Enabling Unconventional Geothermal Energy Development

HEPHAE
ENERGY TECHNOLOGY

IMAPS APPE/CICMT/HiTEC
Conference & Exhibition
April 15-17, 2025

Introduction

Its mission is to be "*a technology enabler of the Unconventional Geothermal Industry by providing* ***differentiated subsurface drilling technology with significantly extended temperature limits*** *beyond existing capabilities while maintaining the ability to accurately* ***steer complicated wellbores precisely in hotter and deeper wells*** *and thus increasing the potential for greater heat recovery and power generation*."

Hephae's strategy is to "**continuously *improve temperature ratings and durability of selected directional drilling technology (tools or components)*** *proven in the unconventional drilling for oil and gas and apply it to Unconventional Geothermal Drilling*". Hephae will sell or lease these products to service providers for application in high temperature drilling environments."

Hephae Enables the World
to
Drill Unconventional Geothermal Wells Hotter & Faster

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1. What is Unconventional Geothermal

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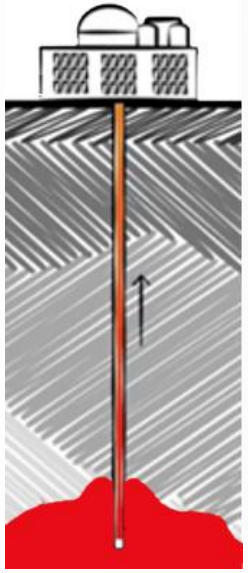
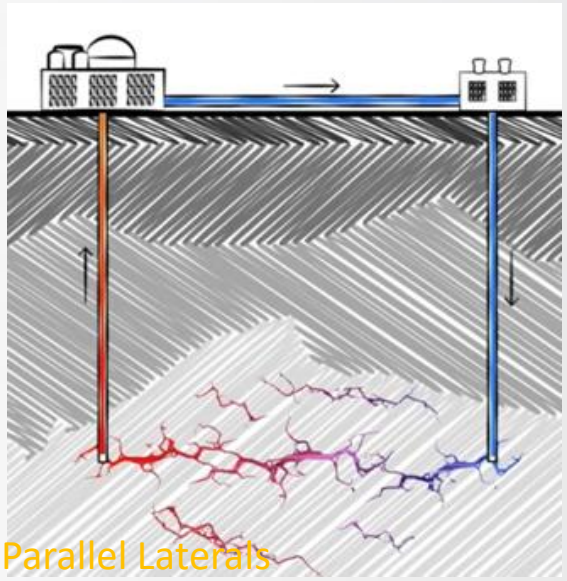
Traditional Geothermal



350C+
Steam

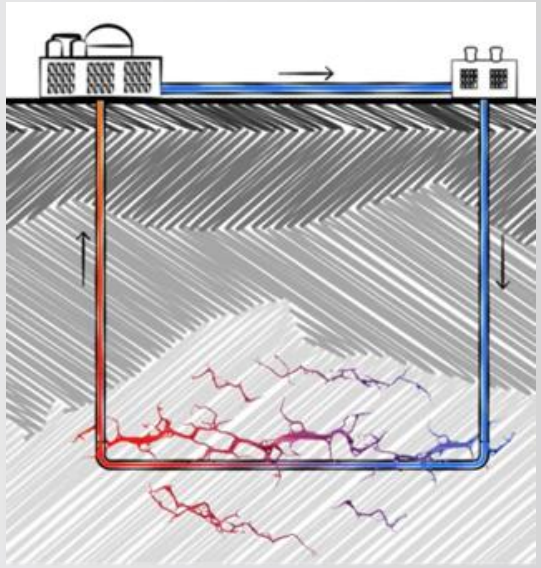
Unconventional Geothermal



~200C Dry Rock

300C+

AND
OR



~200C Dry Rock

300C+

AND
OR

~200C Dry Rock

300C+

Profitable Geothermal ANYWHERE

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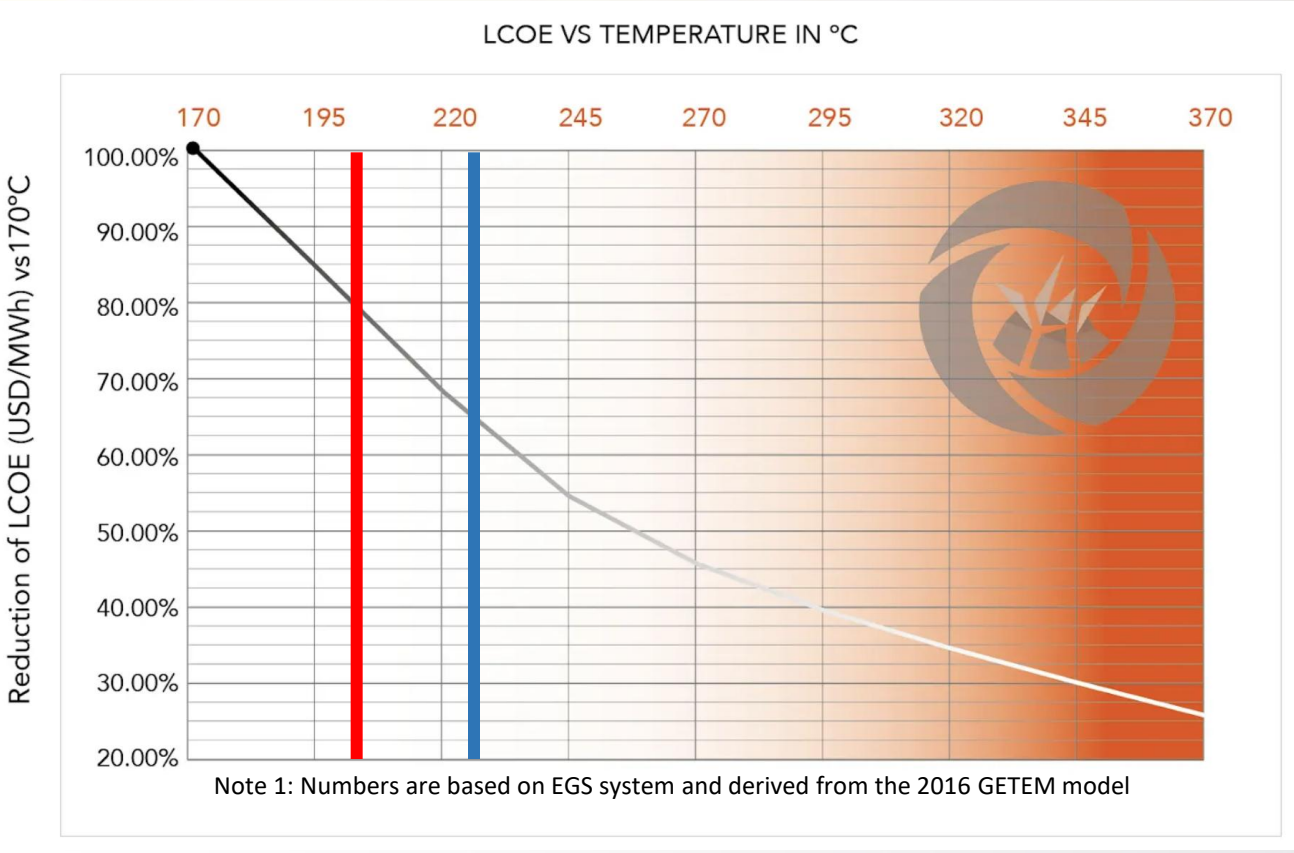
Key Challenges – Production Value



