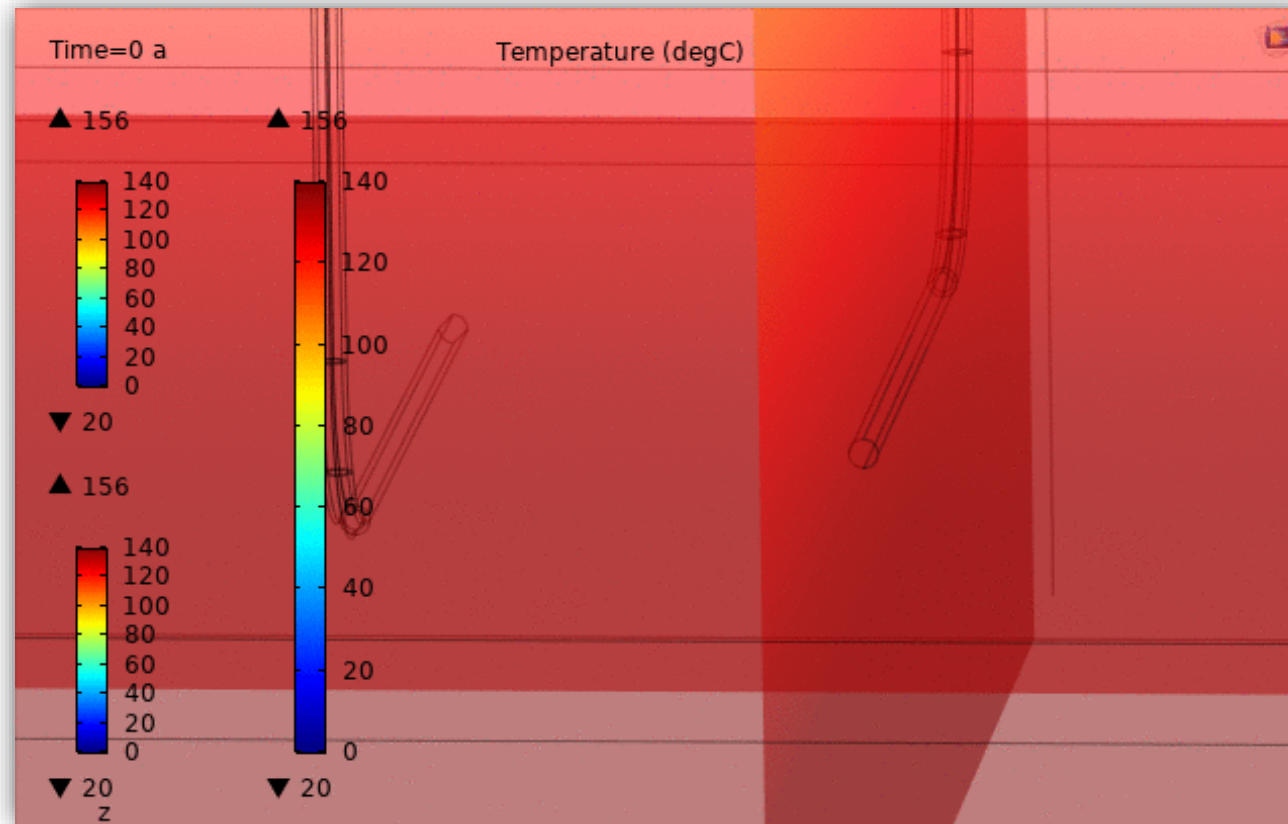
GEOHERMAL ENERGY: HOT SEDIMENTARY AQUIFERS



Example: D-J Basin Colorado



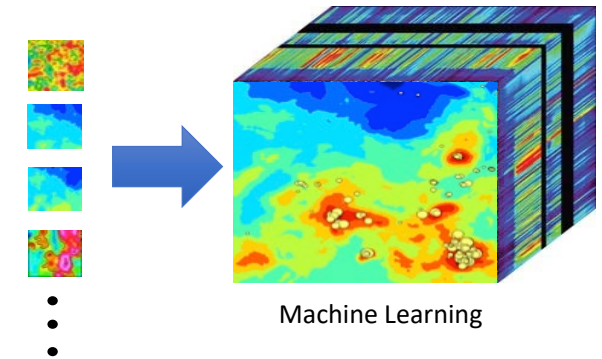
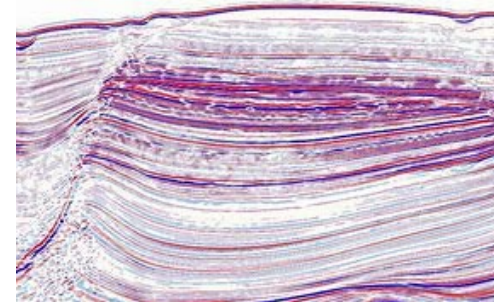
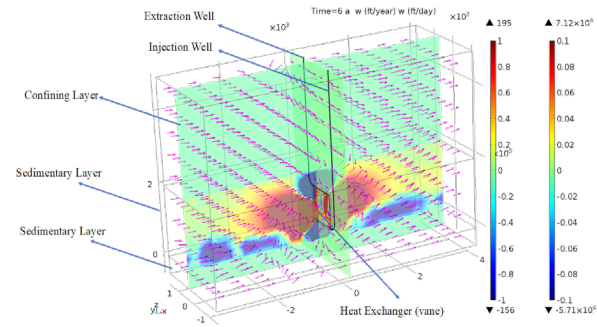
