



Geothermal Wellbore Surveying Challenges

Ross Lowdon
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Geothermal Technologies



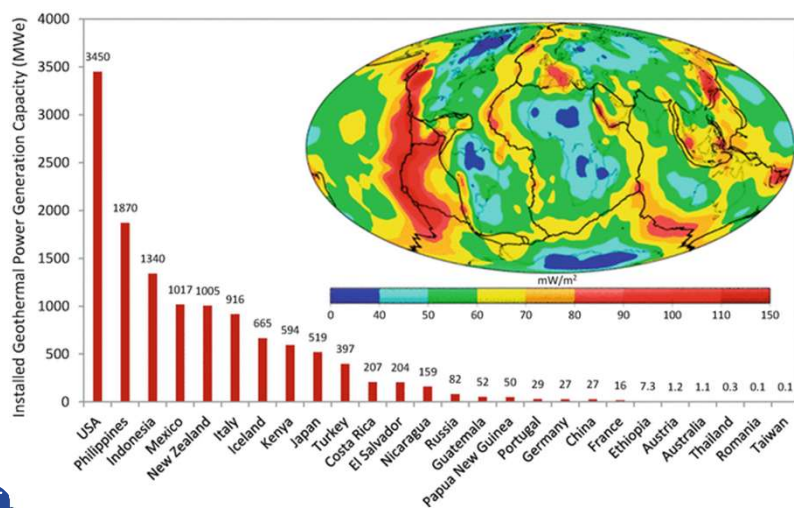
- Conventional

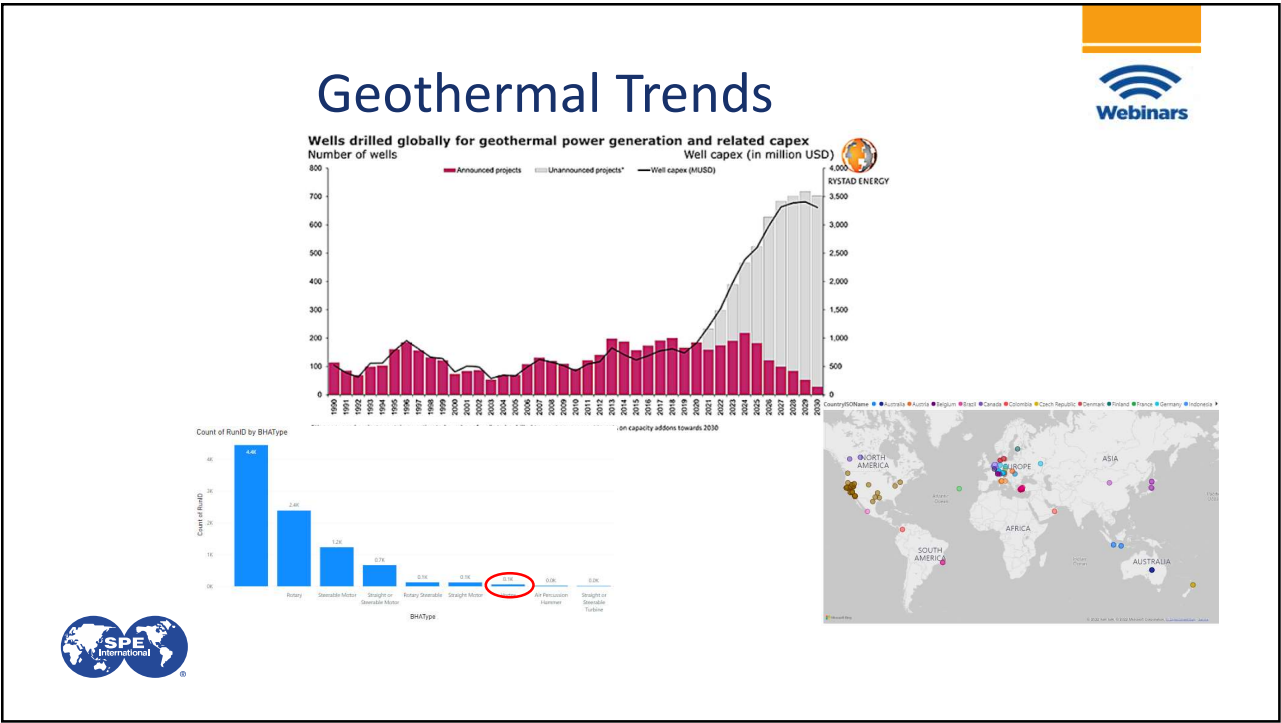
- Hydrothermal systems
 - Ring of fire and Iceland
 - 300° C
 - Highly Fractured
 - Pump water in – superheated water out
 - Run steam turbines or similar
 - Losses and pollutants

- Unconventional

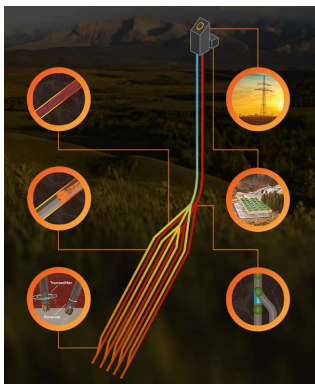
- Low temperature Geothermal
 - Enhanced Geothermal Systems
 - Advanced Geothermal systems
 - Deeper wells
 - Usually twins
 - Requires more technology

