

# The DEEPLIGHT project

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TNO innovation for life

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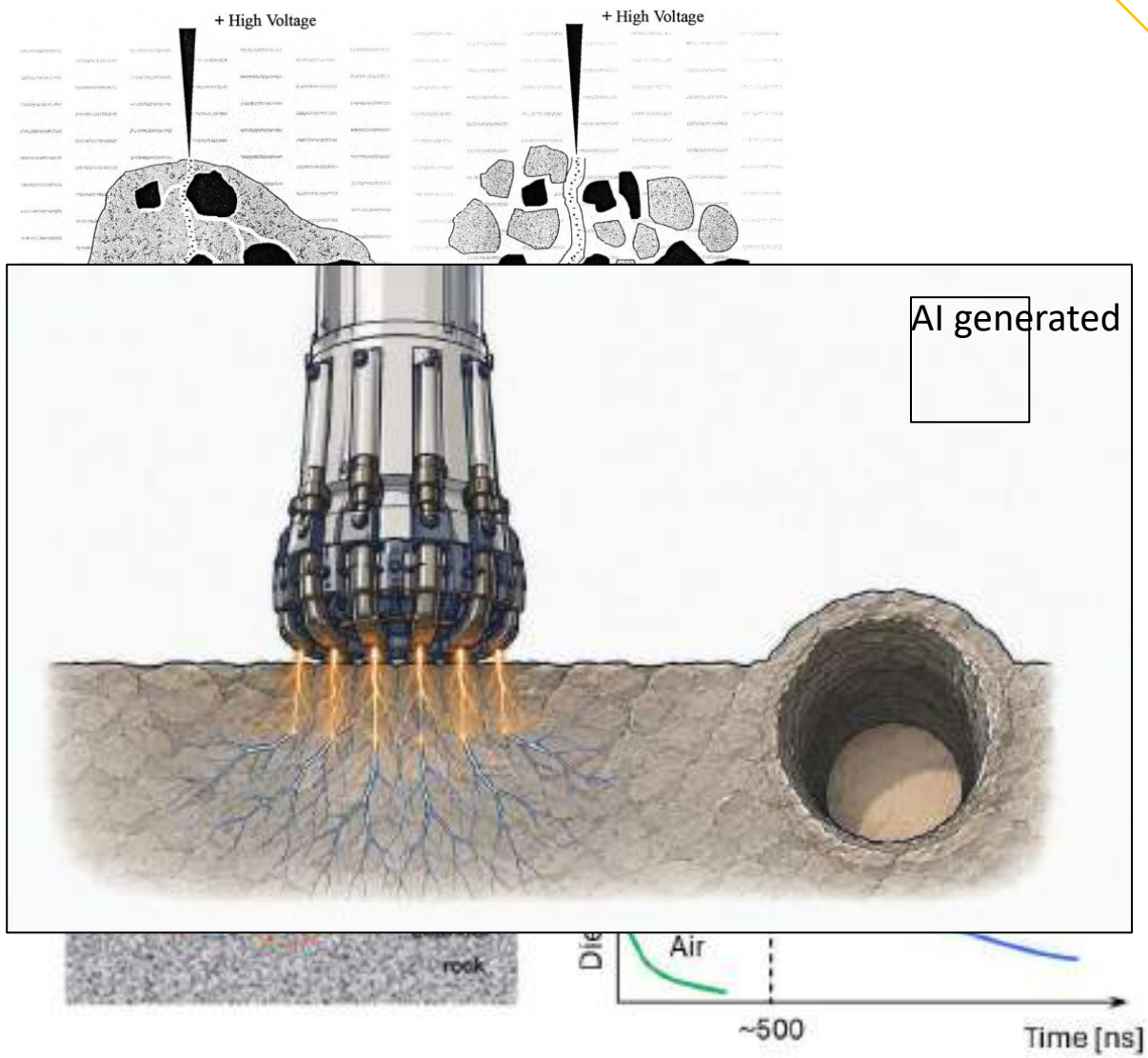
# Introduction

- Drilling costs constitute up to 50% of total costs in geothermal wells (Doubled, Enhanced Geothermal Systems, Superhot Rock) and possibly up to 70% in Advanced Geothermal Systems
- Development of novel hole making technology and tailored well design is paramount to foster the market uptake of deep geothermal energy (drilling faster, less tool wear, cost-effective well construction, etc.)
- Several new drilling technologies are emerging (see recent IEA study), among which electric pulsed power (EPP) drilling (also referred to as electric spark, pulsed plasma, or plasma channel drilling).
- Particularly interesting for hard and tight formations with high temperatures
- The DEEPLIGHT project is a European project executed by a consortium that aims to construct and test an integrated EPP drilling and well construction system

