



Transition Energies

Our Company



“... a return to ‘business as usual’ [for oil and gas] is no longer an option. Government support is in the context of delivering our net zero target. The sector is already coming under significant pressure from investors and the public more widely to respond to the challenge.”

Energy White Paper 2020

Be a low-cost UK producer of baseload geothermal power

Maximise the conversion value of geothermal heat

Provide handsome IRRs for capital providers according to risk assumed

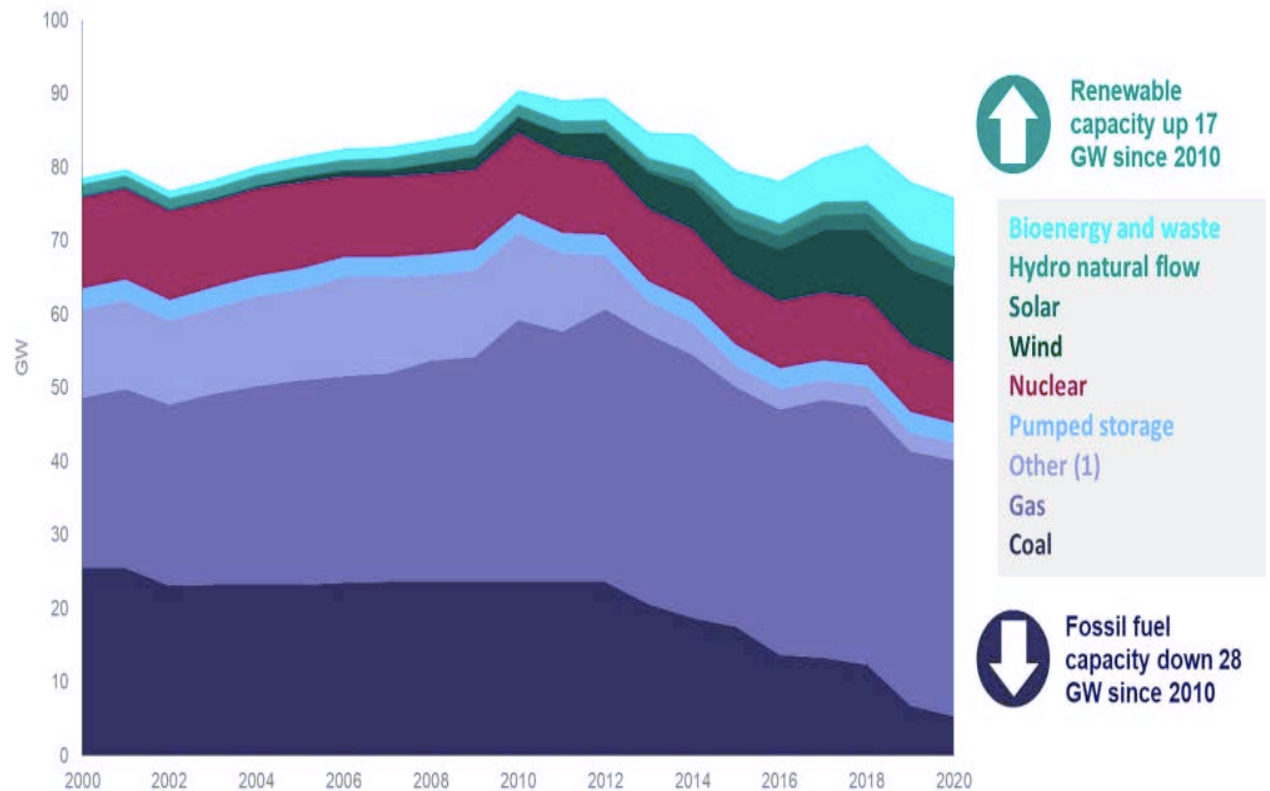
Advance the production of hydrogen from clean energy

