Our Next Speaker

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BS, Geology, Princeton University, 1973

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Founder/President and CTO AltaRock Energy 2007

Founder HERO 2016

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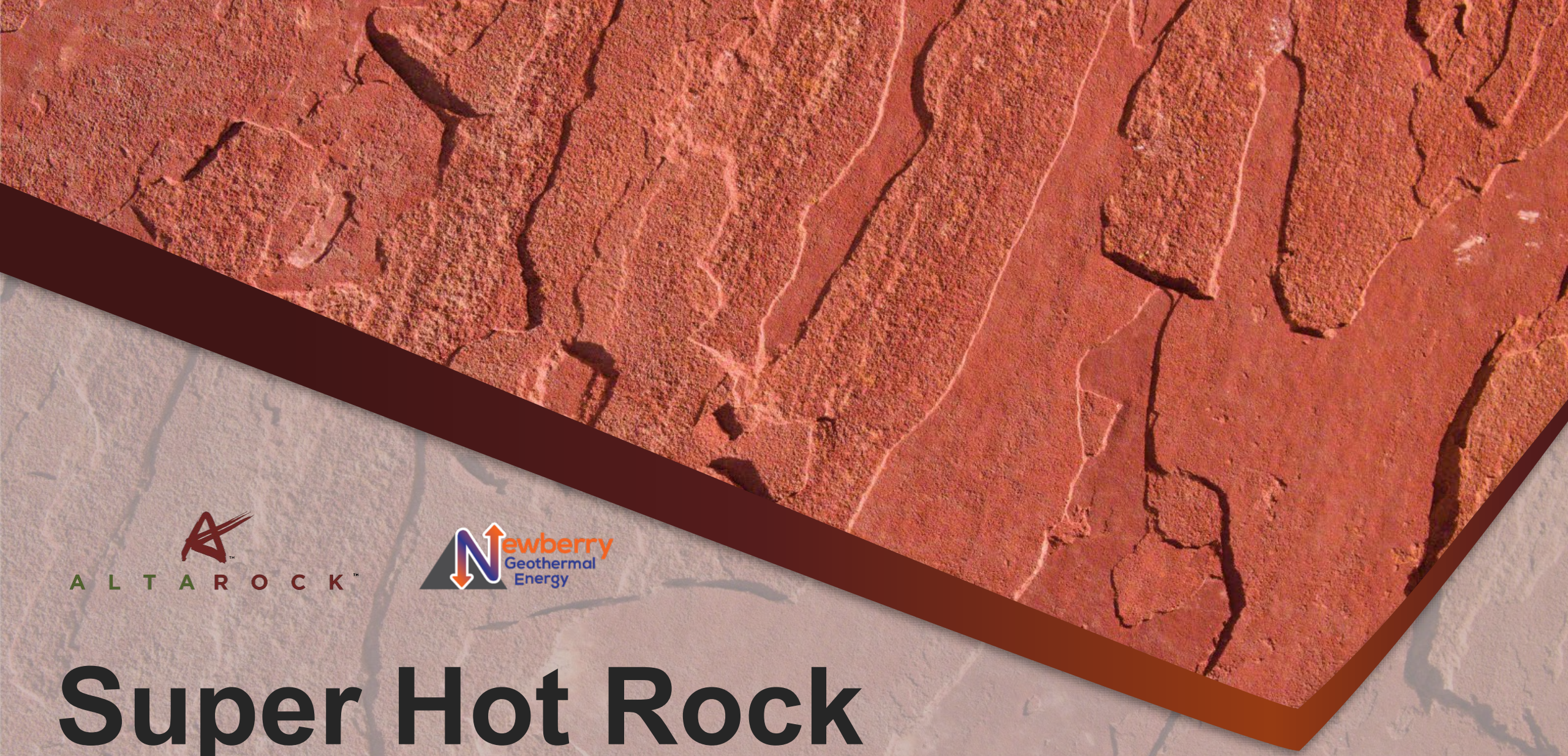


ALTAROCK™

Newberry Geothermal Energy

Super Hot Rock

A Renewable Energy Breakthrough

May 2019

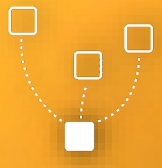
http://altarockenergy.com/super-hot-rock


How
do we meet
future electrical
demand with
clean power?

The ideal energy source:

Dependable

Flexible

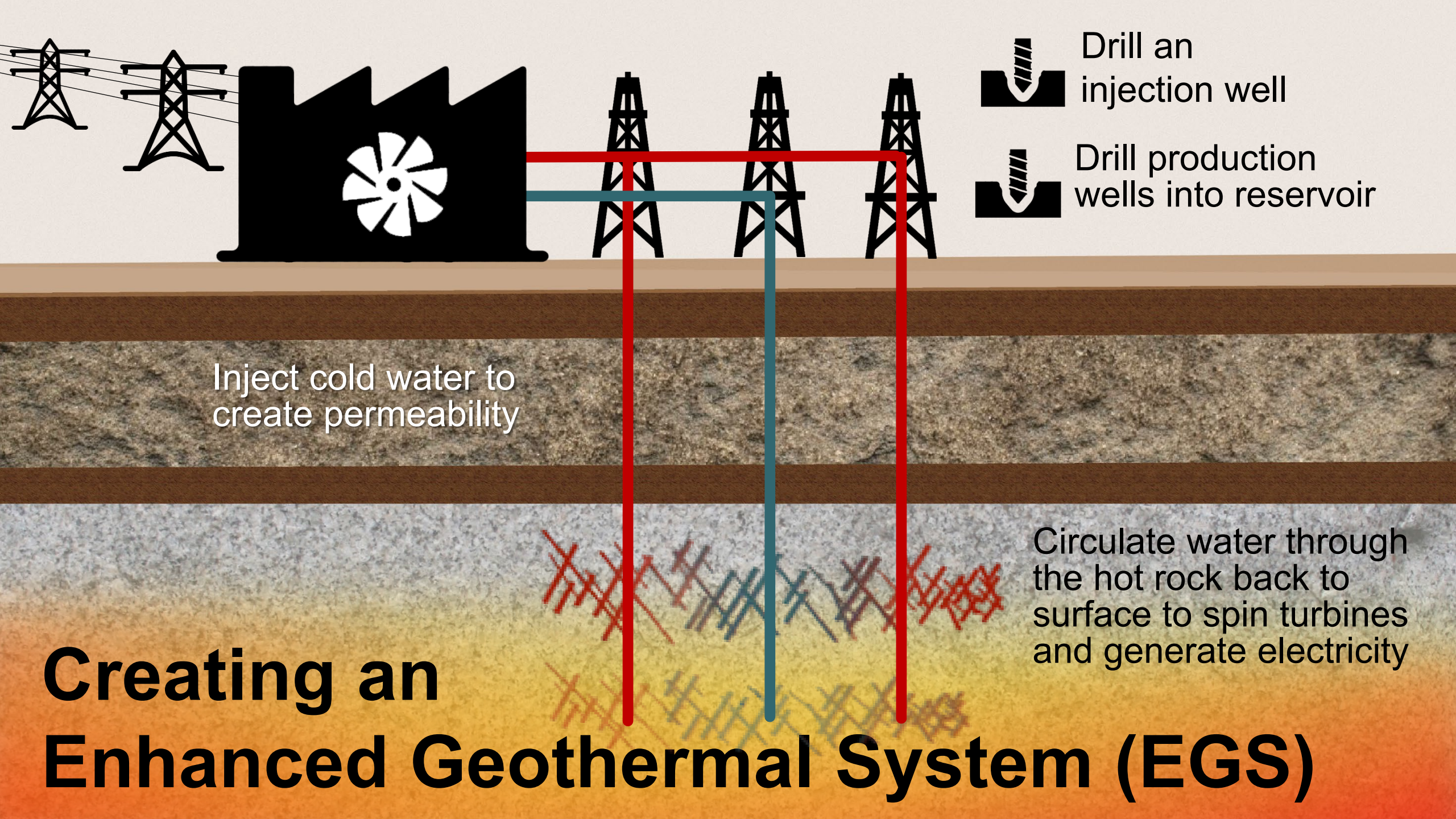


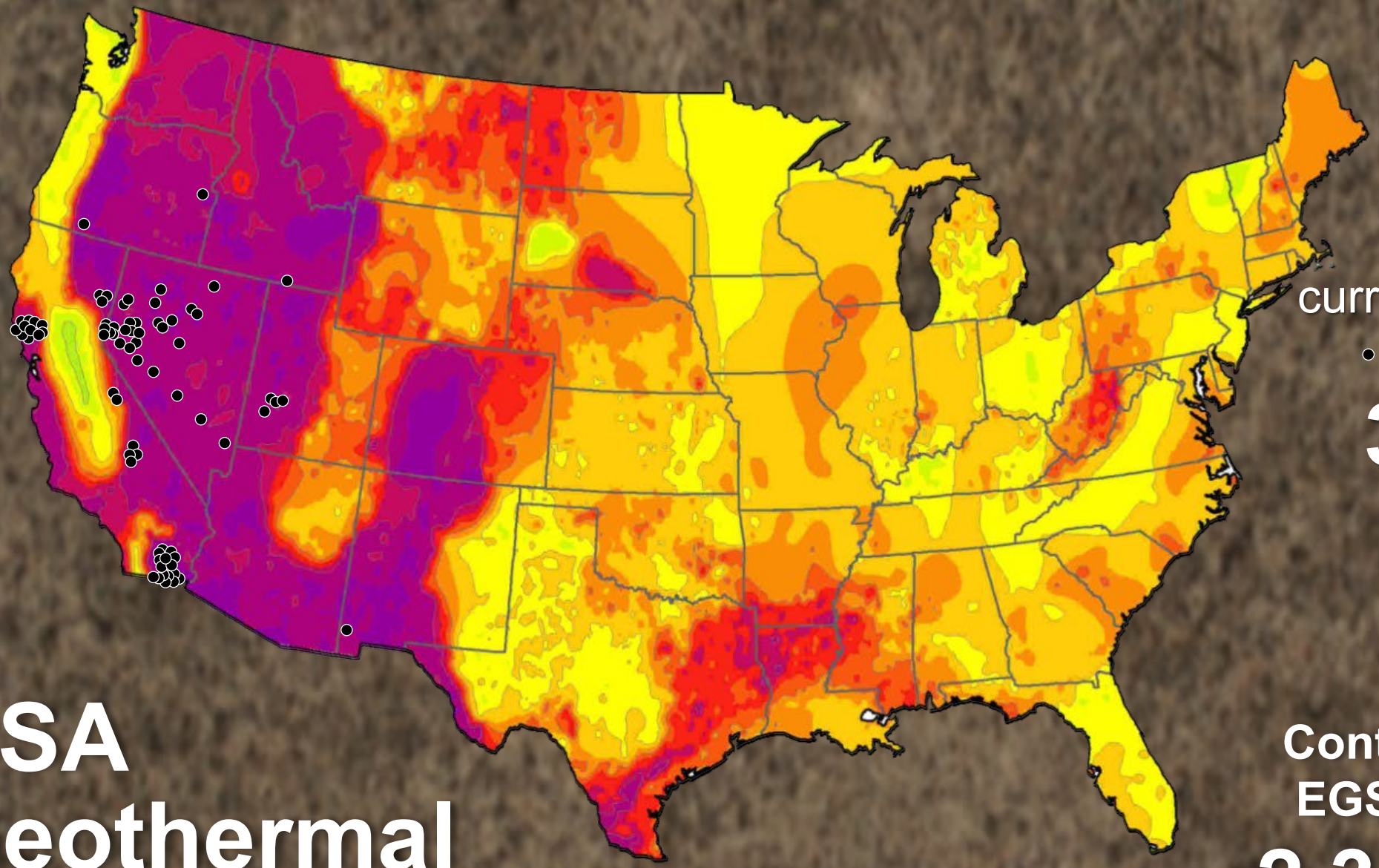
Widely Deployable

High Energy Density

Free Fuel

Low Cost


Drill an injection well
Drill production wells into reservoir
Inject cold water to create permeability
Circulate water through the hot rock back to surface to spin turbines and generate electricity
Creating an Enhanced Geothermal System (EGS)