HOTTER IS BETTER!!

As opposed to O&G Hotter is better for UCG

Today UCG still relies on existing oil & gas drilling technology,

- Largely limited to 175°C
- No tools currently rated above 200°C

  (Except Hephae Pandora210™)

The industry knows how to drill these wells,

we need the Electronics to drill them hotter

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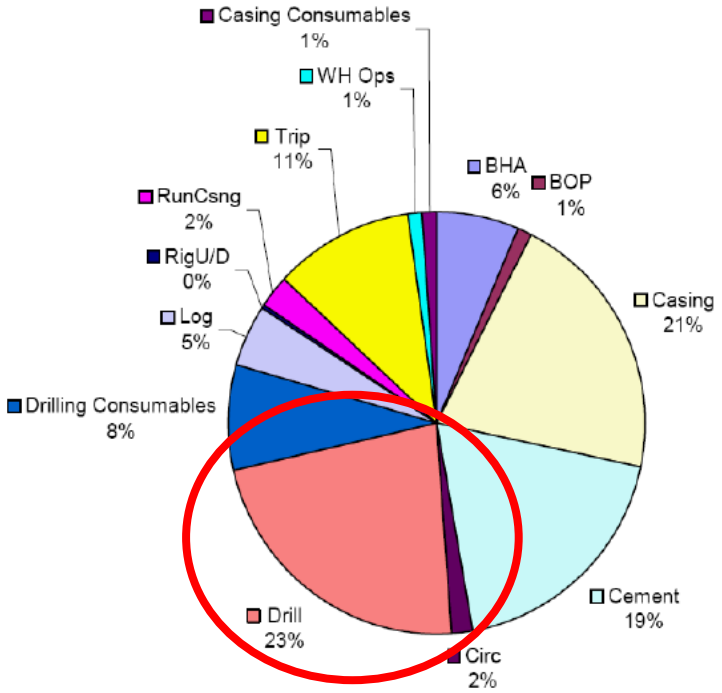
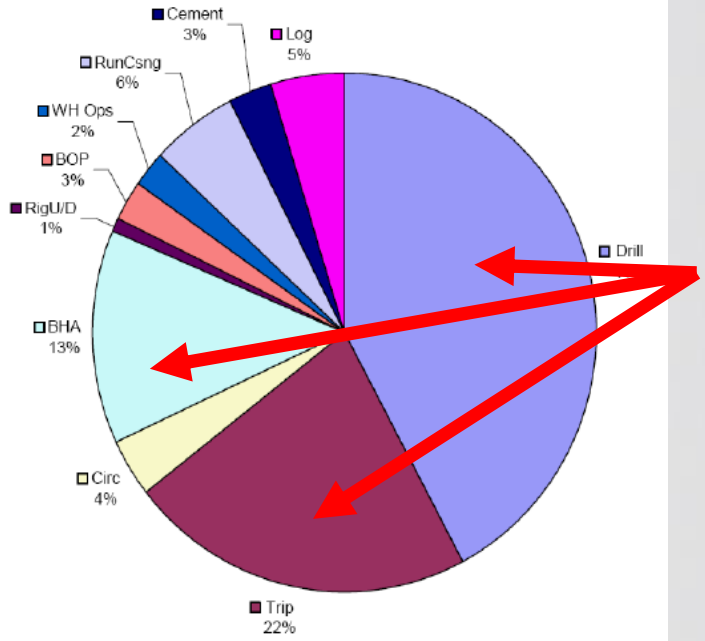
Key Challenges – Drilling Cost



Well cost (%) breakdown by task.



Well construction task time percentages.

- Reliable HT Tools Also help to reduce drilling costs and drill faster

- **Less NPT**
- **Lower overall operating cost**
- **Faster Rate of Penetration**

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Why should WE (HiTEC) care?

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- HT Drilling History
- Geothermal Market Forcast

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3. Cyclical Oil and Gas – Gas to Oil