Support the wider decarbonization of the economy

Use skills and talent in drilling, high pressure/temperature work and permitting

The Electric Challenge

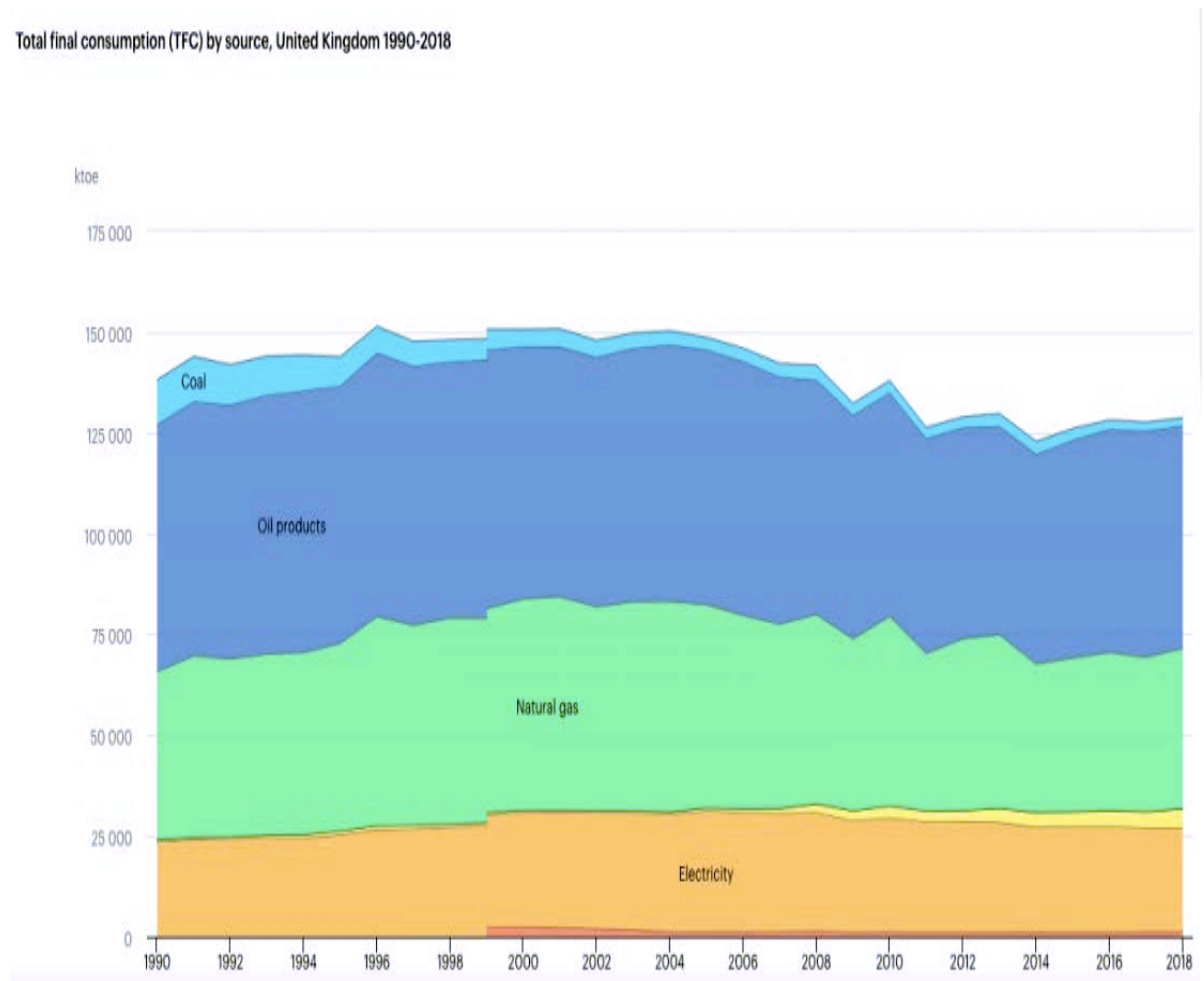
- Natural gas is now clearly the last large carbon intensive element in the 77 GWe mix.
- Much gas capacity is retained simply to support wind and solar.
- The next steps in decarbonization will involve methane to hydrogen transformation and ...
- ... the smoothing of variable output of wind and solar – i.e battery storage or solar/wind used to produce hydrogen
- Geothermal not only could provide a meaningful 2+GWe of baseload or smoothing
- ... but also offer opportunities in the production of hydrogen via high temperature electrolysis of steam or higher temperature water