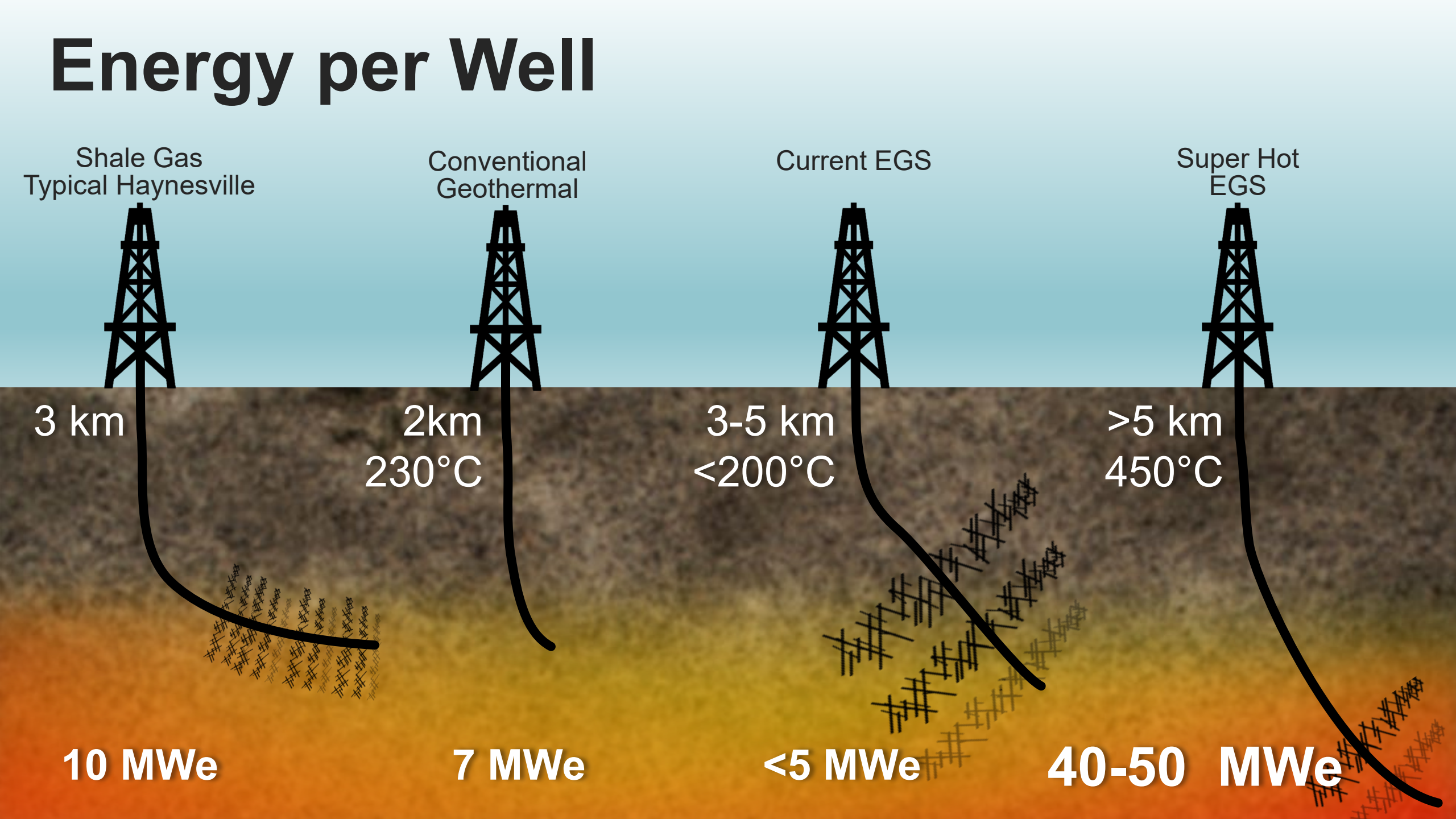


USA Geothermal Resources

current conventional
• geothermal
3.5 GW

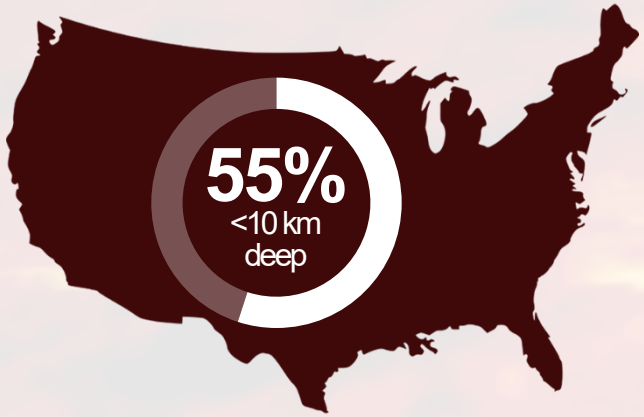
Continental US
EGS Potential
2,300 GW

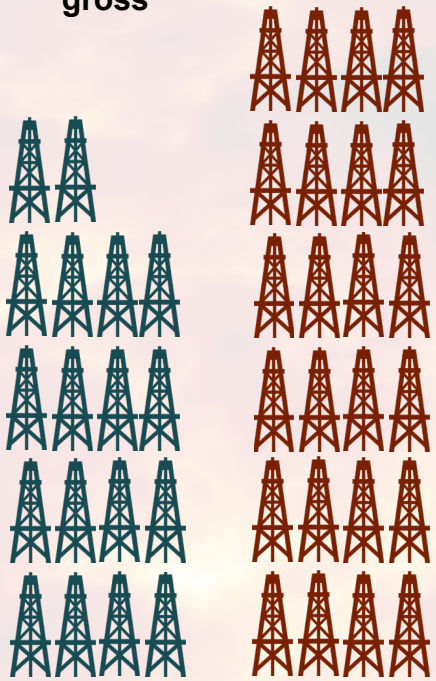
Energy per Well



200°C

120 MW_{gross}





18
injection wells

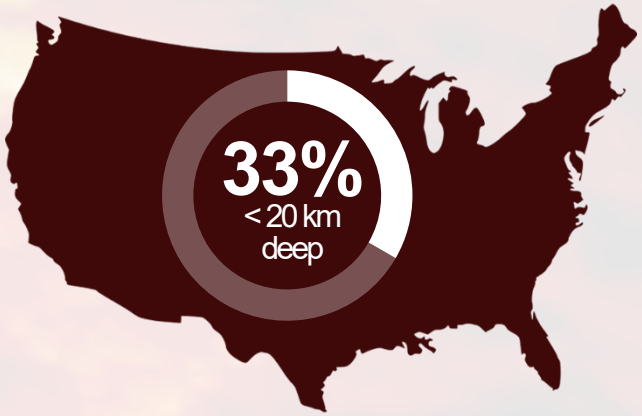
24
production wells

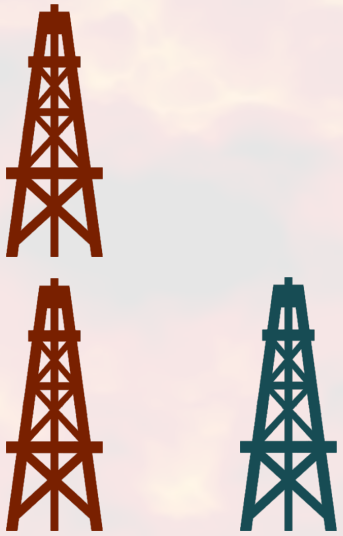
85 kg/s fluid

30km^2
geothermal leases

106 MW_{gross}

400°C





2
production wells

60 kg/s fluid

1
injection well

1km^2
geothermal leases

Temperature Matters

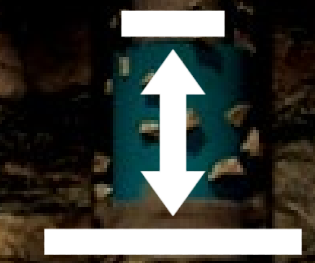
100 MW utility-scale plant

EGS can meet the market if we go hotter and deeper to directly tap the heat source