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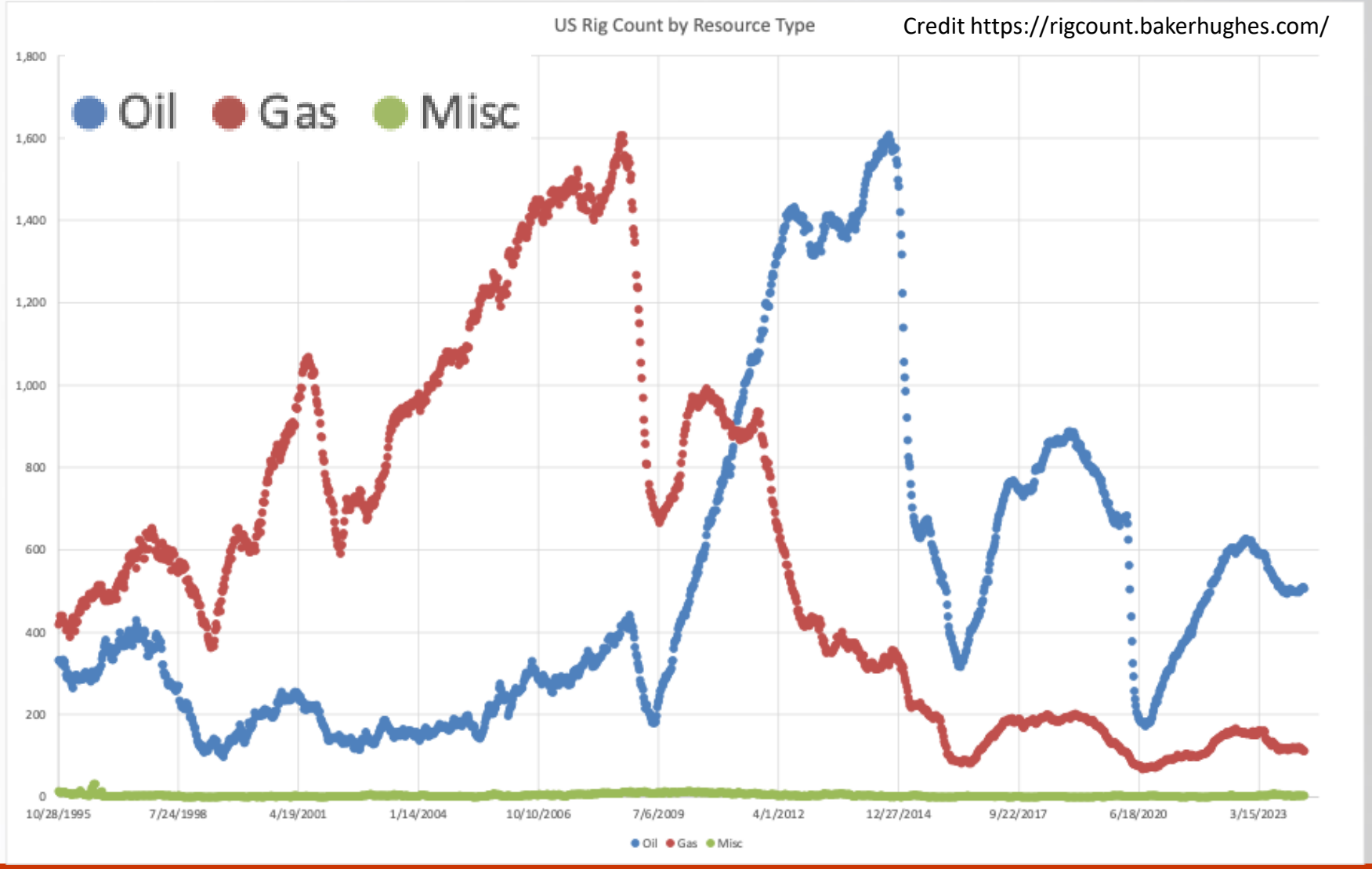

Credit https://rigcount.bakerhughes.com/

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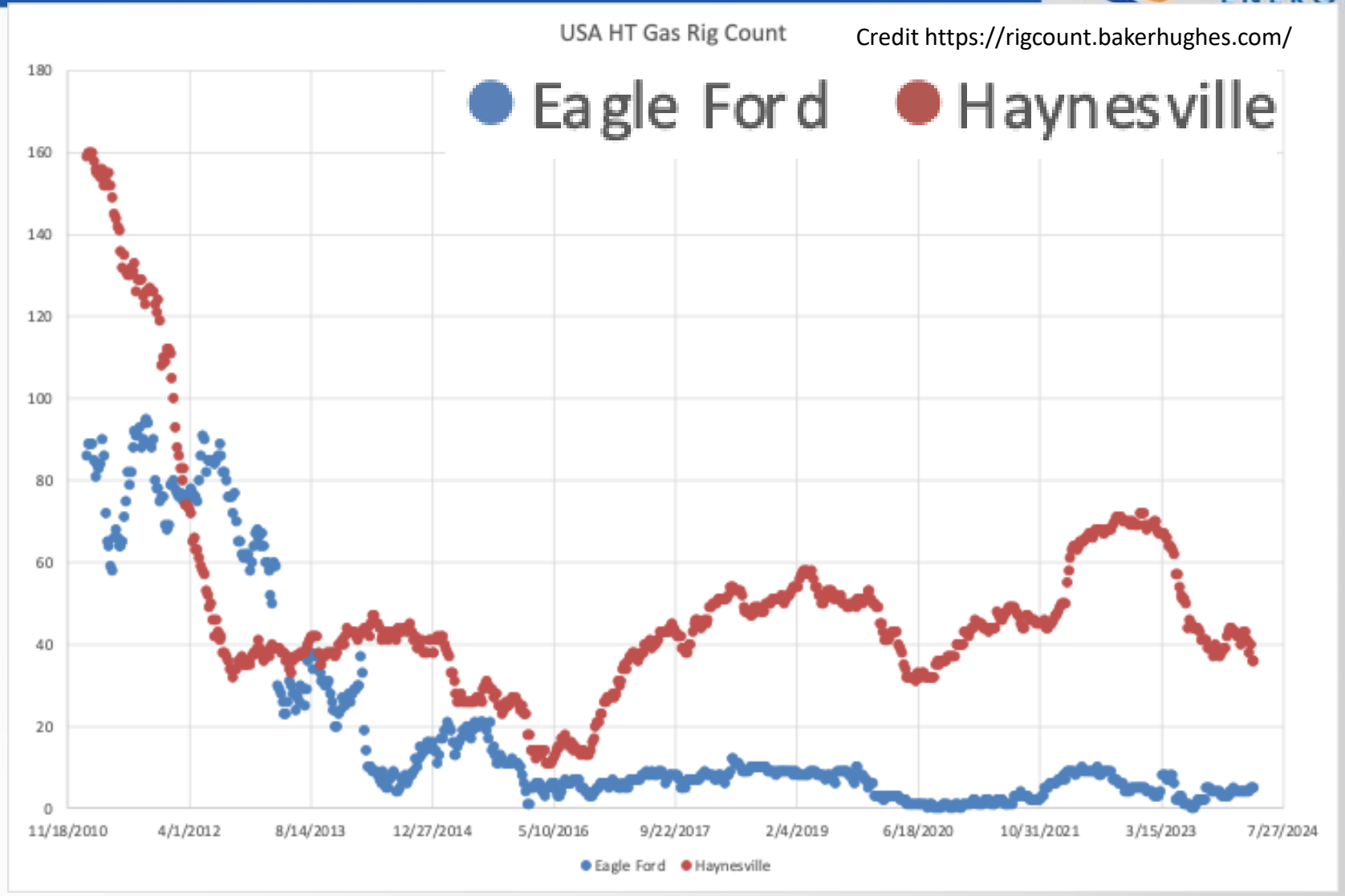
HT GAS Operations Reduced



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Cyclical Oil and Gas - Takeaways

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High Temperature Electronics Investment has been inconsistent and recently very low.

