Deep Geothermal Energy at the Project

Tony Bennett – Operations Director
Eden Geothermal Ltd

eden geothermal

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European Union
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HM Government

CORNWALL COUNCIL
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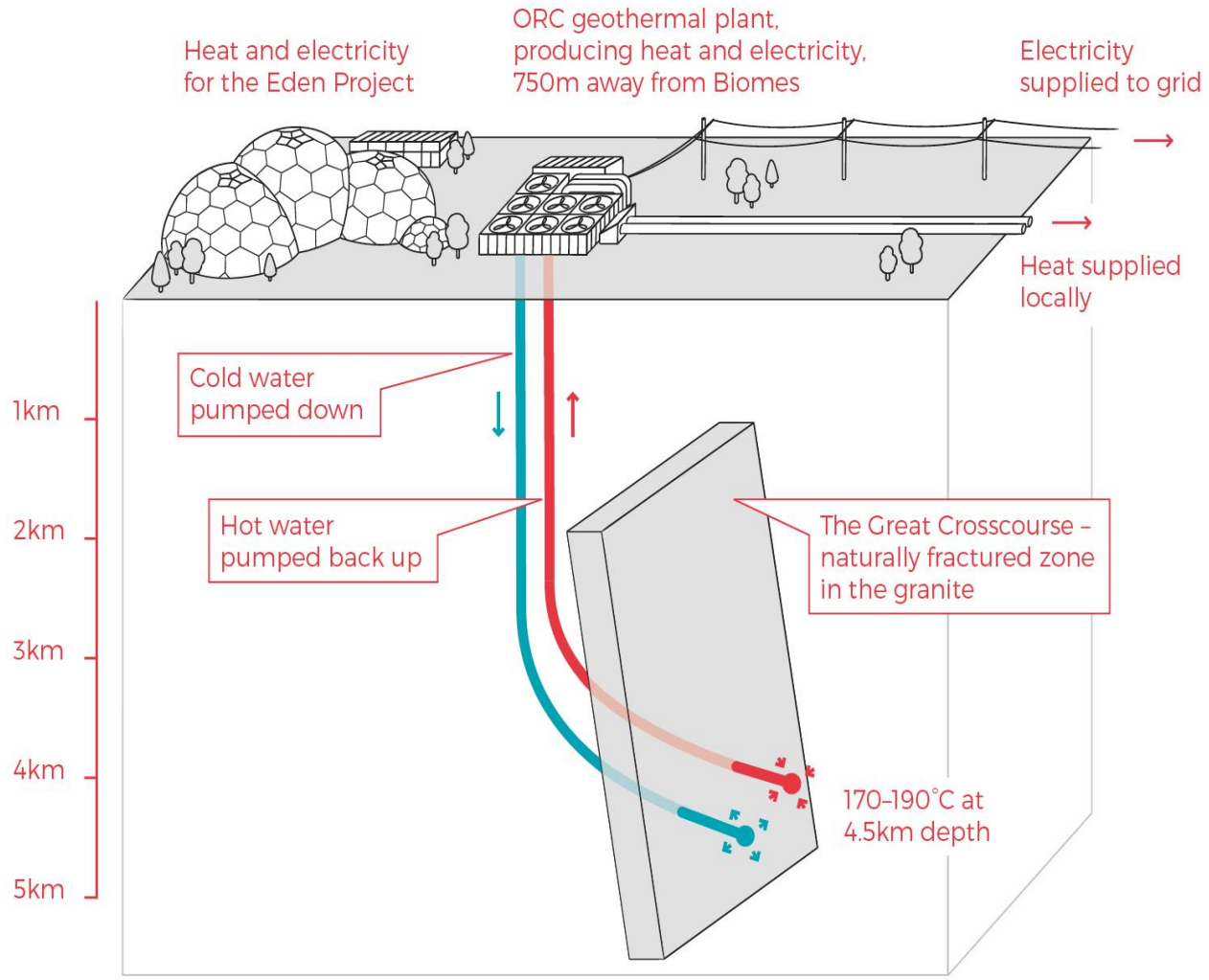
The concept - subsurface

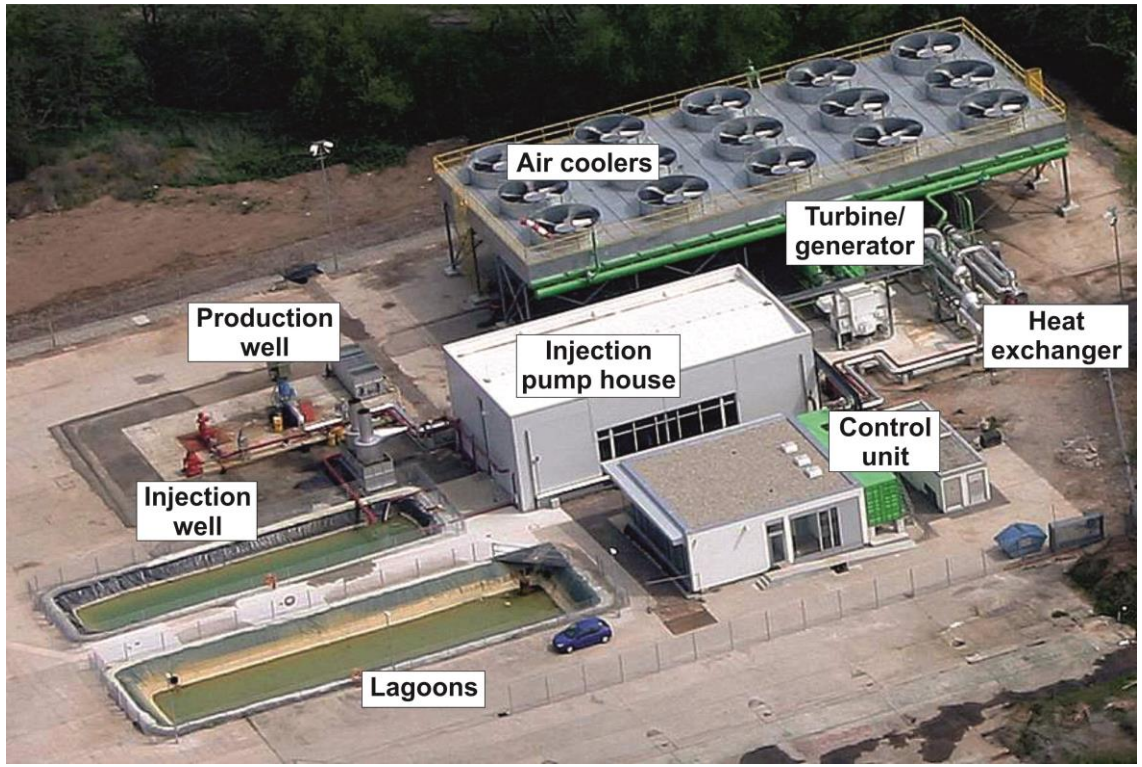
The aim is to drill two deviated wells to intersect a fault structure at a depth of 4,500 metres.