Temperature > 400°C

10x production per well

Rock-type independent mechanical behavior



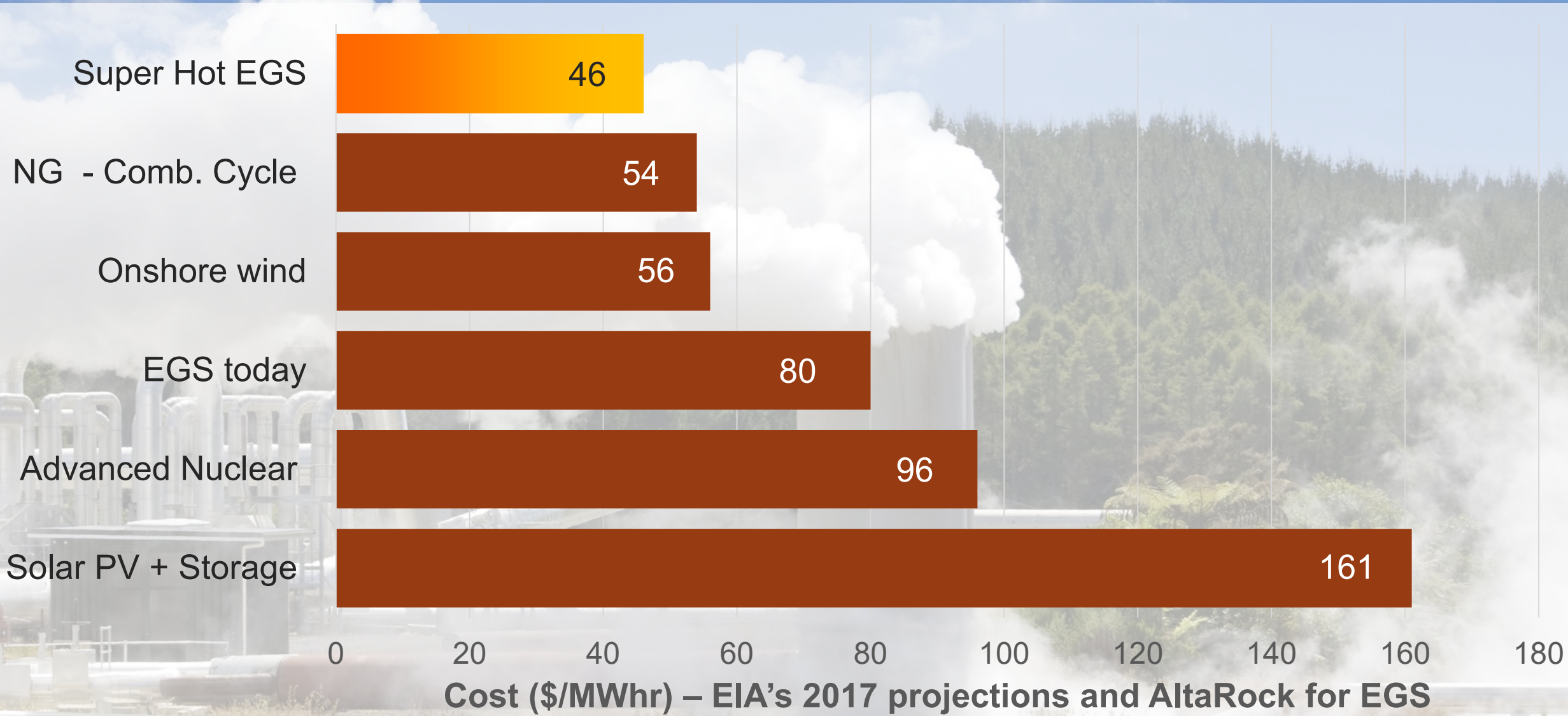
Depth > 10 km

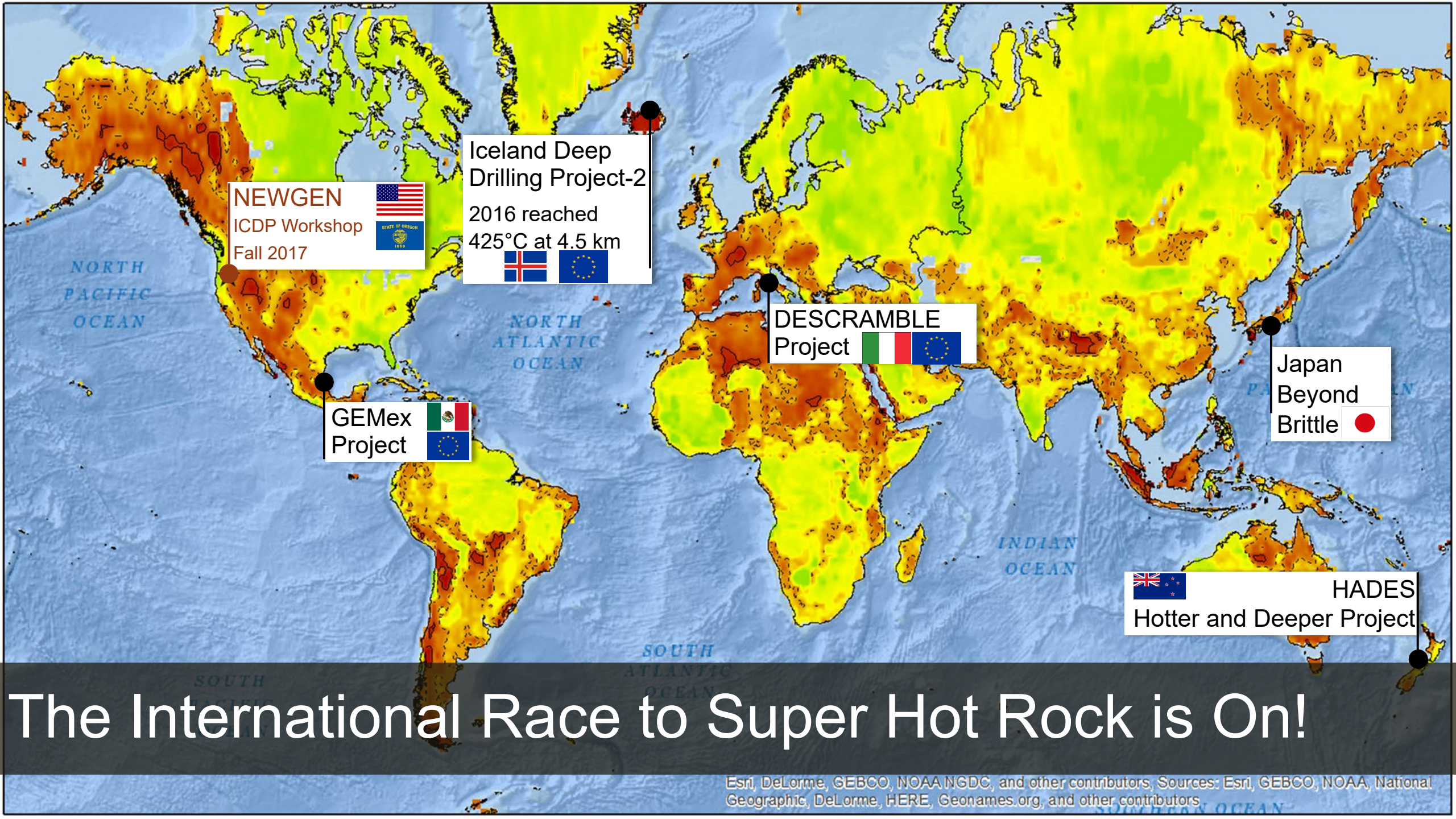
Allows expansion of Super Hot EGS globally