Co-funded by the European Union

# EPP Drilling Principle

- Very high voltage pulse (hundreds kV) in very short time through pair of electrodes in fluid that are in loose contact will disintegrate the rock
- Could become very efficient, as it uses 2-3 times less energy for same fracture surface as mechanical drill bits that fracture the rock material in shear mode
- Proven to work at surface, but system needs to work under drilling conditions with standard drilling equipment
- Field validation in 2017 with 12 -1/4" non-rotating electro-pulse bit by TU Dresden showed ROPs of 1-2m/h

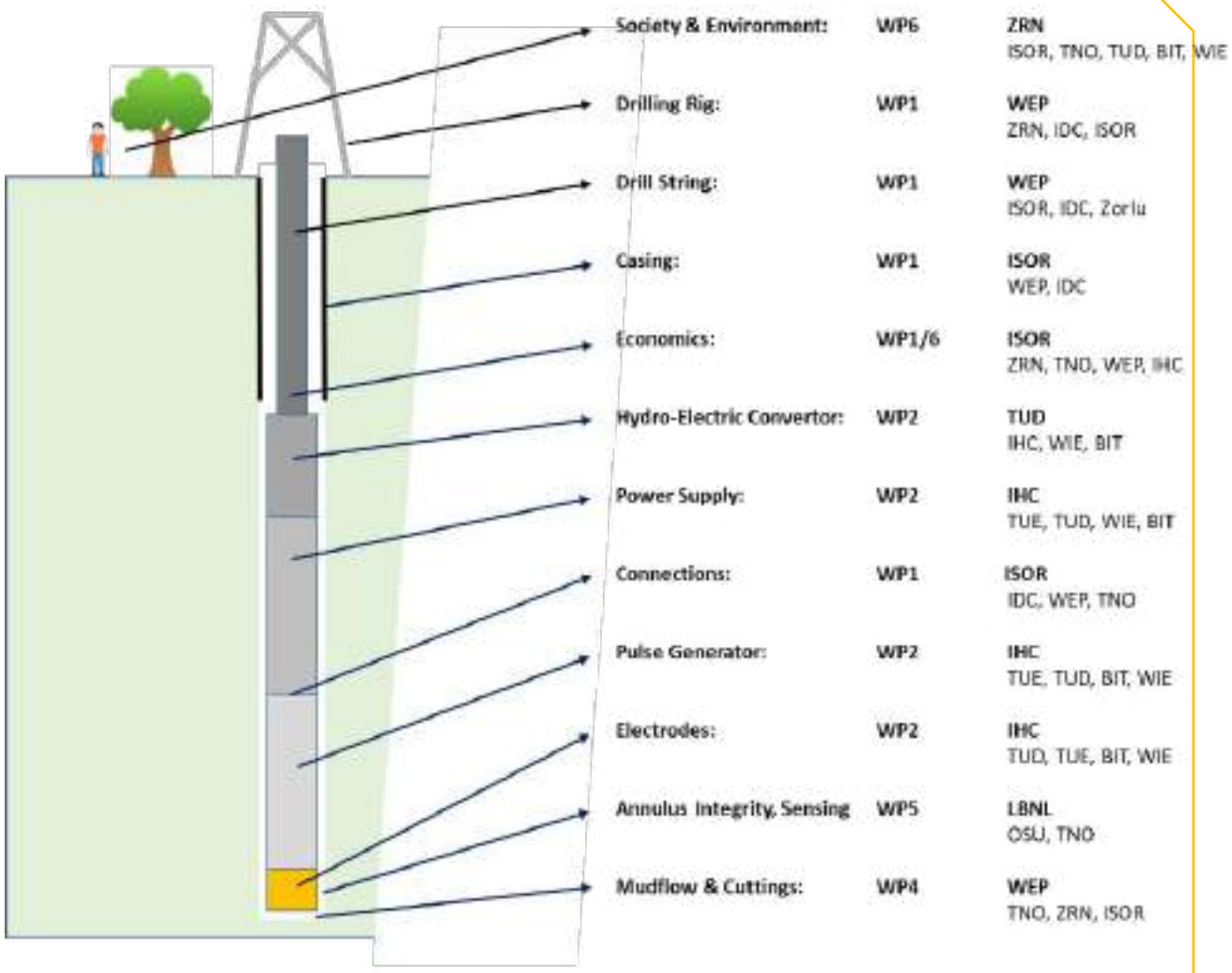



*Anders et al., 2017*

*Bluhm et al., 2000*

# Deeplight project

- DEEPLIGHT project (2023-2026) brings key developers, research institutes and technologies together
- Overarching goal is delivery of an EPP drilling system supported by well construction concepts that is tested at full scale in a realistic operational environment (TRL 6)
- Competitive drilling performance demonstrated (comparable to or exceeding conventional drilling rates)
- A viable EPP system is more than the drill head, DEEPLIGHT integrates the tool with the drilling system, the well and the operating environment (system approach)