Well drilling industry have learned to drill horizontal wells VERY efficiently.

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Geothermal Is Different!!

We are not drilling for Hydrocarbons.

We are drilling for
Electricity and Direct Use Heating

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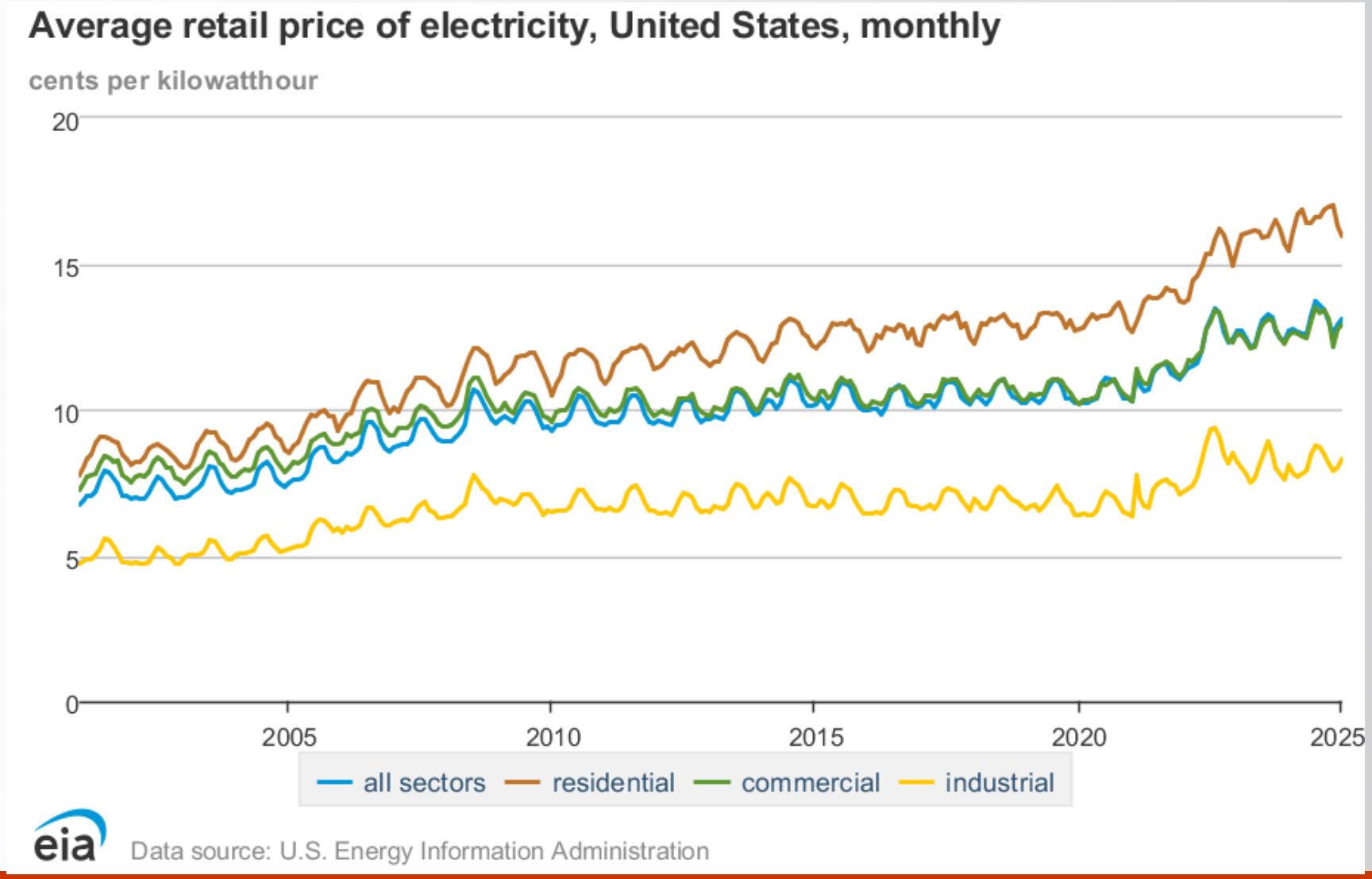
Electricity Requirement