Hot water, at about 175°C, will be produced from one well, passed through a heat exchanger and then the cooled water will be re-injected down the other well.

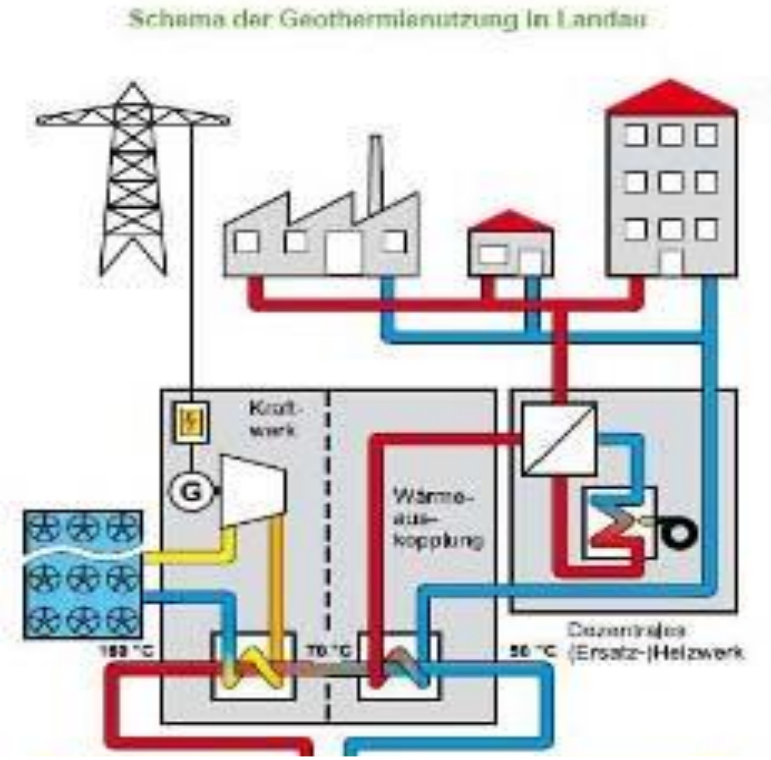
This technology provides sustainable baseload heat and power.



The concept - surface



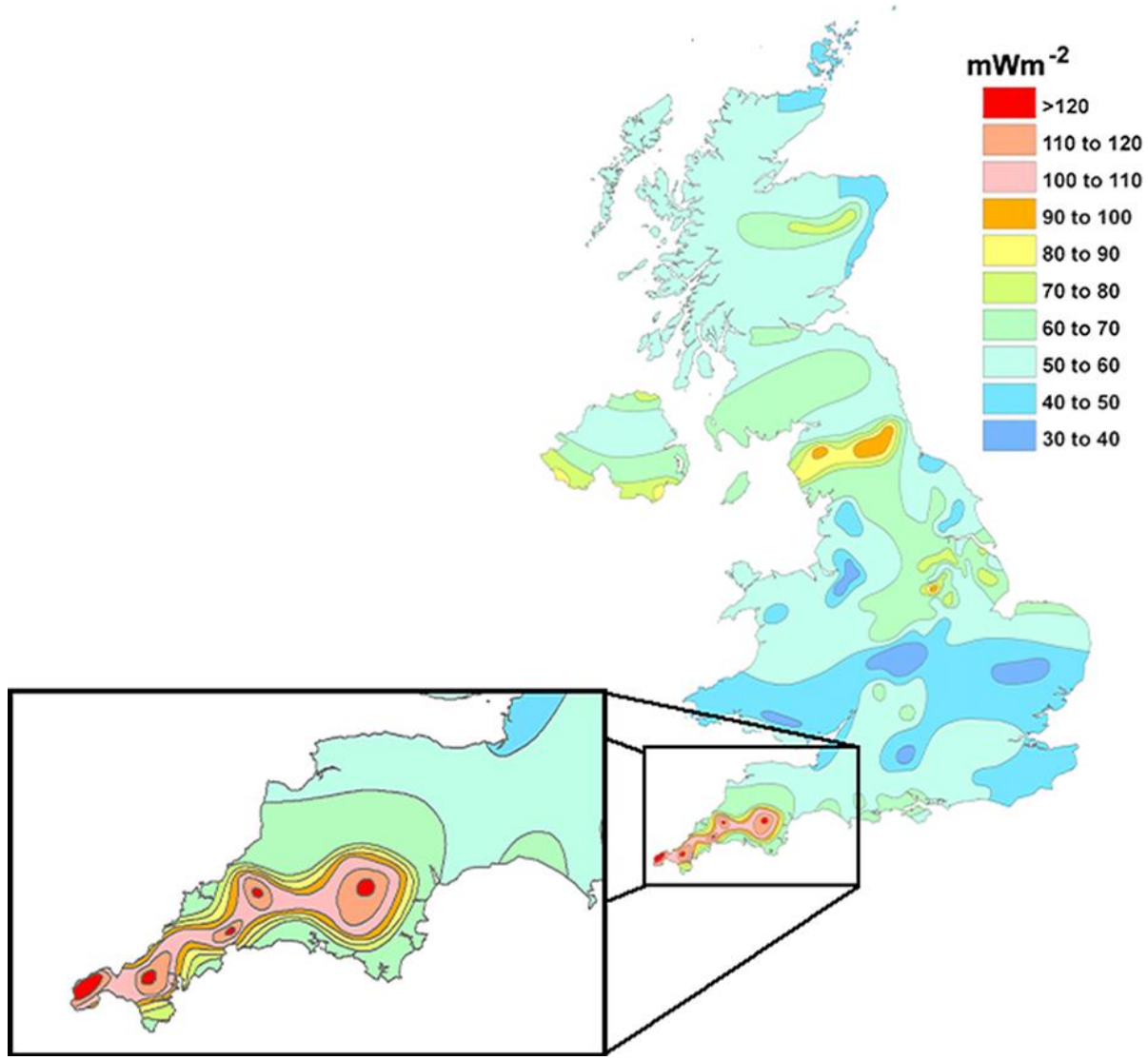
The deep geothermal heat and power plant at Landau, Germany



General operating principal of an EGS plant using a closed-loop binary cycle (ORC) to provide power and heating. For power production the production temperature needs to be >160^{0}C.