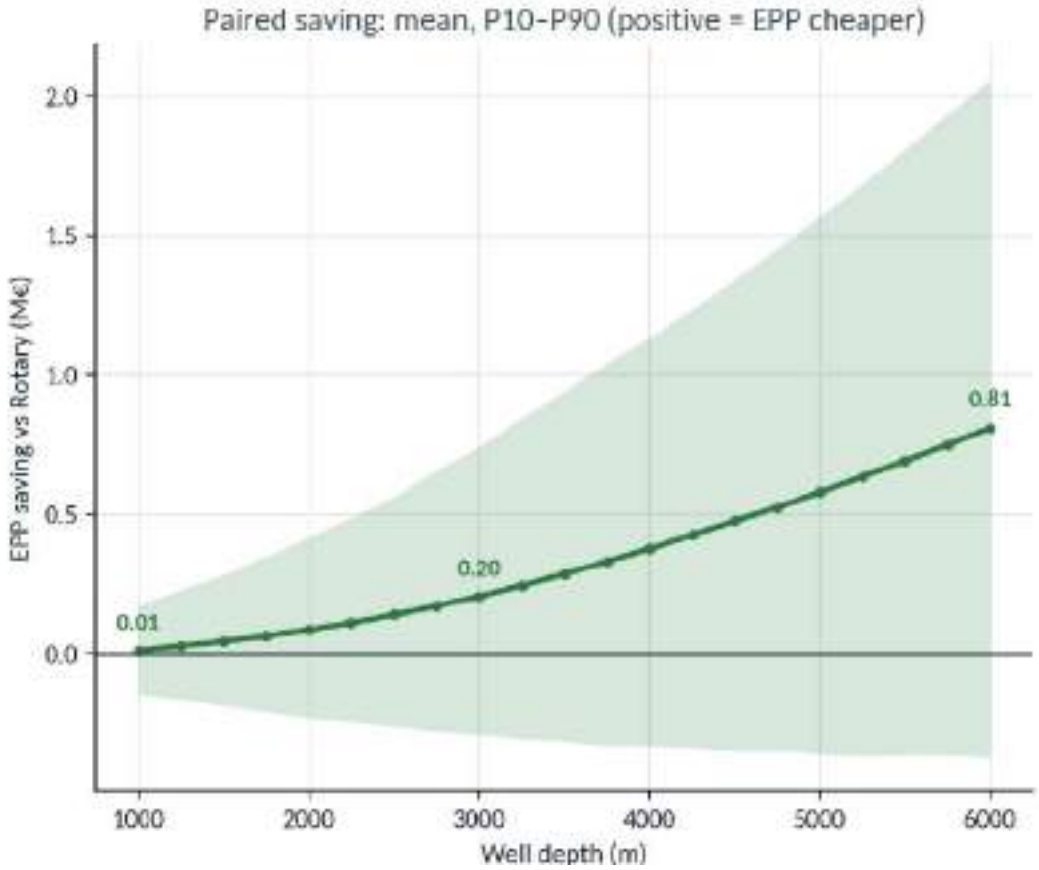


# Six work packages connect design to deployment value

**Coordination • tests • integration • communication • knowledge sharing | Lead: TNO**

| DESIGN BASIS | CORE TECHNOLOGY | WELL CONSTUCTION SUBSYSTEMS | | DEPLOYMENT VALUE |
|---|---|---|---|---|
| **SYSTEM DESIGN** | **EPP DEVELOPMENT** | **HYDRAULICS** | **WELL INTEGRITY** | **IMPACT** |
| **Lead: WEP** | **Lead: IHC** | **Lead: WEP** | **Lead: LBNL** | **Lead: ISOR** |
| Use cases • system requirements | Tool • electrodes • pulse power • controls • full-scale test | Fluid effects • cuttings transport • hydraulics model | Smart cement • sealing • thermal-integrity models | Economic • environmental • social value |

# EPP is a lower cost, lower emission option with robust performance predictability




### EPP eliminates tripping

Extended BHA EPP lifetime outweighs slower drilling. Effective in deep and hard rock wellbore construction.