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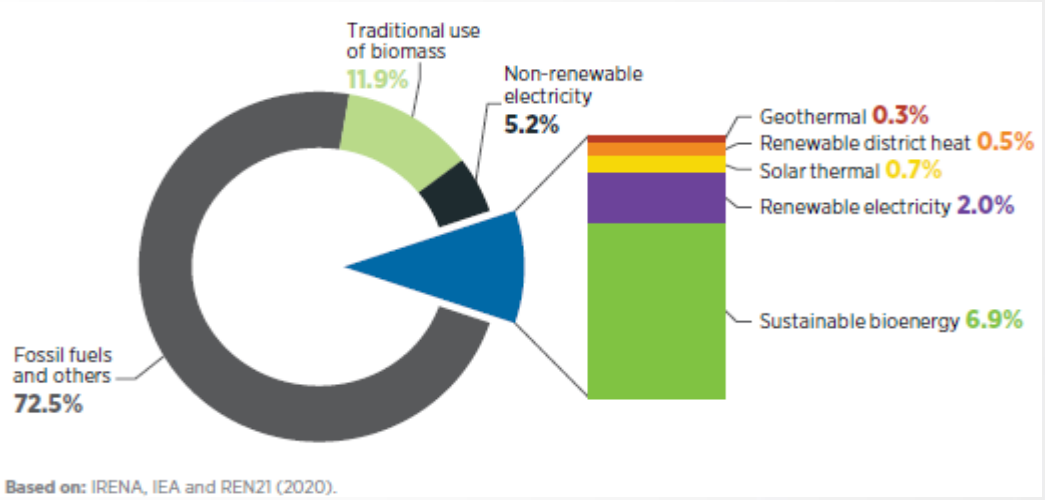
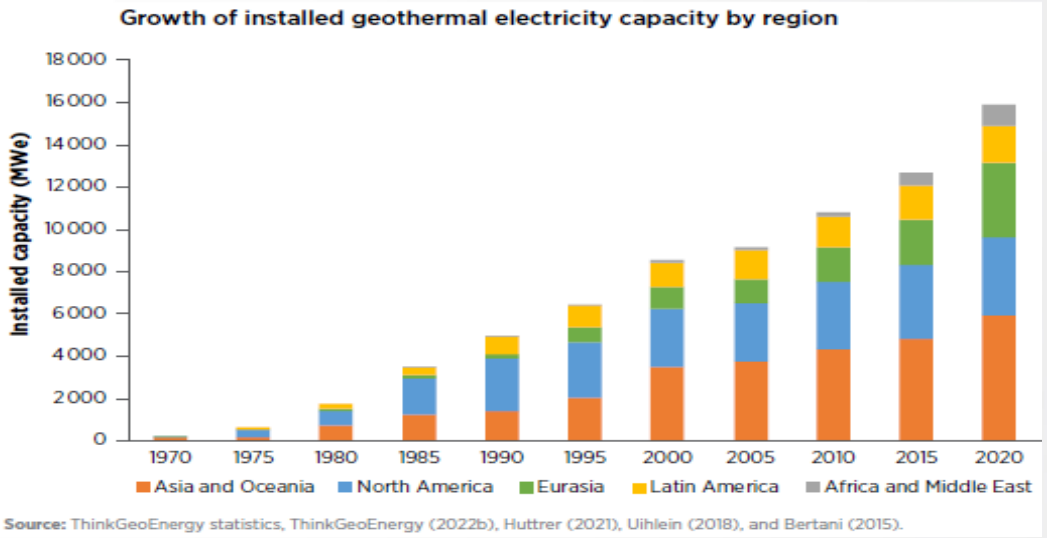
Historical Geothermal market



Based on: IRENA, IEA and REN21 (2020).



Source: ThinkGeoEnergy statistics, ThinkGeoEnergy (2022b), Huttrer (2021), Uihlein (2018), and Bertani (2015).

- Geothermal represents only 0.3% of the global renewable electricity market as of 2022
- 3200 wells drilled globally in the last 50 years
  - 18 GWe combined
- Drilling unconventional Geothermal wells will be more efficient compared to conventional Geothermal wells
- O&G learnings being applied rapidly to Geothermal Wells. Driving down cost. Improving pricing.

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Geothermal Market Forecast

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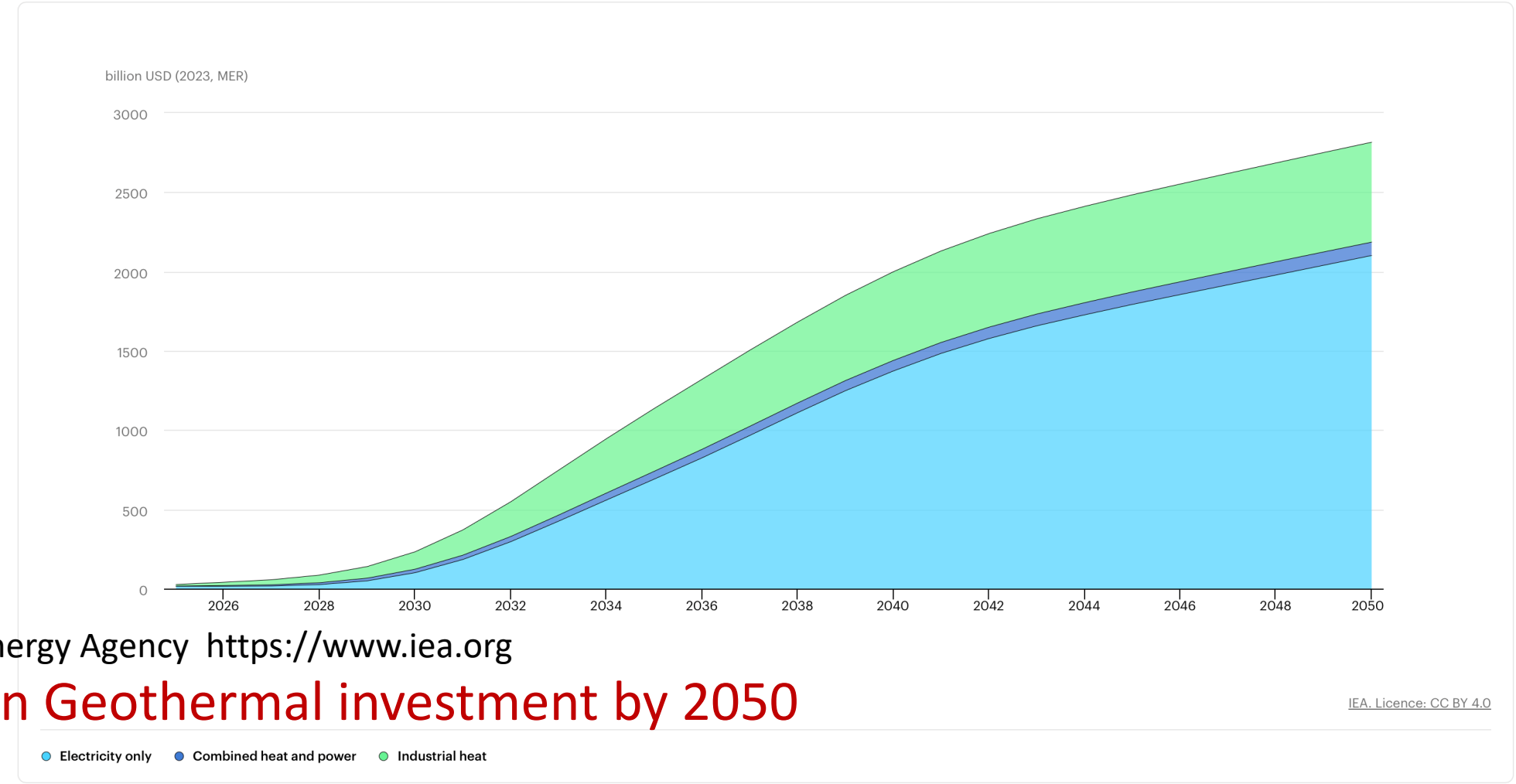
"In the longer te
of 110 GWe by 2(