Thermal gradient

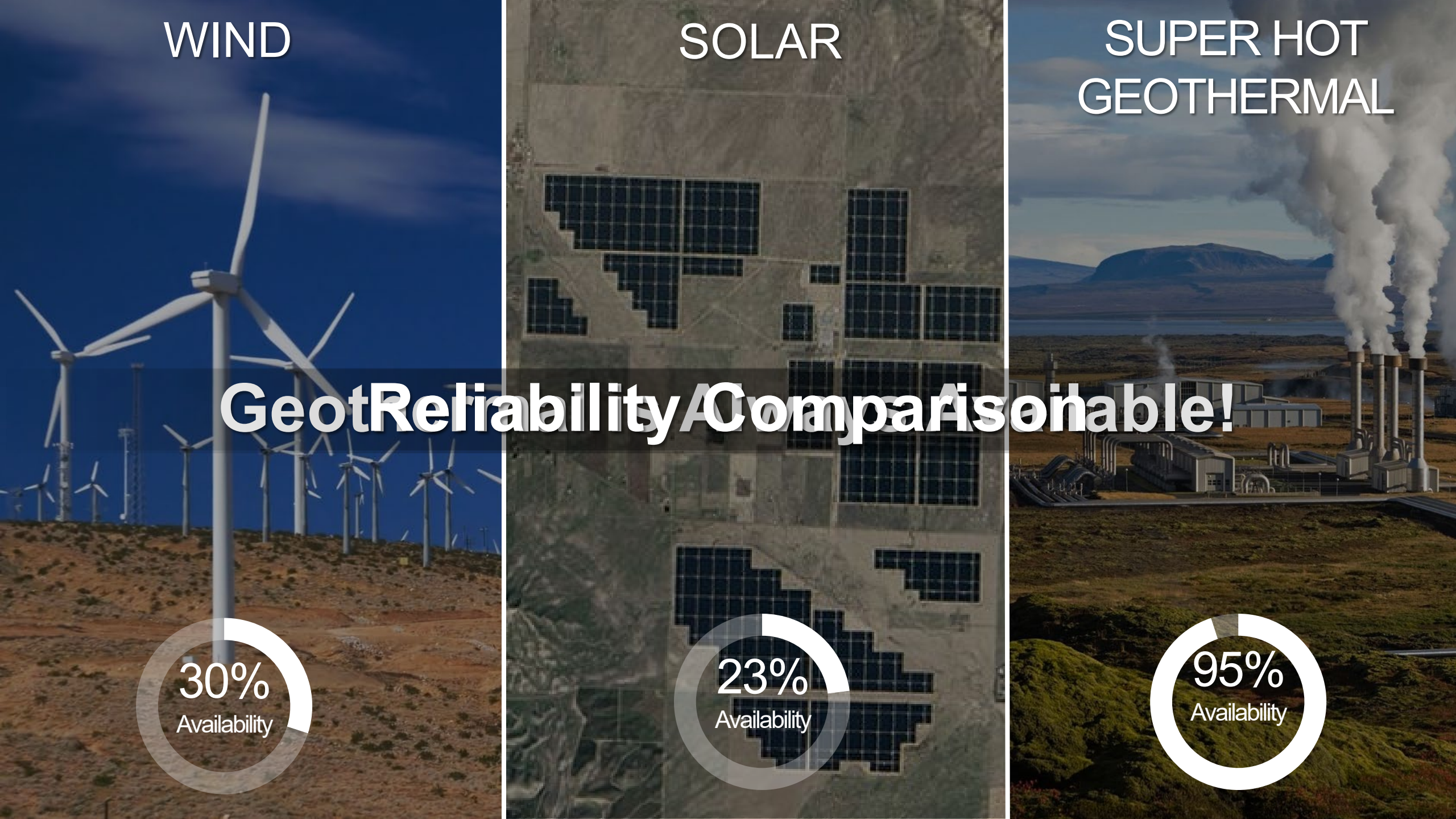
30 – 80 °C/km

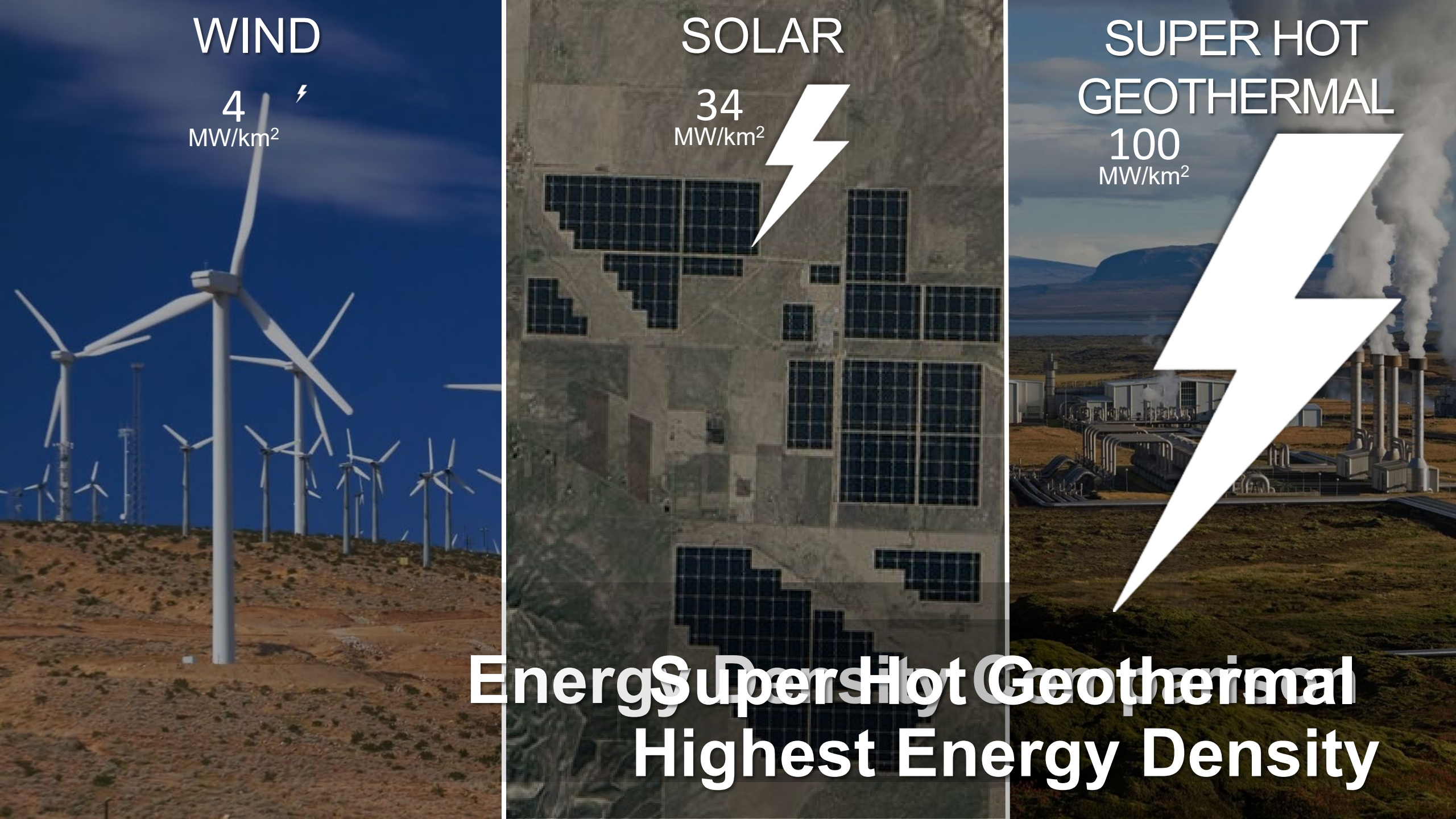
Levelized Cost of Electricity ($/MW-hr)





The International Race to Super Hot Rock is On!