### EPP's advantage is robust

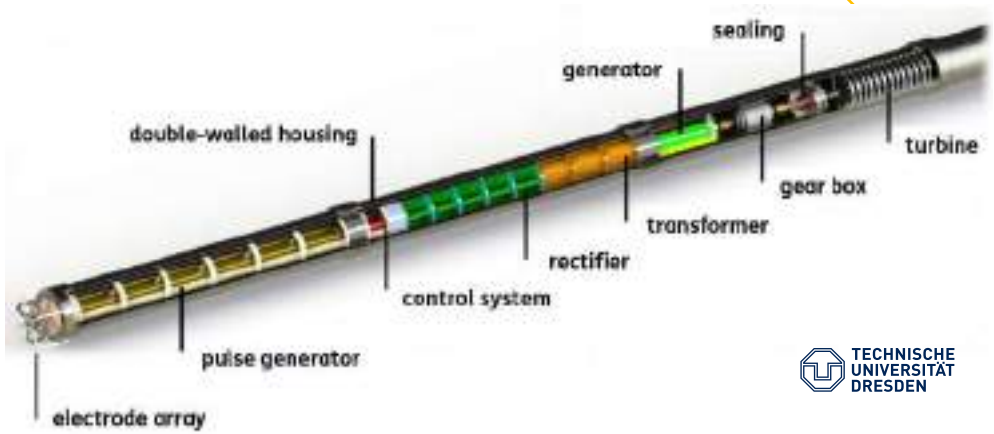
Large variations in EPP's performance & cost assumptions are required to lose its edge over rotary drilling median cost.

### EPP has environmental benefits, but e-rigs are key

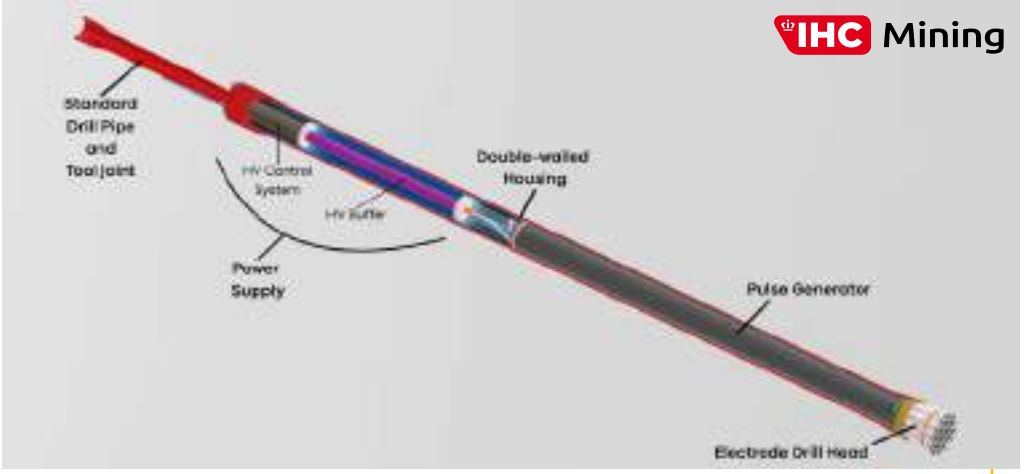
Main $CO_2$-eq reduction is driven by electrification and country grid factor. Footprint of deep, hard rock wells will benefit most.

# Advantages of EPP Drilling

- Drilling with limited WOB saves wear on bit, leading to shorter drill time (fewer trips for drill bit replacement)
- Lighter rotary equipment since there is no need for torque and weight
- Future potential for cost-efficient large diameter wells (higher production per well)
- Options for casing while drilling




Electric Pulsed Power BHA containing all components for downhole electro-pulse generation (Anders et al., 2017)