Geological parameters

Permeability and temperature



The project development

The Eden Deep Geothermal development will be carried out in three stages:

Stage 1 - a 40 month industrial research project costing £16.8m, majority funded by ERDF and co-funded by Cornwall Council and an institutional investor to prepare the site and drill and test the first deep well – late 2019 – early 2023.

Stage 2 – to drill and test the second deep well and the circulating system – approximately 9 months from mid-2022 to early 2023.

Stage 3 – design, build and commission the power and heat plant – approximately 18 months from early 2023 to mid-2024.

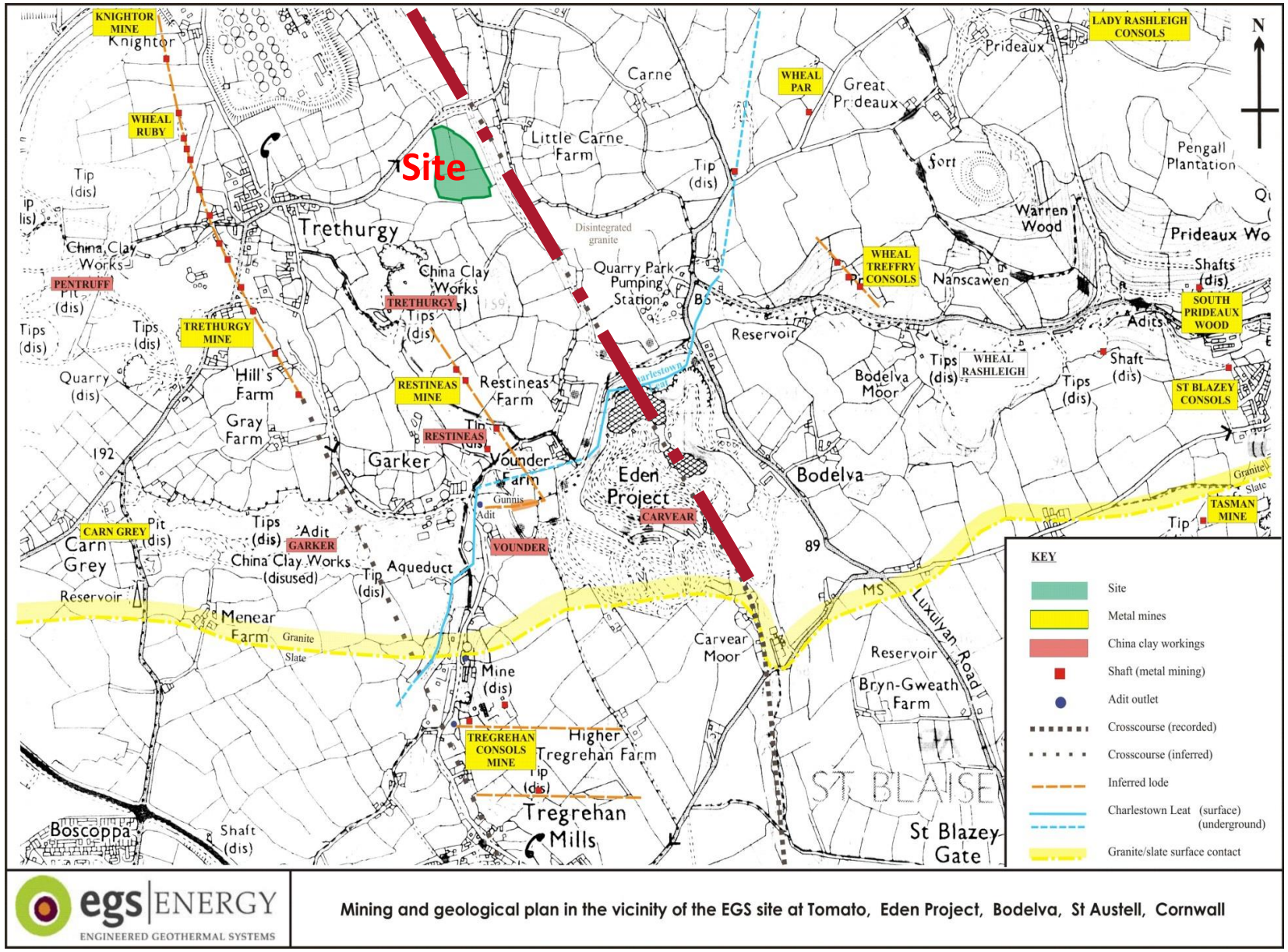
Commence operation of the plant in mid-2024

The first well project

Item	Activity	Duration (months)	Actual Date Started
milestone	Project starts		April 2019
1	Preparation, recruitment, tenders for main contractors	5	Apr 2019
2	Preparations - finalise design, procurement	7	Oct 2019
3	Site enabling works	4	Sep 2020
4	Drill and complete the first well	5	Mar 2021
milestone	Completion of drilling		Aug 2021
5	Well testing	2	Oct 2021
milestone	Evaluation of target hydrogeology		Oct 2021
6	Reporting - evaluation, reporting and dissemination	4	Feb 2022
7	Deploy single-well heat system and heat main		
8	Run single well heat output	12	Feb 2023
9	Final reporting and dissemination	1	Mar 2023
milestone	End of Project Activity		**Mar 2023**

The target

The target structure is a natural fault named **The Great Crosscourse** that strikes NNW – SSE and is inclined steeply to the NE. The outcrop of this structure lies close to the geothermal site.



Regulatory framework

There are no bespoke HSE regulations for geothermal energy in the UK.