WIND
SOLAR
SUPER HOT GEOTHERMAL
GeotReliability Comparisonable!
30%
Availability
23%
Availability
95%
Availability


WIND
4
MW/km2
SOLAR
34
MW/km2
SUPER HOT
GEOTHERMAL
100
MW/km2
Energy Density Comparison
Super Hot Geothermal
Highest Energy Density

The path to Global Penetration

Assemble the dream team.

Innovate required breakthroughs.

Install successful demonstration site.

Iterate!!

Go deeper and hotter as needed.

Innovations needed: Temperature

Improvement in drilling equipment, instrumentation and techniques at >400°C

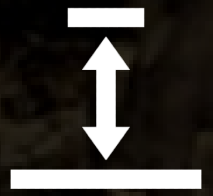
Advanced well construction materials

Reservoir creation techniques in super hot rock

Start in Magmatic Areas

Breakthrough

Innovations needed: Depth

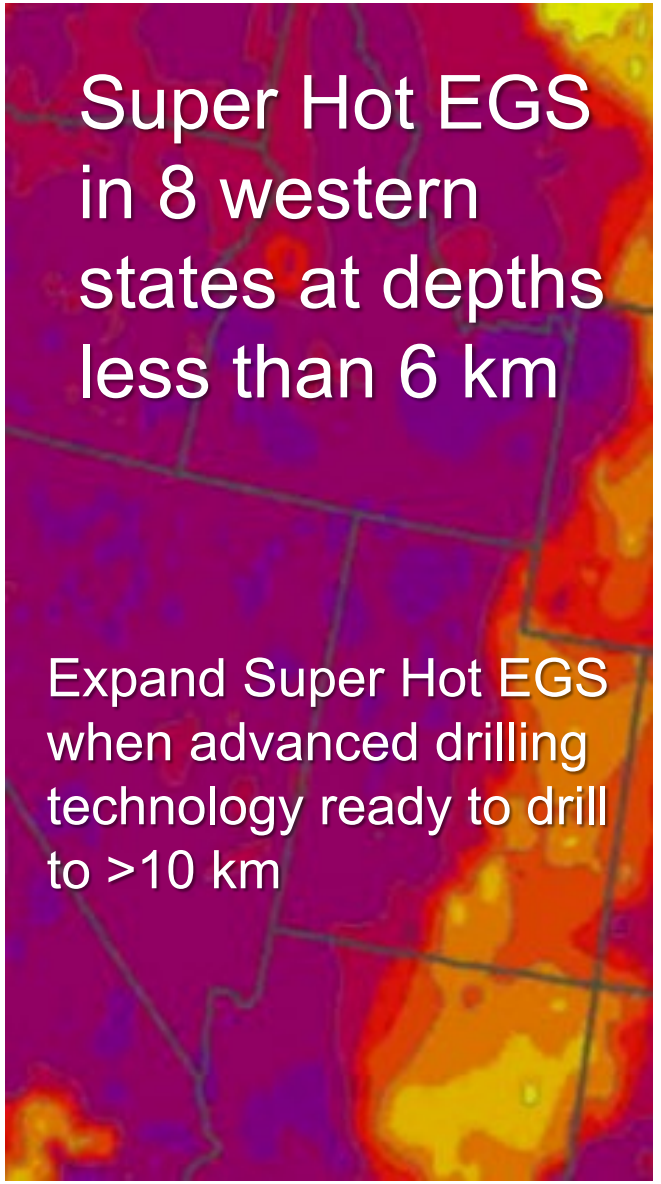


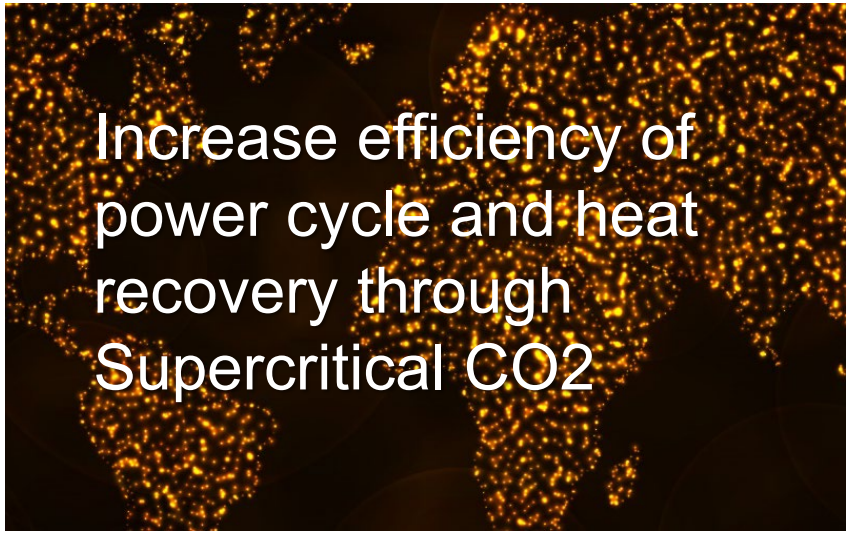
Well completion techniques and materials to economically reach 10-20 km