Shruti Raghuran

Next gener

ROSS LOWDON SLB Fellow



International Energy Agency https://www.iea.org

$2.5 Trillion Geothermal investment by 2050

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Functional Requirements - Steering

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Power Management:

- Switches and Current Monitoring
- DC-DC Buck/Flyback & Linear – 40V rated

Measurement:

- Sensors – Accelerometers/Magnetometers
- Amplifiers
- Filters
- Analog switches
- Analog to Digital Converter
- Precision references

Brains:

- Controllers/DSP
- NV Memory
- RAM

Control:

- HV switches
- Gate Drivers
- Motors/Solenoids
- Feedback systems (Hall/resolvers)
- Analog to digital converter

Operating Temperature Requirements

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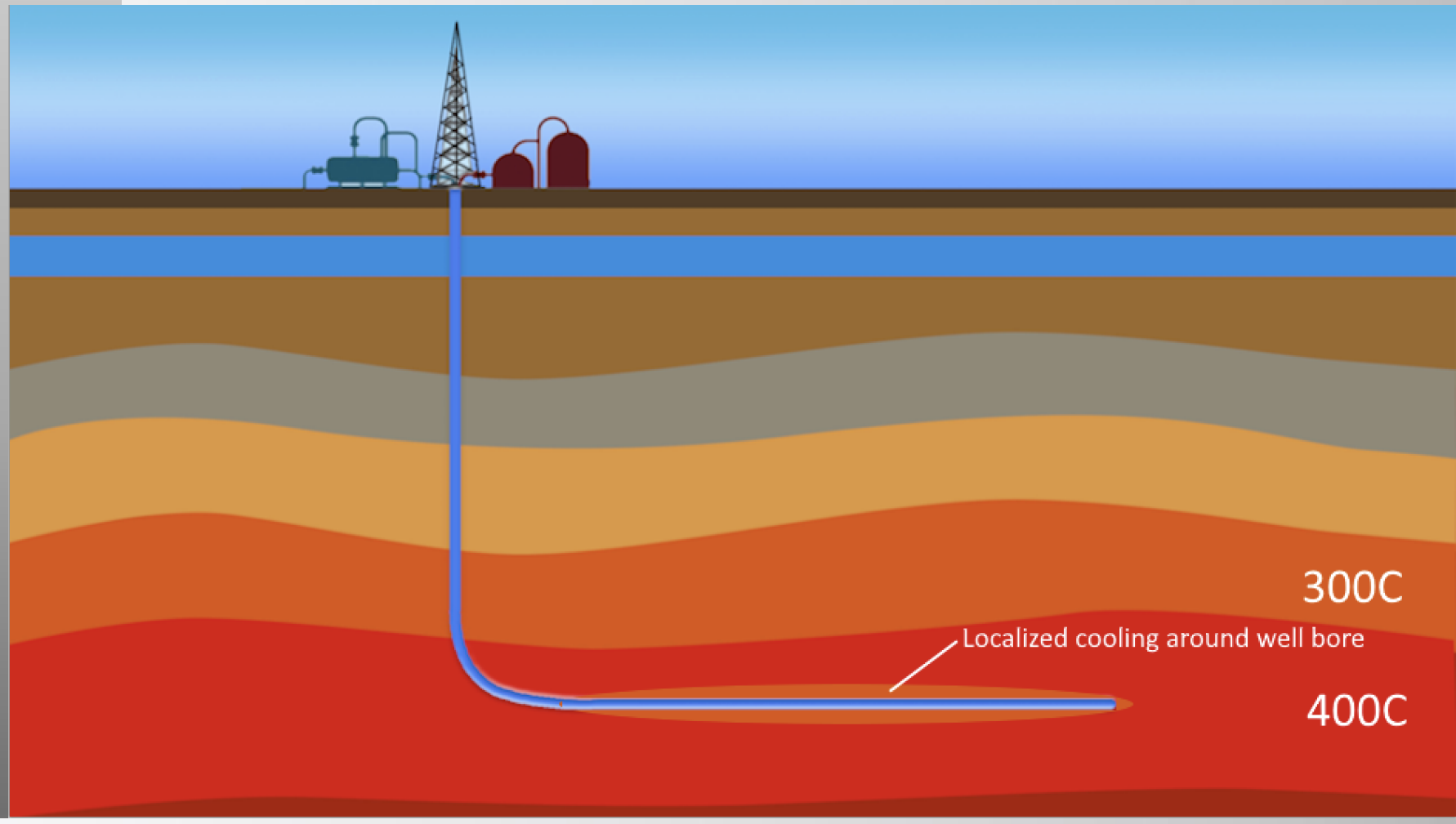
Once we are pumping, we can Keep the nearby well cooler than the Surrounding rock.