CDM applies for site civils work, but for drilling and testing the deep wells the following specific regulations apply:

- Borehole Sites Operations Regulations (1995)
- [*parts of* Offshore Installations and Wells (Design and Construction) Regulations, 1996]
- Ionising Radiation Regulations (2017)
- Waste Management Regulations (2006)

Notification of drilling is covered by the Infrastructure Act (2015)

Rig selection

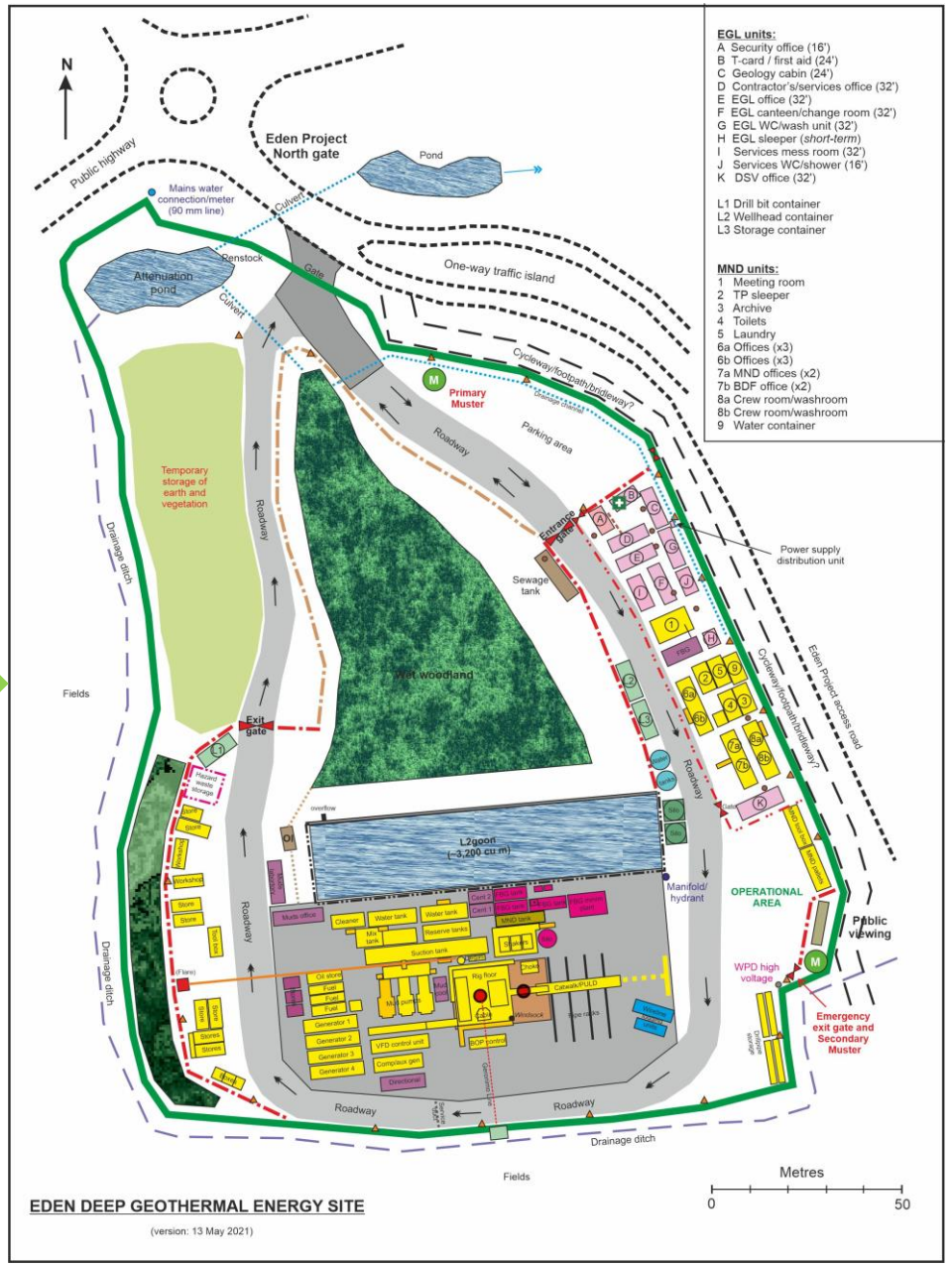
One of the first tasks was to procure the drilling contractor and rig to drill the first well.

The capacity of the rig is determined by the weight of the heaviest load, which in this case is the 4,000 m of 9⅝” casing. The loading of this casing, including couplings and allowing for buoyancy, a coefficient of drag in the deviated section of the well and a safety factor, was estimated to be ~300 tons.

So a tender was issued for a >350 T rig - there are no rigs of this capacity based in the UK.

Site preparation

- a level working area of 15,000 sq metres.
- a rig pad to accommodate a 450 T rig.
- two 4 metres deep cellars.
- a 3,000 cu metre storage lagoon.
- a one way road system around the site.
- temporary office buildings.



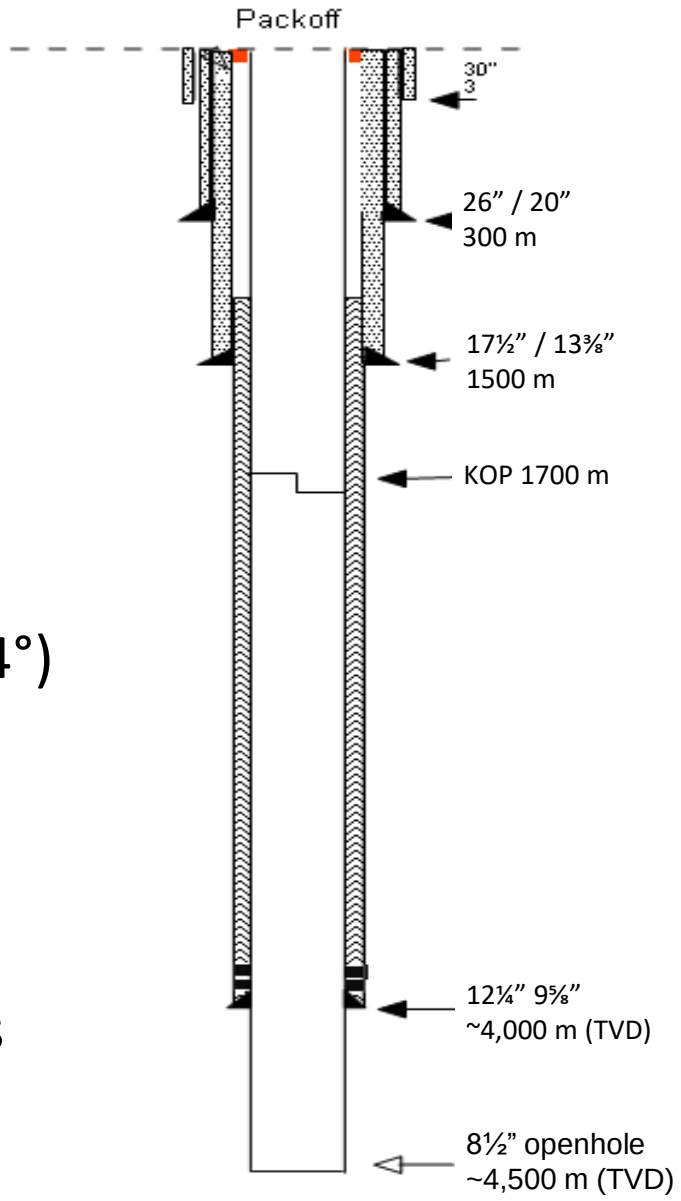
Site preparation – November 2020 to April 2021