# Deeplight WP2-IHC, visualized



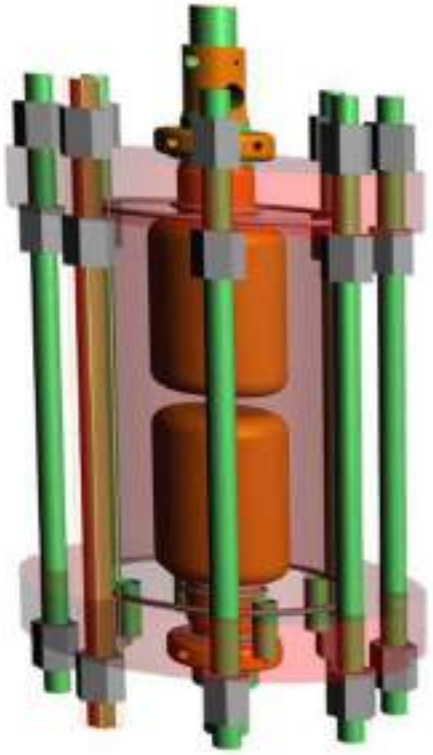
# Design of system components

- Examples of component designs and testing

Housing design
by WEP & IHC



Generator design
by IHC



Electrode Arrays
by TUD & IHC



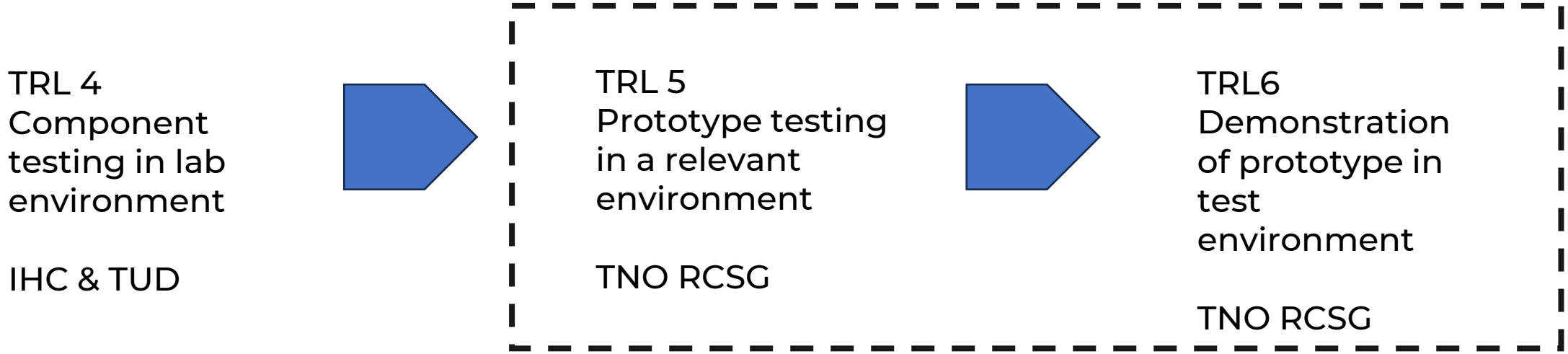
# Full scale system testing in controlled rig environment

- Tests are executed at the 250T research drilling rig
- Herrenknecht B-003 semi-automated skiddable drilling rig
- Positioned above completely cemented and cased research well (380m deep, 20” diameter)
- Connected to full capacity mud circulation system (2600 l/min @ max 690 bar pump pressure) with pumps and ring line



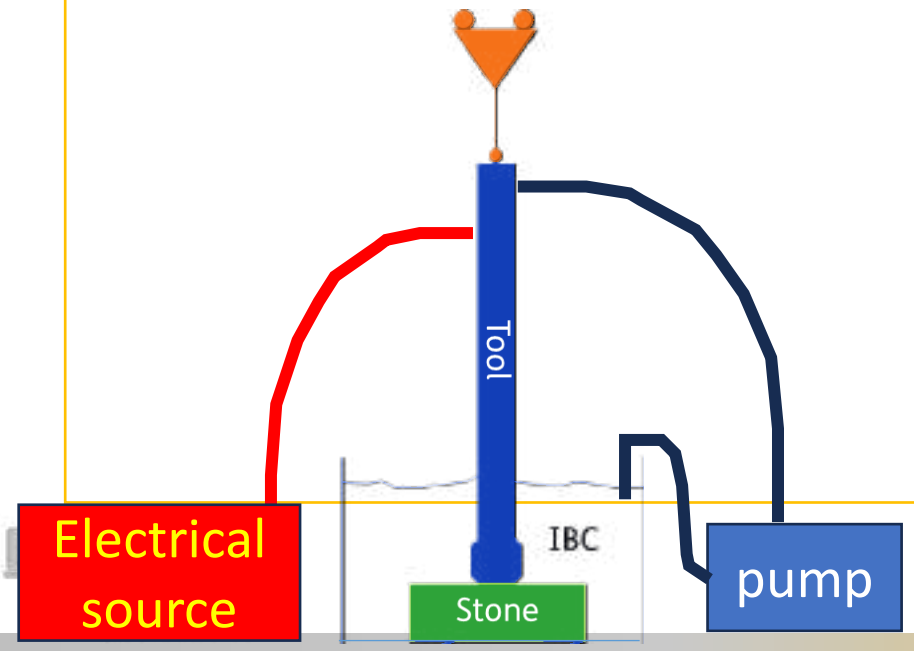
# Technology maturation of EPP system

- Goal: mature technology from development of prototype and its components to testing in an operational drilling environment.
- Two different types of EPP drilling tools are developed in the project
  - TU DRESDEN
  - IHC



# Prototype testing in a relevant environment (TRL 5)

- Tool is hanging in the elevator of the rig into fluid filled IBC tank on the rig floor
- Drilling of high strength concrete samples and rock samples from relevant geothermal areas
  - E.g. Kizildere geothermal field in Türkiye.
- Concept tested in June 2025, follow-up tests in 2026