Lateral Production and Injection Well Design, drives
Thermal Recharge via Convection



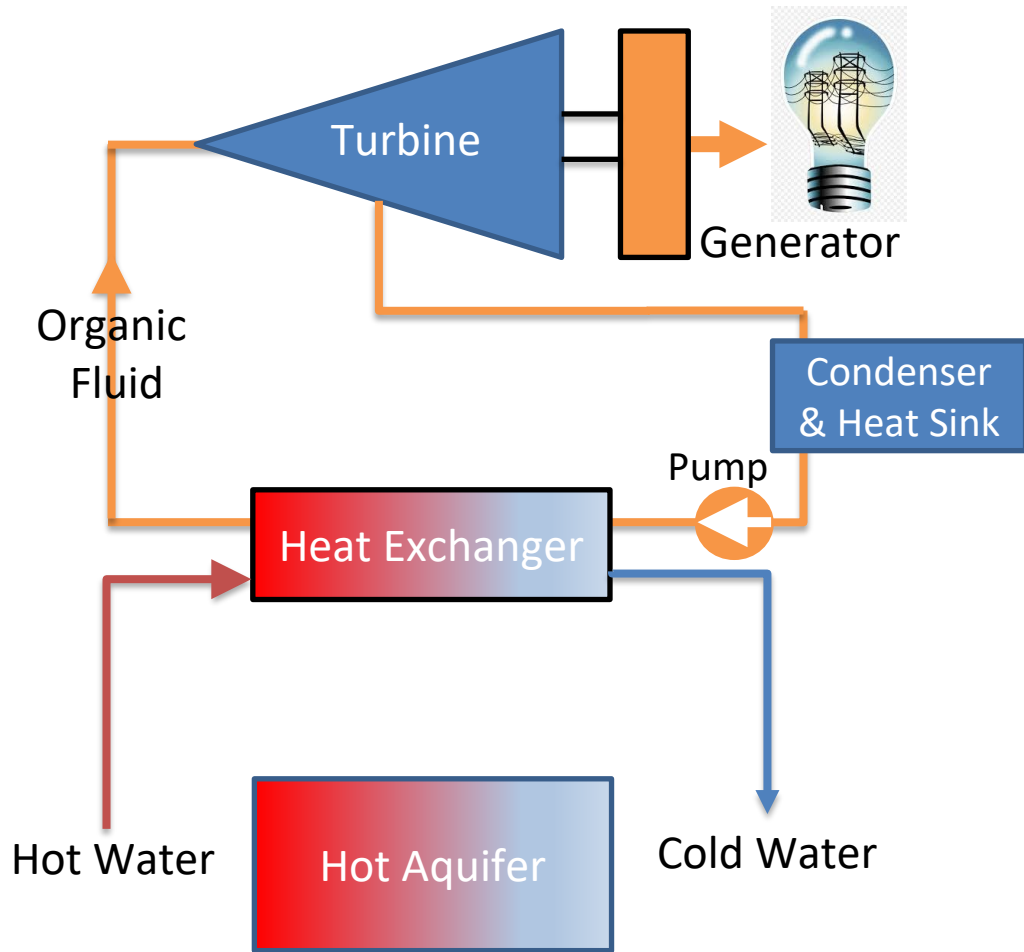
Thermal recharge enhances system longevity,
dramatically reducing energy cost