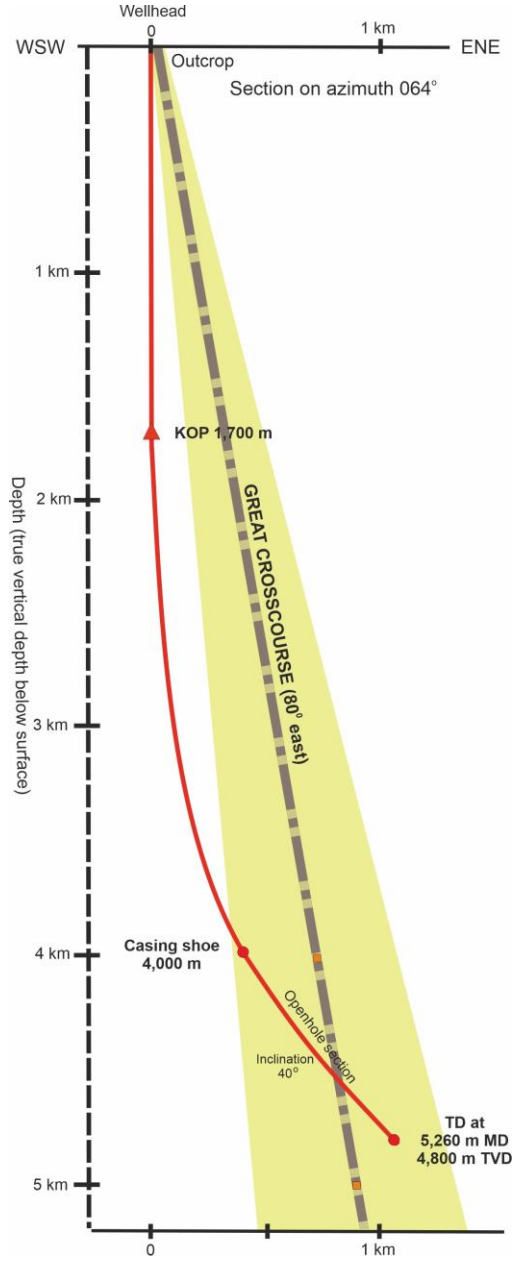
Well plan

The well plan for EG-1 was based on a conventional geothermal well design:

- 26” with 20” casing to 300 m
- 17½” with 13⅜” casing to 1,500 m
- Kick-off at 1,700 m (<1.5°/ 30 m @ 064°)
- 12¼” with 9⅝” casing to 4,000 m
- 8½” openhole to TD at ~4,500 m (TVD)