Geothermal Landscape





Closed loop Geothermal

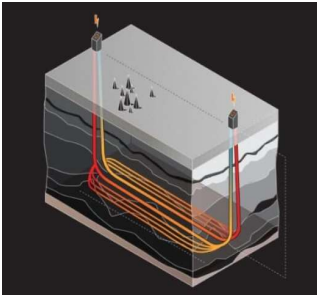


Source: Eavor



- Un-Conventional
 - Low temperature Geothermal
 - Advanced Geothermal systems
 - No Fracking
 - No GHG emissions
 - No earthquakes
 - No water use or produced brines
 - No aquifer contamination

Closed Loop Geothermal design



Source: Eavor

- 2 wellbores
- Multilateral
- Join to close the loop
- Use Thermal convection
- Heat drives surface 'engine'
- Local power distribution

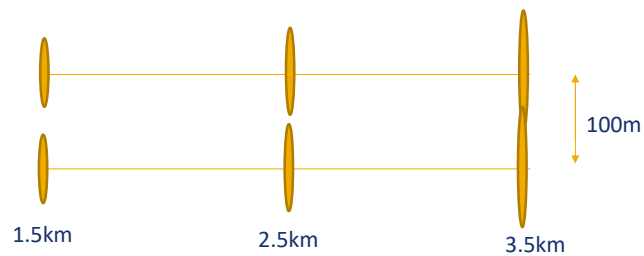


Geothermal Conventional Surveying Errors



- All wellbore survey tools have errors

Horz section length	Lateral error	TVD (Vertical) error
1.5km	35m	16m
2.5km	43m	21m
3.5km	60m	26m



Geothermal Surveying Challenges



- Vertical Spacing
 - Temp difference drives power
 - Higher offset = more power
- Lateral Spacing
 - Maximized Thermal recovery per site
 - No poaching
 - No stranded 'reservoir'
- Connecting wells
 - Must have hydraulic connection



- Absolute position ❌
- Relative position ❌
- Absolute + Relative position



Wellbore Surveying - Ranging



Technique	Conveyance	Detection Range (m)	Dependencies	Ranging time @ 4500m MD
PMR	MWD	15	Single offset wellbore	4-6 hours
AMR	WL	100	Formation resistivity	30 hrs
AAR	WL	70	Formation Slowness	15hrs
ARR	LWD	60	Formation resistivity	Near Real time
RMRS	WL	75	Rotating magnets in offset well	Depends on MD
CPMR	MWD	20	Single offset wellbore	Near Real time



RMRS - Description

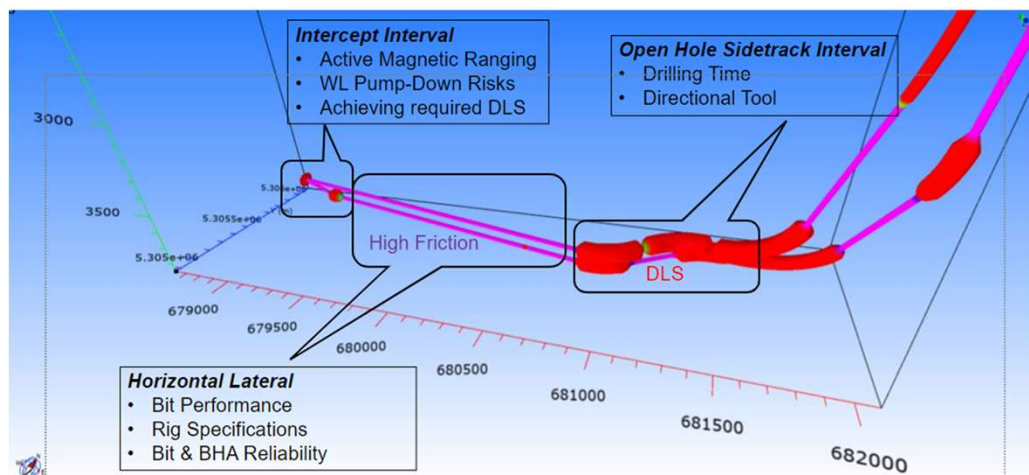


Source: ISCWSA



- Drilling BHA
 - Magnetic Magnet sub
 - Maximum magnet density
 - Alternating polarity
 - Rotation is necessary
- Target Well
 - WL conveyed sub
 - 6 axis MWD and inclination package
 - Looks for alternating magnet signal

Geothermal Drilling Challenges



Closed Loop Geothermal Surveying & Drilling Development



- Real Time ranging tools
- Improved survey accuracy
- Improved RSS trajectory control
- Improving Drilling performance
- Process automation
- ???



Conclusions



- Advanced Geothermal will be a game-changer
- Advanced Geothermal is challenging and needs proving
- Best in class Wellbore surveying required
- Adapted Oil and Gas technologies
- New techniques and technology to be developed
- Huge opportunity for the drilling industry



Thank You

Q&A