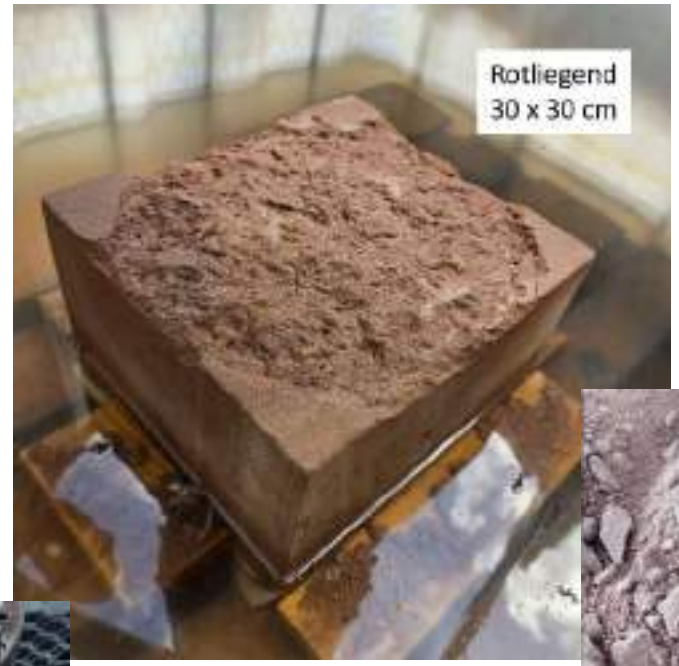


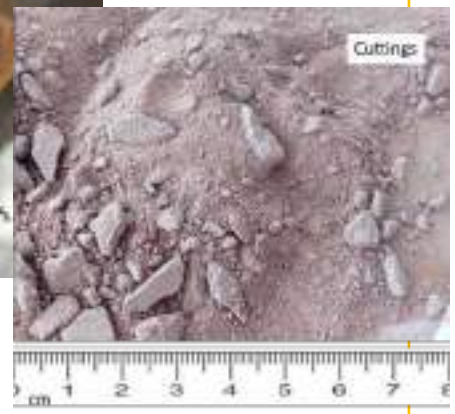





# Testing results of prototype testing

- Good progress in the tool development
- Successful system test with use of EPP bits on rig without damages to bits or equipment
- First drilling, although limited penetration, of rock under water
- Identification of weak spots in the technology that needs further improvement





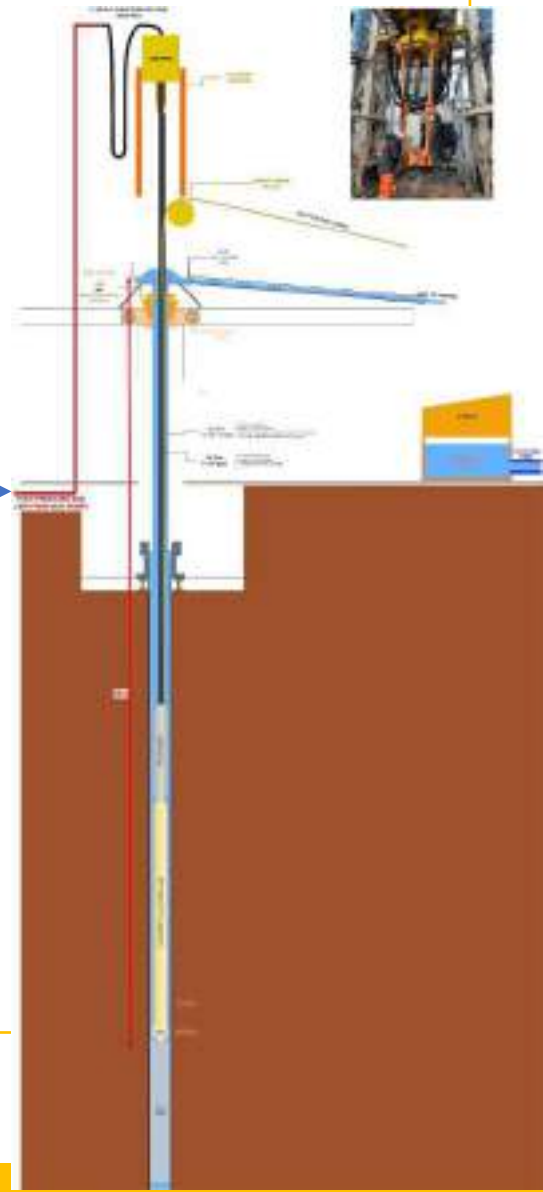



# Demonstration of prototype in test environment (TRL 6)

- Full BHA and system test planned for follow-up
- Drilling high strength cement sample with 2000L/min circulation of fluid
- Concrete cast inside 16” sample holder of 3 m length, bolted onto 13-3/8” casing string as fluid conduit with various lengths (max. 60m planned)
- Target for the full-scale tests is continuous drilling over at least 1m at depth with a rate of penetration of 10m/h