Next generation drilling equipment

Super Hot EGS Anywhere

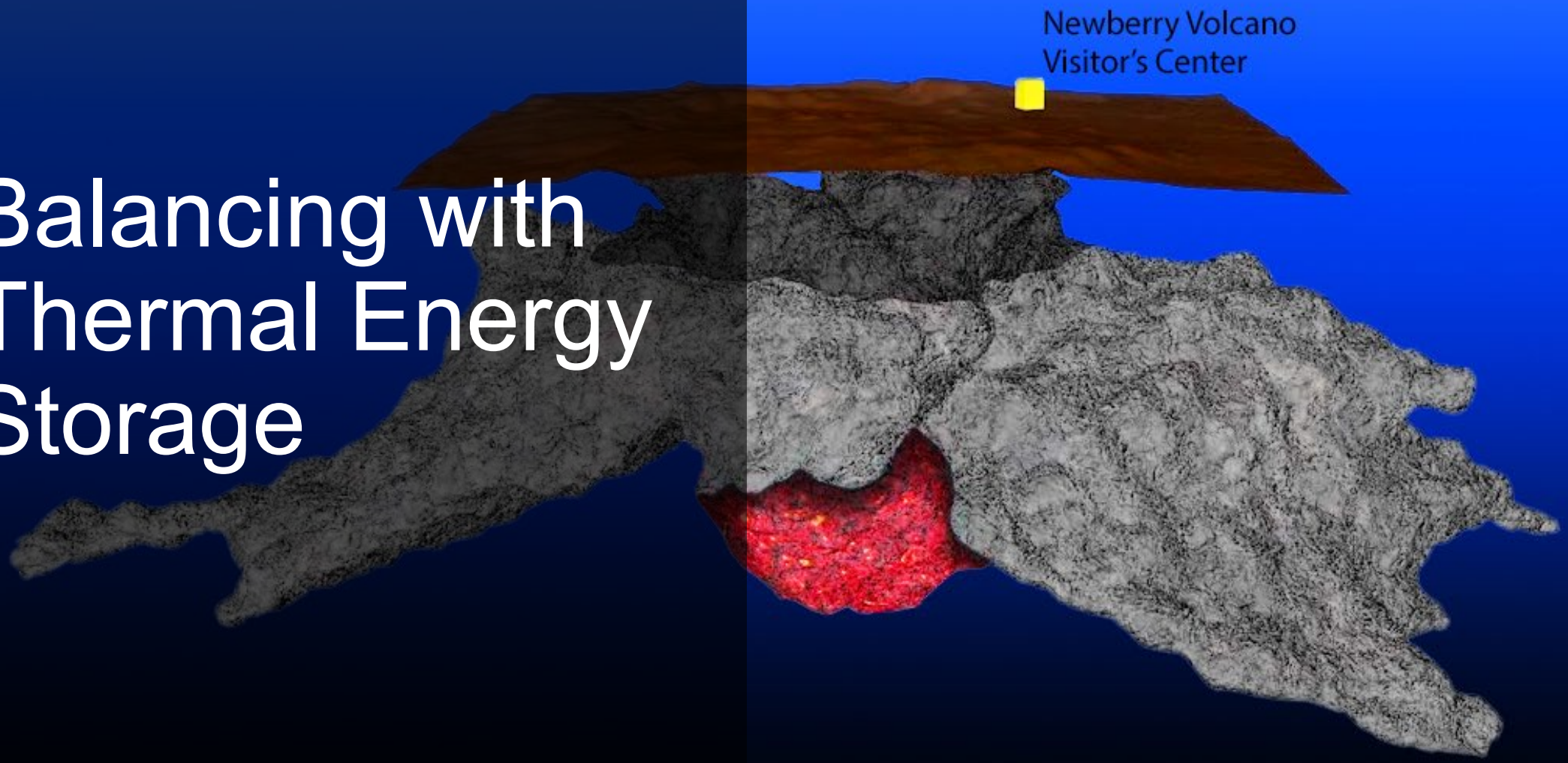
Breakthrough



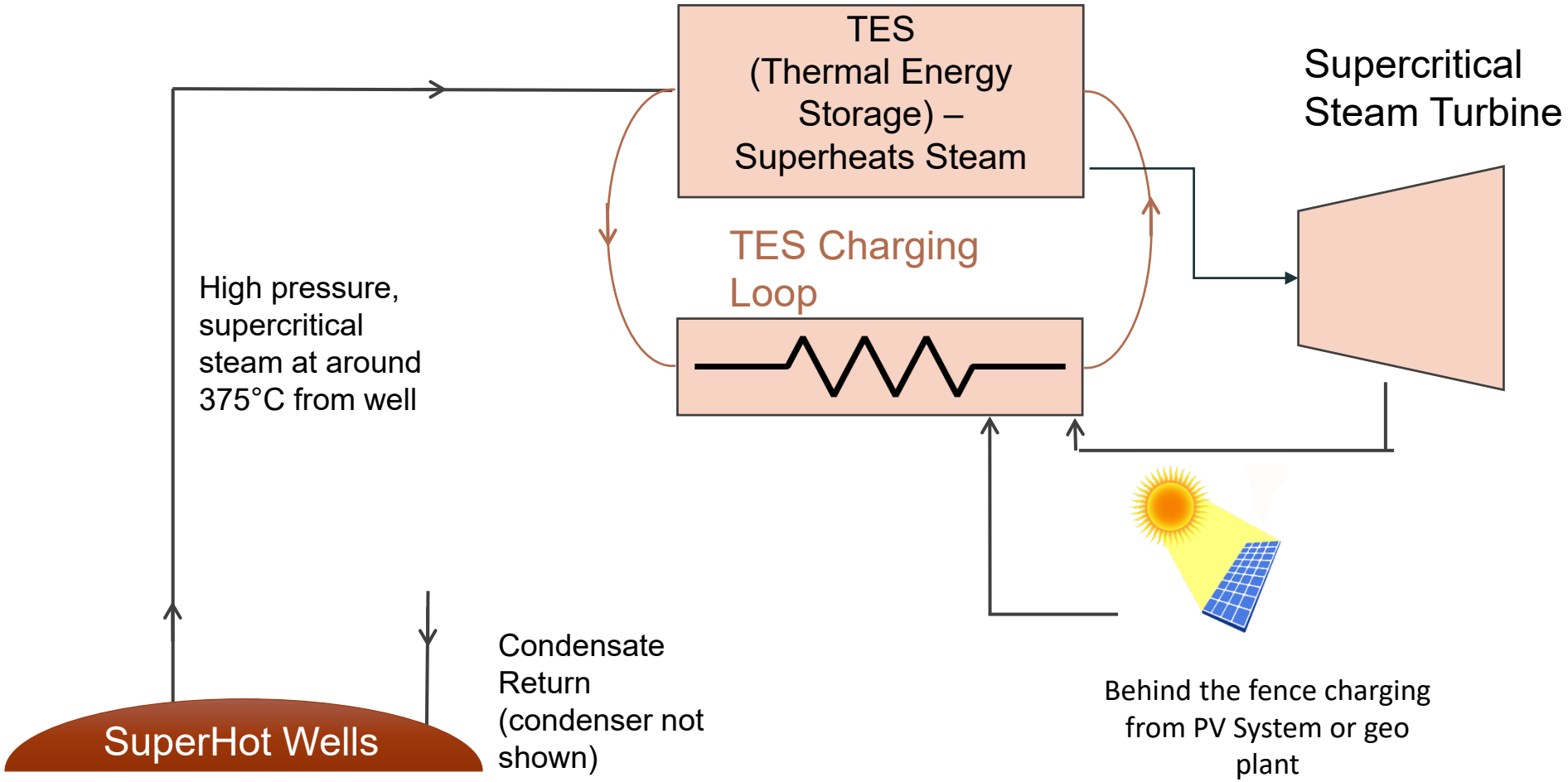


SuperHot EGS Advancements

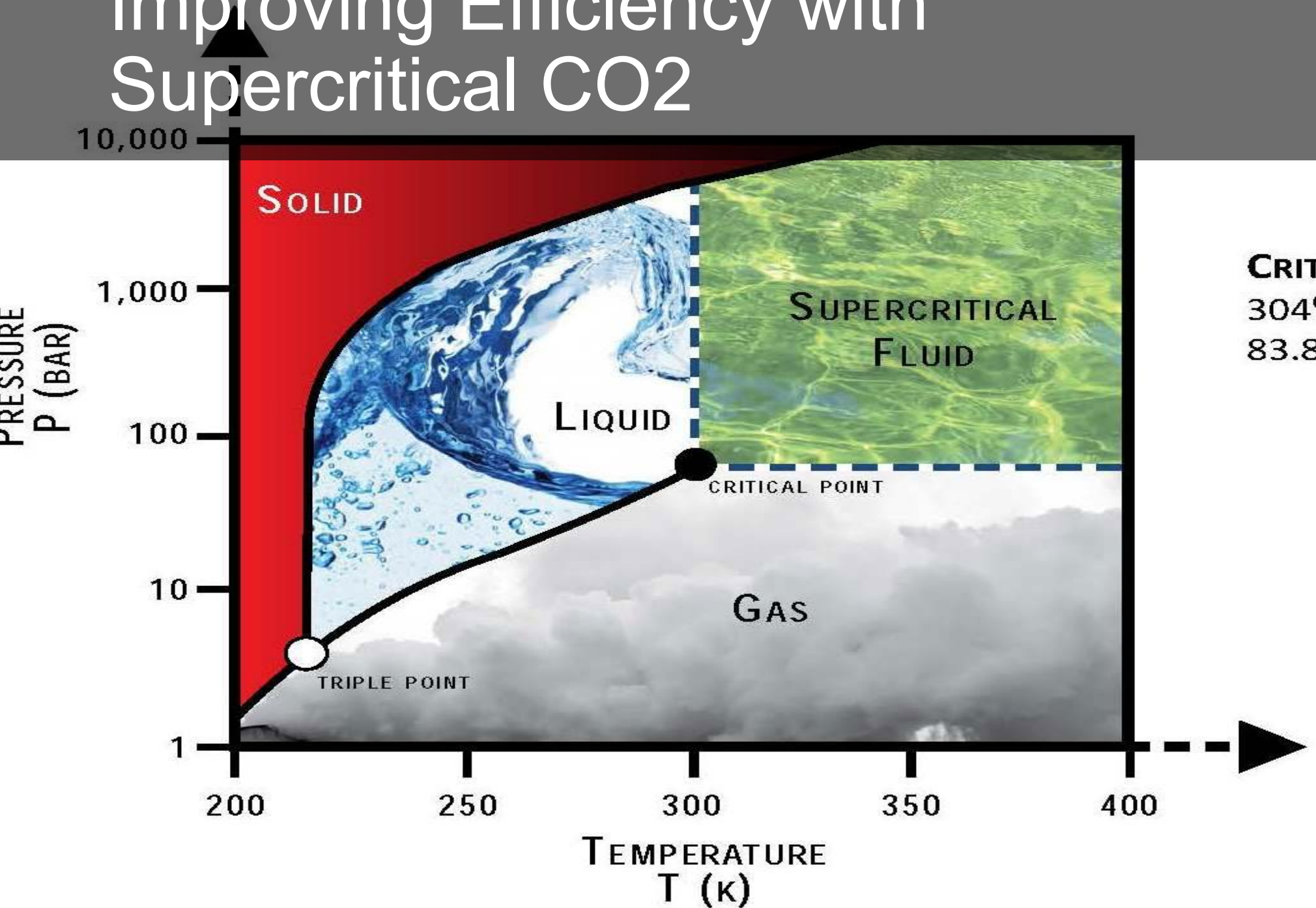
Balancing with Thermal Energy Storage



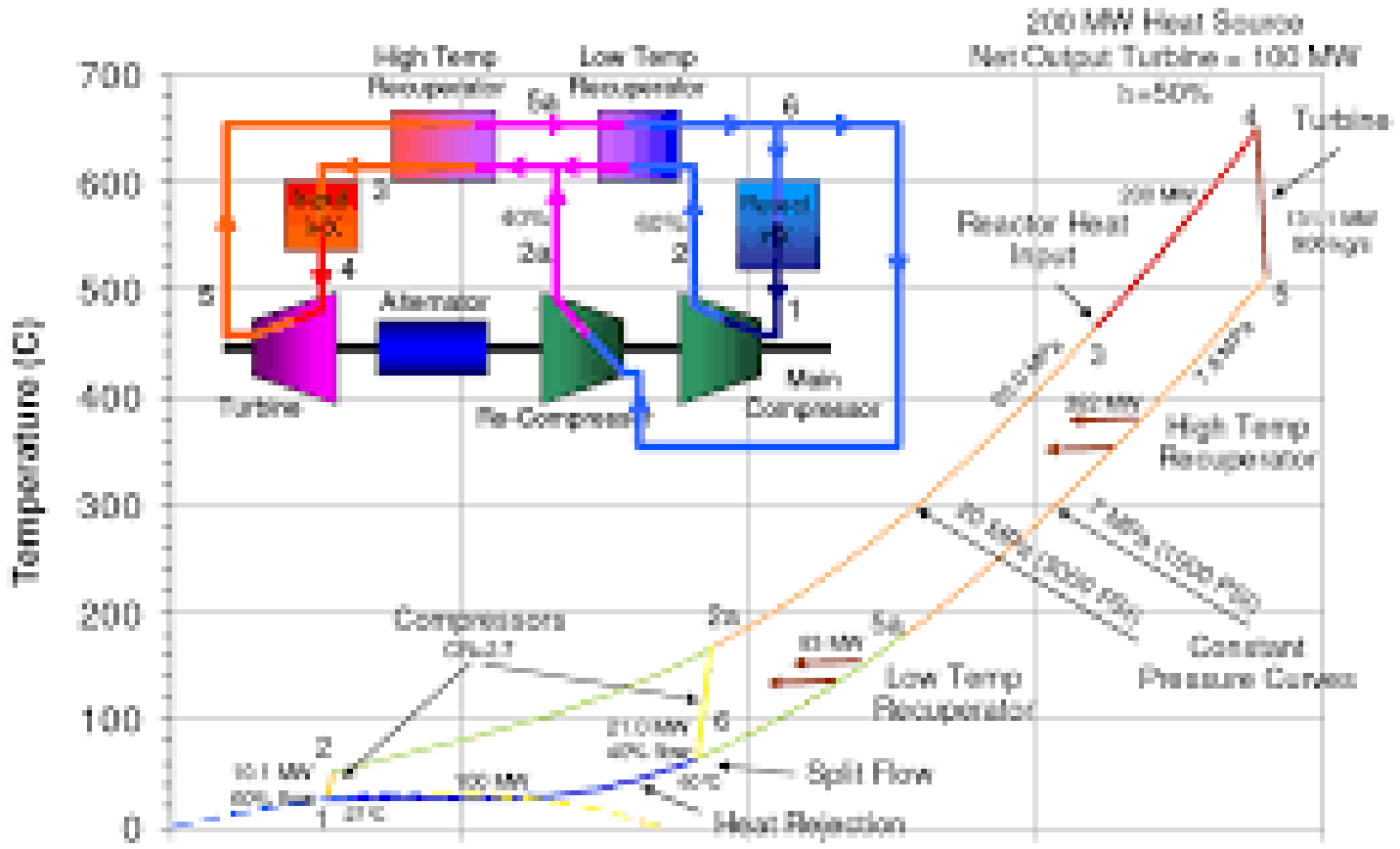
Geo+PV+TES System Layout



Improving Efficiency with Supercritical CO2



CRITICAL POINT
304° K = 31° C = 88° F
83.8 bar = 8.38 Mpa
= 1,070 psi



Numerical modeling studies showed that it is almost impossible to completely dry out the reservoir

Corrosion is an issue with wet CO2.

Corrosion rates of steels significantly decreased with increasing temperature

By using CO2 as the heat extraction fluid in an EGS reservoir at very high temperatures, efficiencies above 45% can be achieved.

Density difference between compressed cold CO2 and hot, supercritical CO2 makes pumping unnecessary

Low viscosity means lower pressure drop in the reservoir

CO2 dissolves reservoir rock improving permeability

Super Hot EGS *is* the ideal energy source

Dependable

95% available

Flexible

Peaking available

Widely Deployable

16% world pop. at <10 km

81%world pop. at <20 km

High Energy Density

100 MW/km²

Free Fuel

400°C fluid

Low Cost

$46/MW-hr