The programme was due to take 150 days

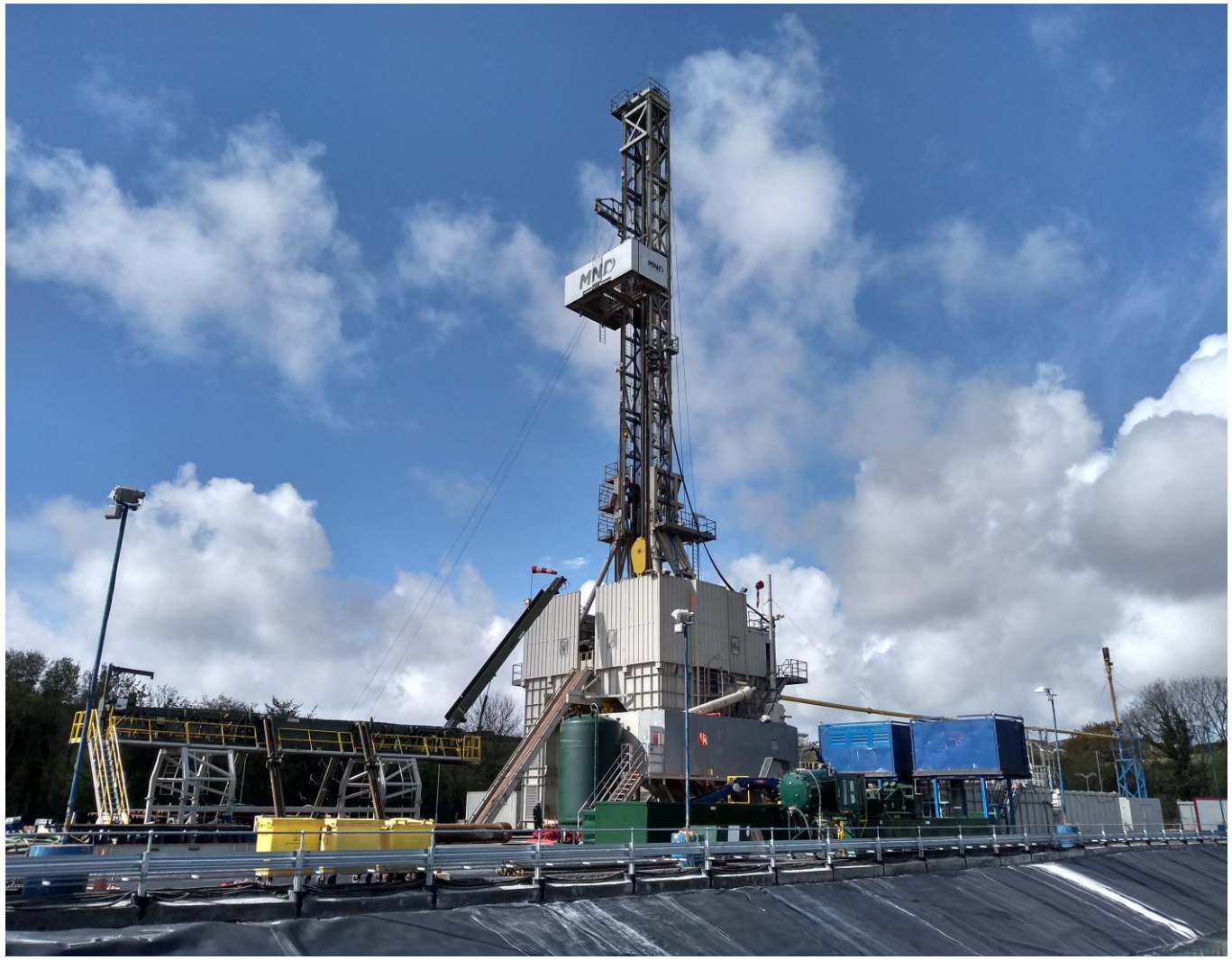




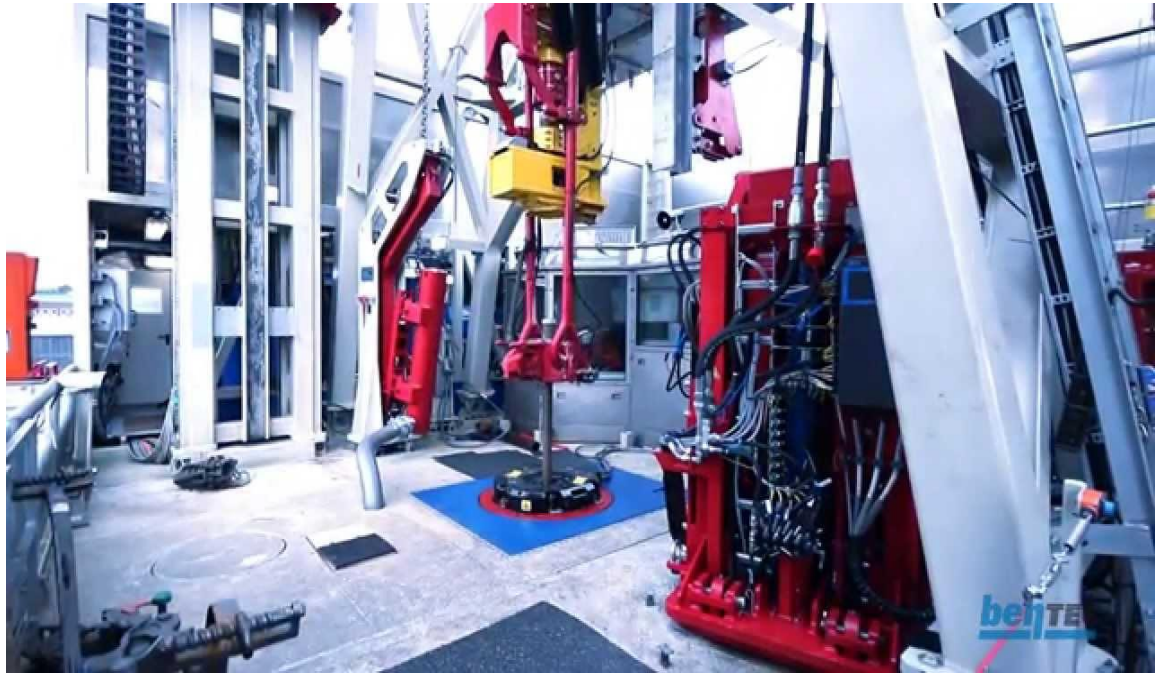
Drilling contract

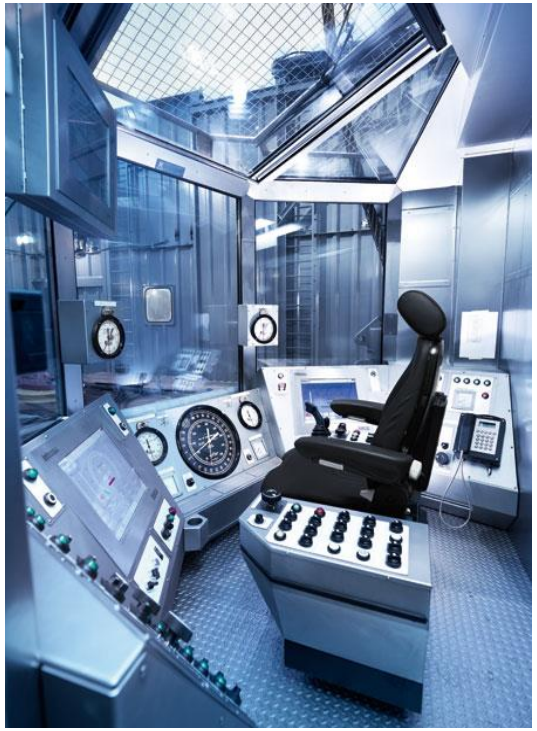
The drilling contract was awarded to British Drilling and Freezing Ltd (BDF), who subcontracted a Bentec 450 Eurorig , with crew, from MND Drilling and Services a.c. based in the Czech Republic.

This is a 2000 HP diesel-electric triples rig, built in 2012.