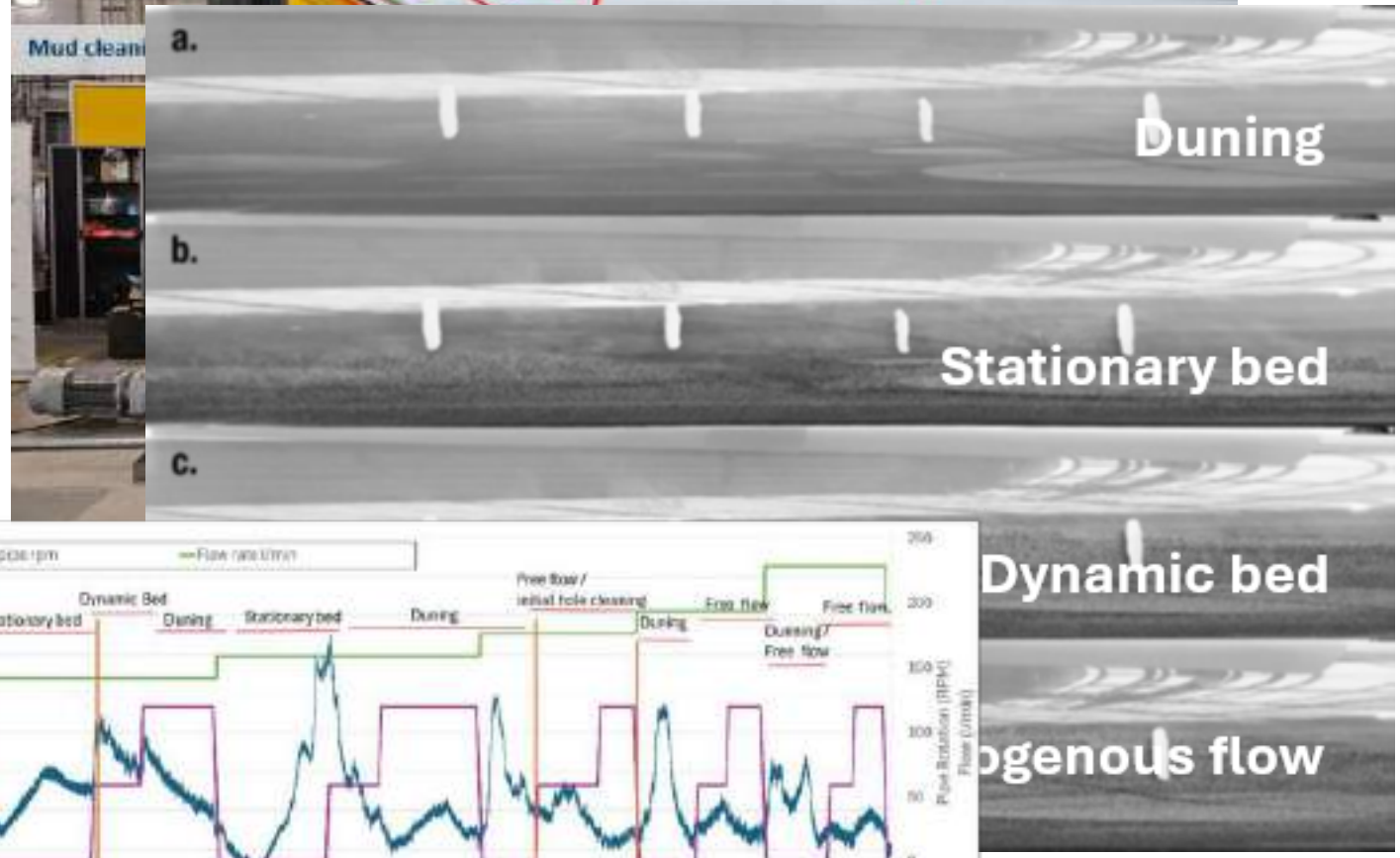


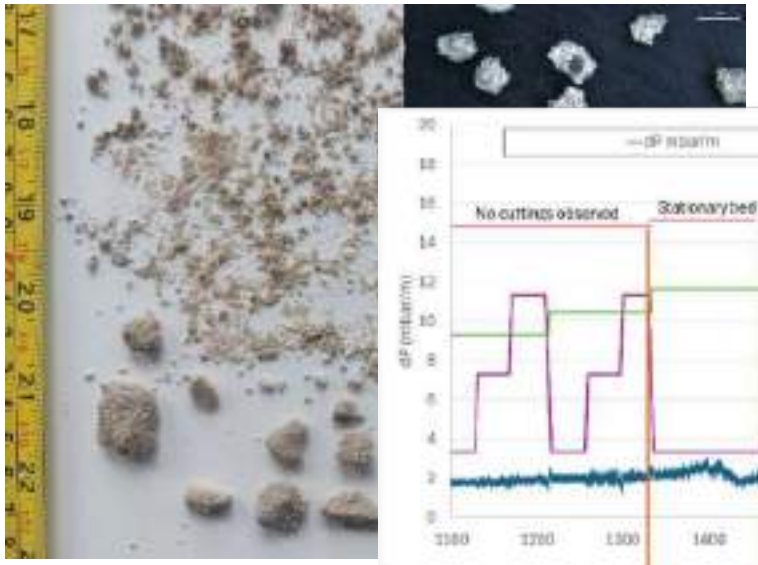


# Associated work: Hole cleaning

- Cutting distribution can be different from conventional drilling. Hole cleaning conditions therefore experimentally established
- Input and validation for dedicated hole cleaning model by WEP






Particles appear

Rotation stops -> stat bed

Rotation adds energy

Rotation adds energy -> hole cleaning

High flow rates ensure a good hole cleaning -> rotation plays a smaller role

# Associated work: Testing flexible coupling





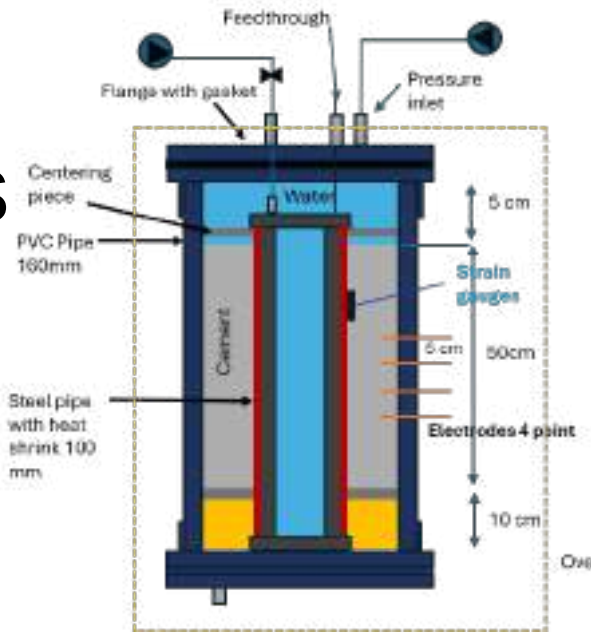





- Torque test results of the Flexible Coupling:
  - Torque testing in 12500 Nm increments under 165 bar-g pressure.
  - no seepage was observed for the 15 minutes loading period.
  - Results are an important step towards improved well integrity of high-temperature and superhot geothermal wells.
  - A successful test of the resilience of the FC and potential candidate for CwD.

# Associated work: Graphene cement integrity tests

- Adding graphene to cement increases conductivity
- It is presumed that the conductivity alters when fractures or cracks are formed in the cement
- This is tested with cement integrity experiments
  - What is the difference in the conductivity response of baseline (neat class G) cement and electrically-improved cement with graphene additives?
  - How is the response of electrical conductivity towards the load applied and enhanced permeability through the sheath?
- Concept could be the base for a future integrity monitoring system








# Way forward and Outlook

- 2026