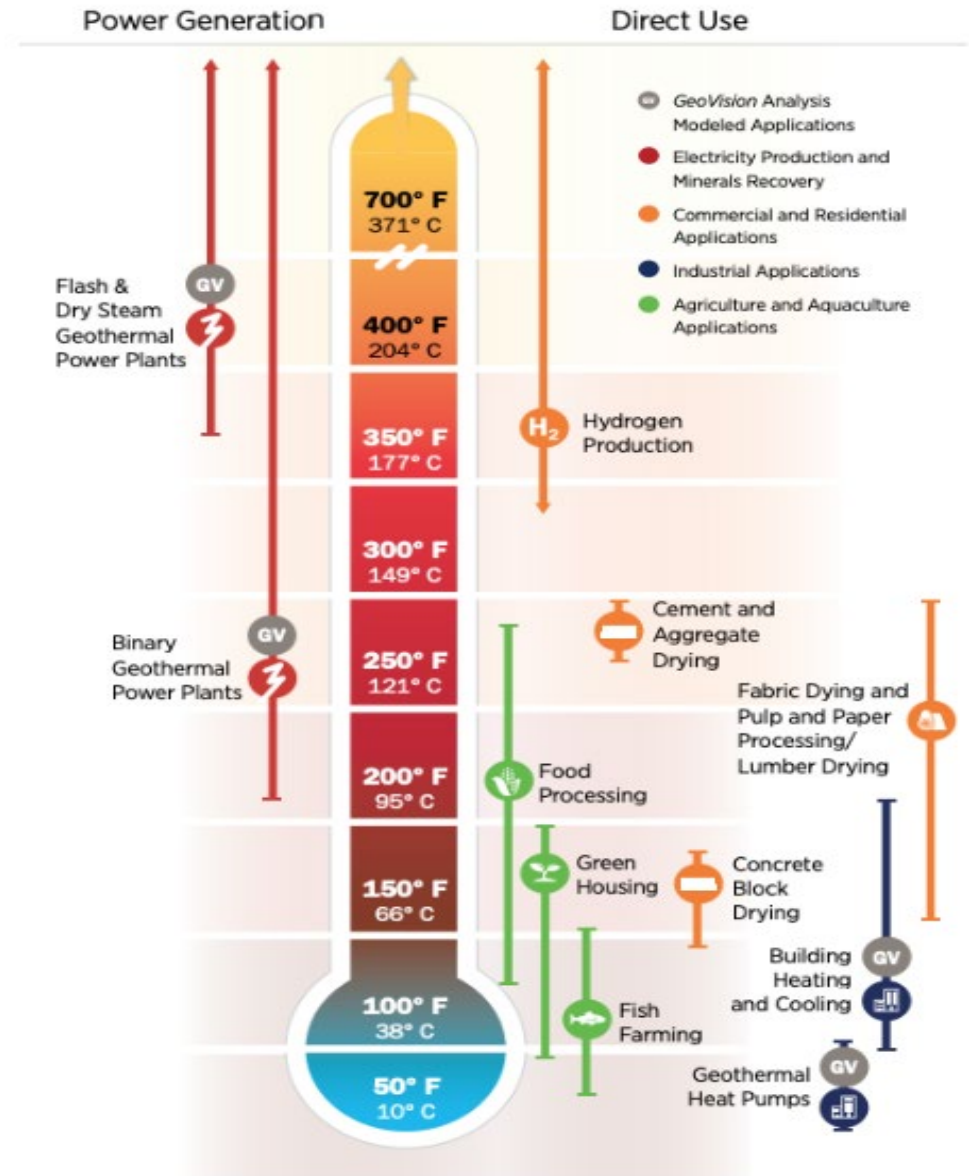
- Cloud-based Forward Modeling the Physics from existing oil and gas data
- Machine Learning Aided Target Site Identification
- Advanced Subsurface Geophysical Imaging
- State-of-the-Art Drilling, Completion and Monitoring Technology



GEOHERMAL ENERGY: ENABLING TECHNOLOGIES



Binary Power Plants (example Organic Rankine Cycle)





Unconventional Geothermal Systems (EGS, CLS, HSA) allow reuse of data, technology, and infrastructure:

- Reuse of Oil and Gas skillsets and technologies: Geology, Geophysics, Reservoir Engineering, Horizontal Drilling, Project Management, etc.
- Reuse of Oilfield Geology & Geophysical data/information
- Reuse of infrastructure (platforms, pads, roads, powerlines, wells for monitoring, etc.)
- Natural Add-on to hydrocarbon production





Questions?

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TECHNOLOGIES**