300C Functional Electronics



Survival Temperature Requirements

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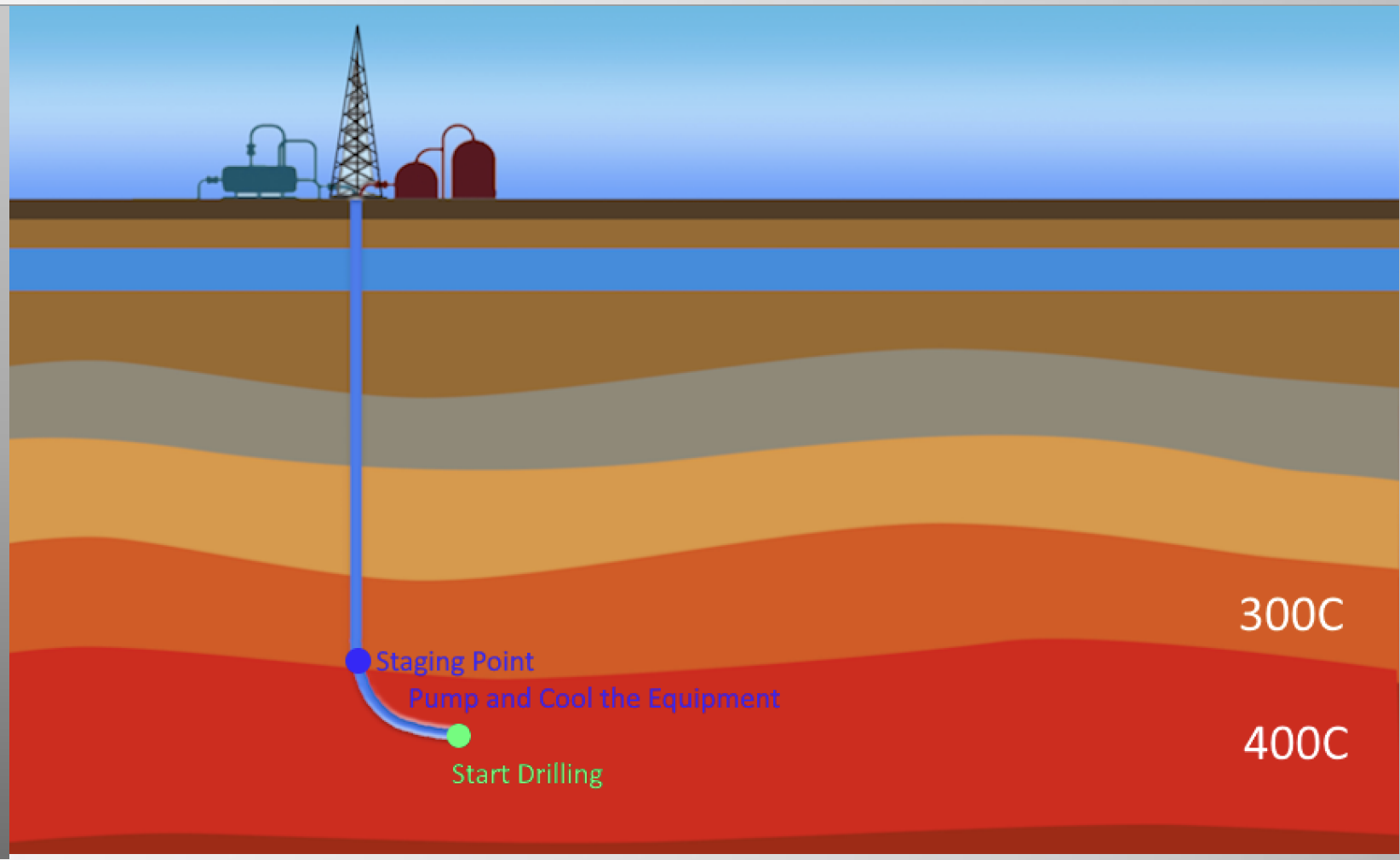
Survival Needs >300 C

- No Cooling from pumping until we are on bottom drilling
- We must Stage in the Hole without higher Survival Temp



Survival Temperature Requirements

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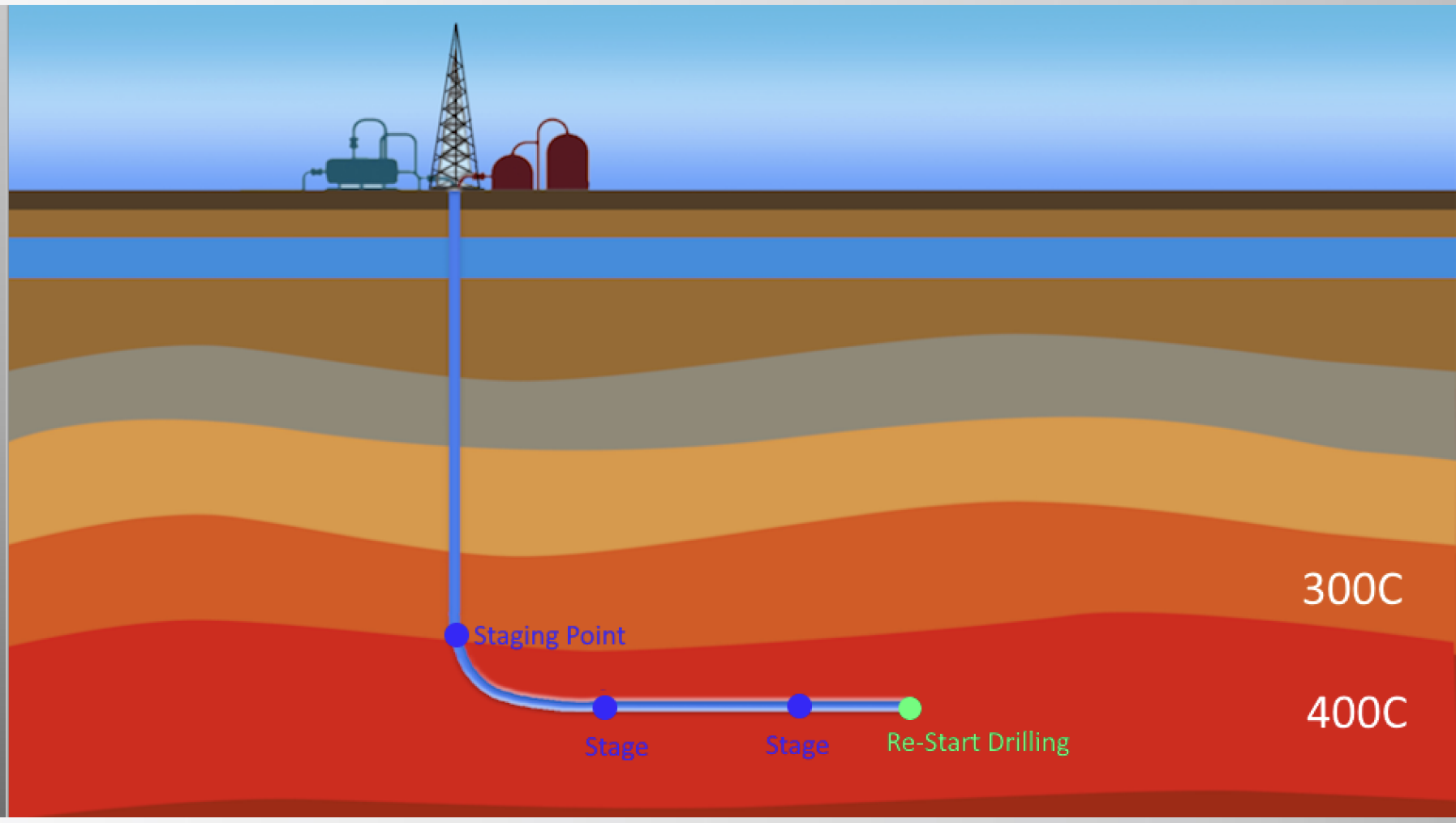
Staging gets worse if you have to come out of the hold due to worn out equipment