  - Completing additional rig test
  - Completing cement work
  - Finishing project and deliverables
- 2027
  - Continuation in FOUND project
    - Nuclear borehole storage
  - Investigating possibilities for follow-up project targeting field piloting in case of successful tests

# THANKS!

www.deeplight-project.eu

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# EPP is a lower cost, lower emission option with robust performance predictability

**Iceland – 2200m – hard rock**

**€141k**
mean saving per well

3.3% of well cost
EPP cheaper in 71% of runs
1.6 days shorter
85t $CO_2$-eq saved

**Turkey – 3500m – hard rock**

**€96k**
mean saving per well

1.5% of well cost
EPP cheaper in 75% of runs
1.9 days shorter
55t $CO_2$-eq saved

**Netherlands – 6000m - mixed**

**€154k**
mean saving per well

1.2% of well cost
EPP cheaper in 74% of runs
2.8 days shorter
38t $CO_2$-eq saved

**Generic – 6000m – hard rock**

**€789k**
mean saving per well

8.3% of well cost
EPP cheaper in 79% of runs
12.7 days shorter
276t $CO_2$-eq saved

### EPP eliminates tripping

Extended BHA EPP lifetime outweighs slower drilling. Effective in deep and hard rock wellbore construction.

### EPP's advantage is robust

Large variations in EPP's performance & cost assumptions are required to lose its edge over rotary drilling median cost.

### EPP has environmental benefits, but e-rigs are key

Main $CO_2$-eq reduction is driven by electrification and country grid factor. Footprint of deep, hard rock wells will benefit most.

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