Bentec Eurorig – semi automation



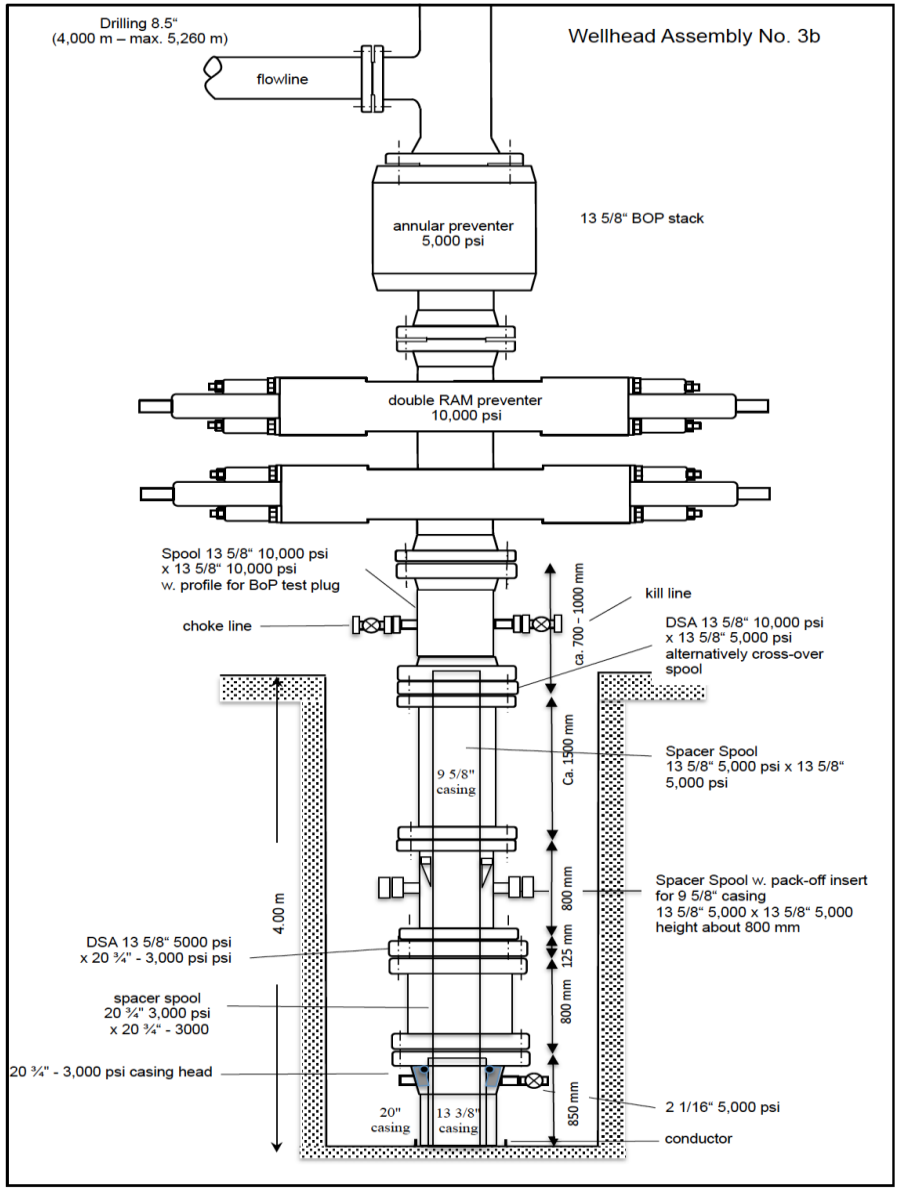


MND's Bentec 450 is is a 2000 HP diesel-electric triples rig, built in Germany in 2012.

Well control

Although the well was anticipated to be sub-hydrostatic with no significant occurrence of hydrocarbons, a full well control system had to be installed for each section of the well.

Annular preventer



Drilling services

Drilling requires a number of specialist services:

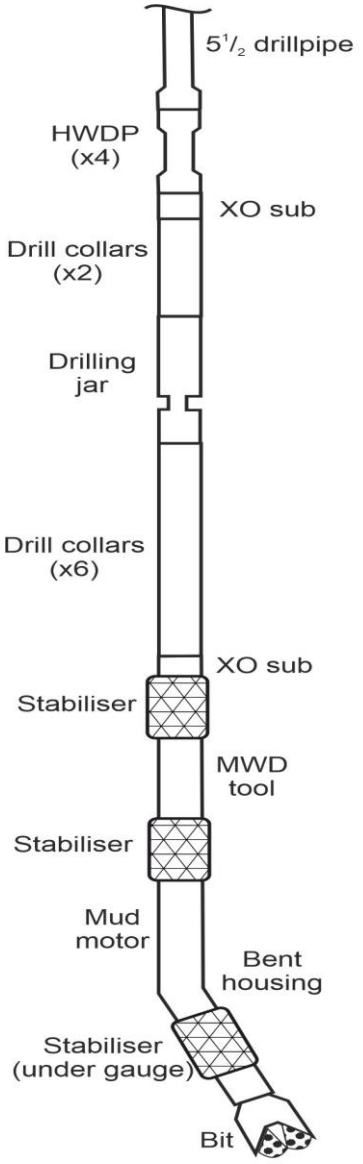
Drilling fluids -	Baker Hughes
Casing running -	Baker Hughes
Waste disposal -	FBG
Mud logging -	Geodata GmbH
Geological services -	GeoScience Ltd
Cementing -	Halliburton
Wireline Logging -	Schlumberger
Directional drilling -	Weatherford

Directional control

Conventional directional drilling, using a mud motor and MWD has been used to maintain the verticality of the upper section of the well and to provide a rotate and slide system for angle build and directional control in the deviated section.

Drilling an inclination of 40° in granite is a challenge and leads to high drag and torque.

Roller cone TCI bits are used throughout



Typical bottom hole assembly

Drilling fluids

A water-based drilling fluids system was used comprising:

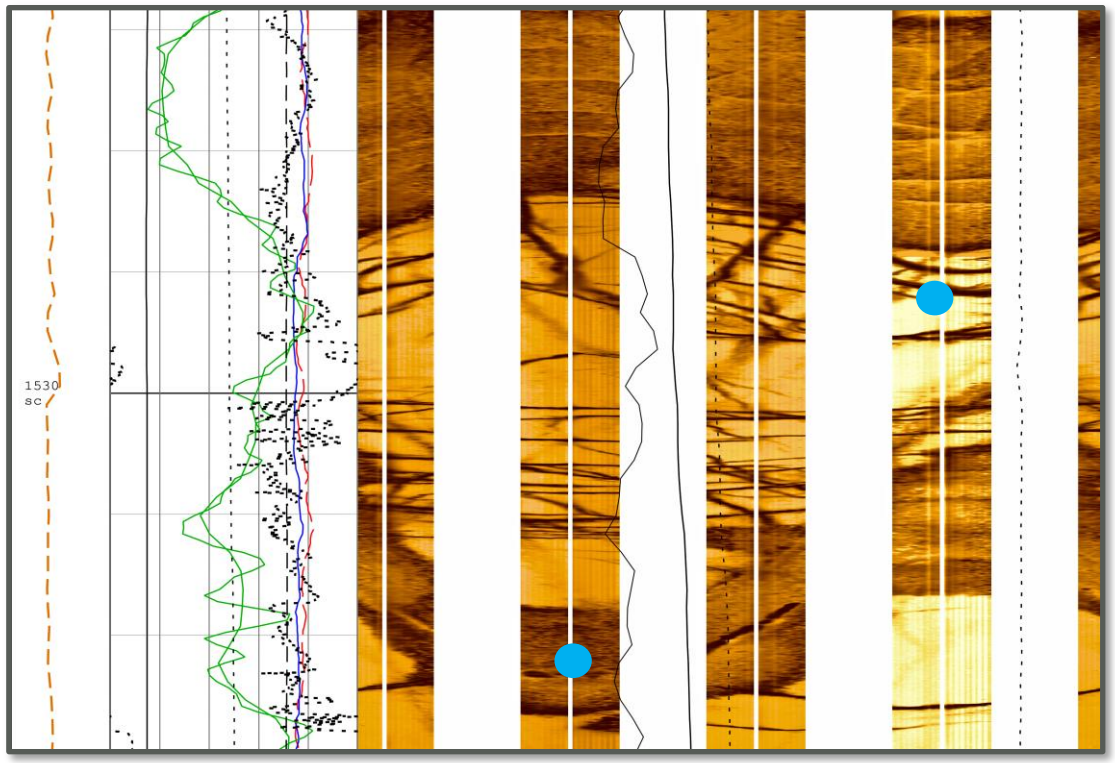
- Bentonite spud mud for the 26” section
- Xanthan polymer for the 17½”, 12¼” and 8½” sections
- Caustic soda for alkalinity control (pH ~10)
- Thermally stable lubricant to reduce torque and drag
- Chippings samples were analysed every 10 metres

Running casing and cementing

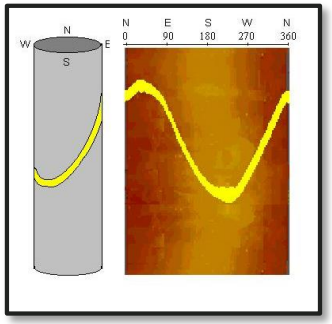
Casing size and type	ID (“)	Weight (lb/ft)	Length (m)
Surface			
20” K-55 BTC	19.000	106.5	30
20”total			**300**
Intermediate			
13⅜” L-80 BTC	12.515	61	902
13⅜” L-80 BTC	12.415	68	311
13⅜” L-80 BTC	12.347	72	287
13⅜”total			**1,500**
Production			
9⅝” L-80 BTC	8.835	40	1430
9⅝” L-80 BTC	8.755	43.5	493
9⅝” L-80 BTC	8.681	47	808
9⅝” HC-L80 BTC	8.681	47	1269
9⅝”total			**4,000**

Wireline logging

FMI



visualisation of vertical bh + log



Logging in 17 1/2” open hole	
Logging depth	1,500 m – 300 m
Type of log	1) Oriented Caliper for cement volume (6-arm) 2) Gamma Ray Log 3) Natural Gamma Ray Spectroscopy 4) Sonic Log
Logging in 12 1/4” open hole	
Logging depth	4,000 m – 1,500 m
Type of log	1) Oriented Caliper for cement volume (6-arm) 2) Resistivity Image or Ultrasonic Borehole Televiewer 3) Gamma Ray Log 4) Natural Gamma Ray Spectroscopy 5) Sonic Log
Logging in 8 1/2” open hole	
Logging depth	5,260 m – 4,000 m
Type of log	1) Oriented Caliper (6-arm) 2) Resistivity Image or Ultrasonic Borehole Televiewer 3) Gamma Ray Log 4) Natural Gamma Ray Spectroscopy 5) Resistivity Log 6) Sonic Log

Completion of the drilling programme

Drilling of EG-1 was completed on 26th October 2021 at a total measured depth of:

5,276.67m bGL

which equates to an approximate true vertical depth of:

4,870 m bGL

The programme took 168 days.

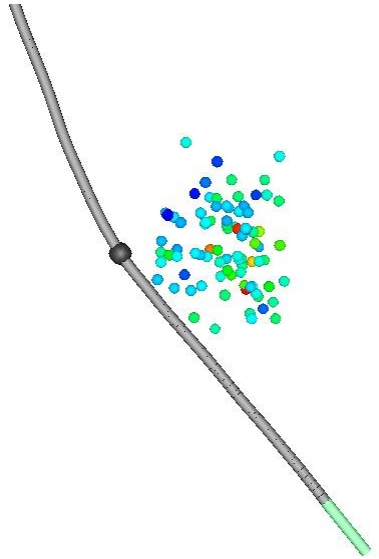
The next phase of Stage 1 is to carry out a series of injection and production well tests

Well testing

The next operational stage is to test the first well to evaluate its likely performance and productivity. This is an essential requirement before committing to drilling the second well and will be repeated once the two well system has been developed.

The initial well testing programme will comprise:

1. A series of step flow pulse injection tests
2. An air-lift production test



These tests will induce microseismic activity and operational parameters will be carefully controlled to minimise the risk of a ‘felt’ seismic event.

Benefits of deep geothermal energy

- a clean, green and sustainable form of energy;
- provides base-load and dispatchable heat and power ;
- power plants operate 24 hours/day for 325 days/year;
- low operating costs;
- low environmental footprint and impact ;
- very low CO_2 emission;
- potential to be a major energy contributor for the UK.
- Public acceptance

Transition into renewable energy

The impact of Climate Change is driving the development of non-fossil fuel energy, with the knock-on effect on the future of the oil and gas sector

Geothermal drilling, testing and operation uses oilfield technology. This offers the oil and gas sector a tremendous opportunity to transition into the renewable energy.

Skillsets

There is a huge skillset within the oil and gas sector that is needed to take forward the development of deep geothermal energy, both in the UK and abroad:

Drilling rig/contracting

Wellhead supply

Casing supply

Drill bits supply

Drill site design/construction

Research

Geophysics/seismics

Well design and planning

Drilling fluids

Casing running

Waste disposal

Mud logging

Geological services

Cementing

Wireline logging

Directional drilling

Drilling supervision

Drilling support

Drilling consultancy

HSE consultancy

Reservoir engineering

Well examination

Fabrication services

Well testing

Reduction in costs

The UK could become a sector leader in the field of deep geothermal energy. However, for this technology to be a viable and cost effective energy source the capital development costs have to be significantly reduced, especially the drilling and associated costs.

Thank you for listening

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