Must withstand thermal Cycling. Tripping and connections



Durability Requirements

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Durability Requirements

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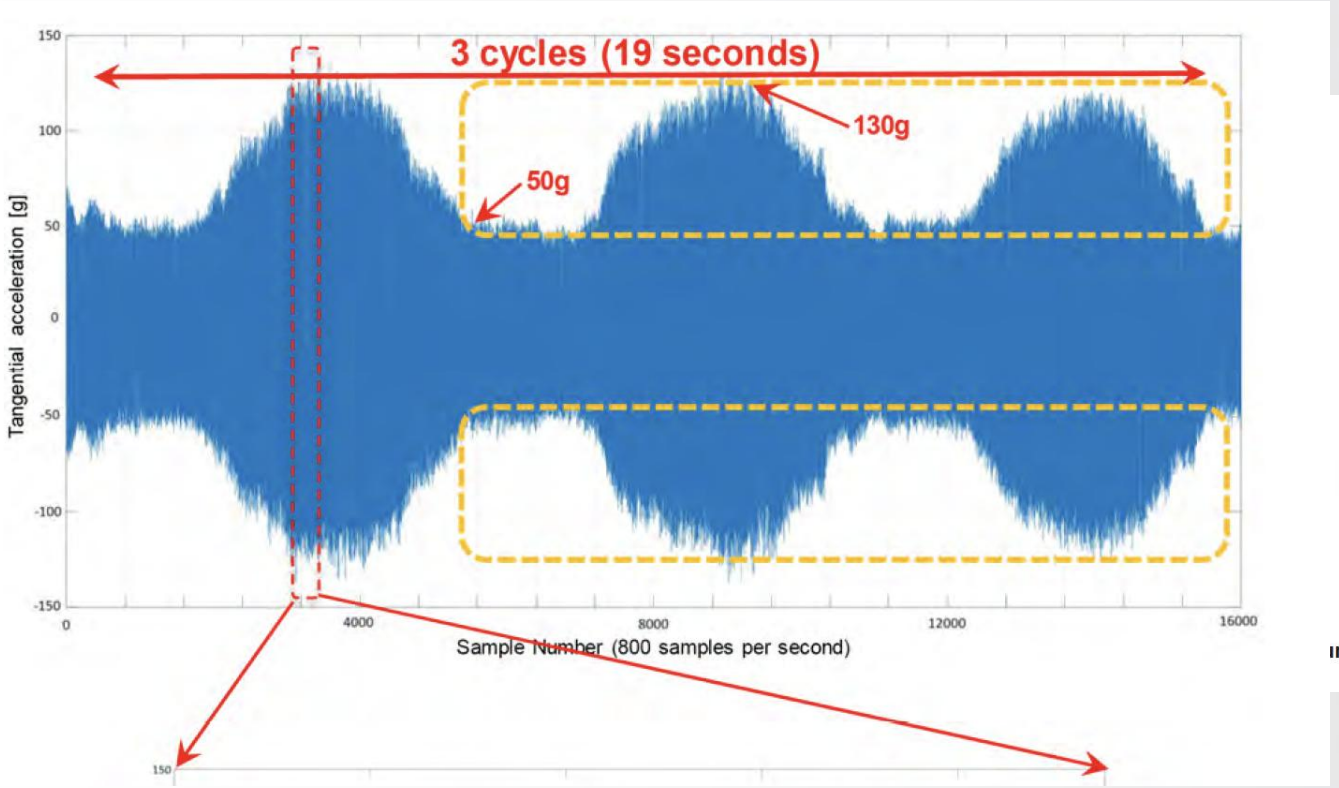
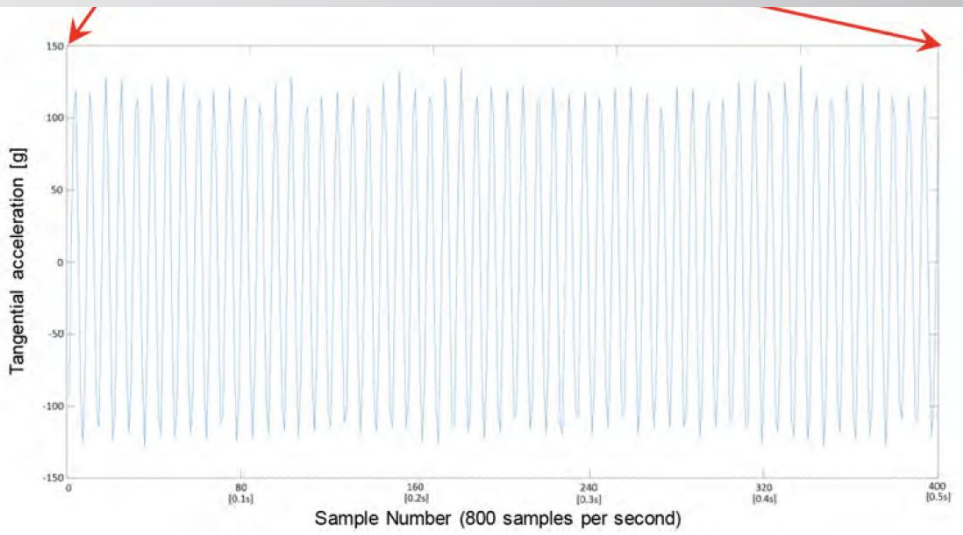
High Frequency torsional Oscillations





ıre 23—Tangential acceleration data at 1:20:00 over 20 seconds, continuously sampled and recorded at 800Hz.

Longevity Requirements

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Drilling tools are Uniquely positioned related to operating time requirements.

Typical Operating time is 100-200 Hours in duration. Not a permanent installation

- 10s of 1000s of operating hours are NOT required.

Each operating cycle has a follow-up maintenance cycle.

Electronics can be replaced at these maintenance intervals in worst case.

- This challenge is a financial challenge, not a technical challenge.
- **Electronics must be reliable during the operating period.**

Thank you for your time.

Questions?

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