The Transport Challenge

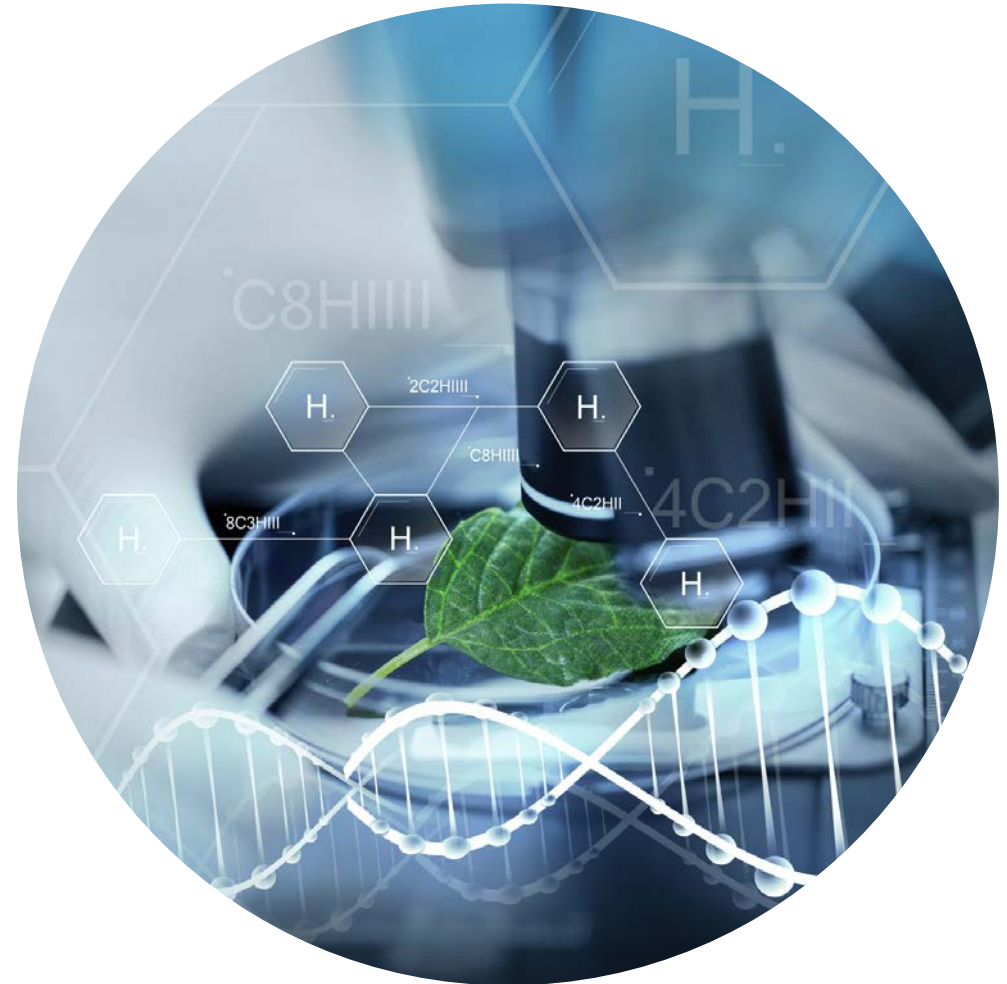
- Over half of UK oil products (blue) consumption is for road transport
- Easy to see that this half is equal to more than 2/3rds of all electricity consumption (beige)
- Switching 100% vehicles to EVs would require almost doubling total UK installed electricity capacity ...
- ... equally implausible upgrades to the transmission & distribution networks
- Thus the development of hydrogen vehicles, HVs, will need to run hand in hand with electric vehicles, EVs, if the UK is to have any chance of meeting its decarbonization goals on transport

Total final consumption (TFC) by source, United Kingdom 1990-2018



Geothermal as dual solution

- Even with high (i.e 200C) temperatures the conversion of heat energy to electricity in conventional steam turbines can be circa 12%
- Thus for every 1 GWe of geothermal electrical generation capacity about 8 GWe of heat energy is, where ancillary use cannot be found, put back into the ground.
- However utilising some of the heat to aid well established alkaline water electrolysis techniques for hydrogen production (at 70 degC +) helps bring green and blue hydrogen onto an even commercial footing.
- Thus well-designed geothermal surface facilities can provide valuable green baseload generation or alternatively a material contribution to hydrogen production.



II: Commercial Proposition



NPV per site for equity holders of £30m at average price of 8p/kwhr

Scaleable proposition from MW to GW

Long-term IRRs for equity of between 20% and 30%

All debt refinanced in year 5 to lower utility style interest rates

Achievable financing with structured mix per site of £16m equity and £60m mezz debt/site

As with O&G exploration, Angus will seek farminees/JV Partners on a site to site basis.

Illustrative Economics

Target per site – 20 MWe

- Long-life assets 30 years +
- Low technology steam generation of electricity
- Baseload generation
- Sustainable heat reservoir
- Opportunity to offtake as electric or hydrogen
- Carbon free generation of energy

Capex and Opex per site – 20 MWe

- Assumes 4 doublets of disposal and producer wells
- Capex £10m/producer well, £4m per disposal well
- Surface generation modular – i.e. added per doublet. Surface Capex £5m per doublet
- Ancillary and Connection capex – i.e. £3m average total per site
- Opex of £1 mn per year including multi year maintenance and replacement schedule

Revenue Assumptions

- Based on 190C reservoir
- 30 year lifetime
- Conversion efficiency of 12-14%
- Long term offtake prices given as weighted average of
- 5-6p/kwhr – long term PPA or hydrogen production
- 9-10p/kwhr – assumed CfD auction outcome or
- 10p-12p/kwhr – direct local industrial/commercial user

Financing and Outputs per site

- First Doublet finance by Equity (Angus + ANOs)
- Mezzanine Finance for Surface Doublet 2,3,4 added at 15% p.a. in years 2, 3, 4
- Mezzanine refinanced with 7% debt in year 5
- Pre-tax equivalent IRR/NPV(10) for Equity (assuming some local heat sales) at blended offtake price of
 - 10p/kwhr = 31% - c. £60m/site
 - 8p/kwhr = 22% - c. £30m/site

Any economic analysis provided herein is intended solely to be illustrative of management's own views. Investors must make their own judgements based on their own research.

Economics Different for each Site

- Management believe that the variability of the economics is overwhelmingly to the grid wholesale price of electricity and the efficiency of conversion of heat to electric
- 4p/kwhr is, in our view, likely breakeven territory, or estimated levelized cost
- Local electric sales could achieve better than 10p/kwhr according to our review of tariffs
- The government CfD scheme is presently indicating prices greater than 12p/kwhr but there is no guarantee of prices or availability at auction
- Longer term wholesale PPAs look likely to achieve 6p/kwhr but could attract better financing terms
- Local domestic heat sales will add profitability

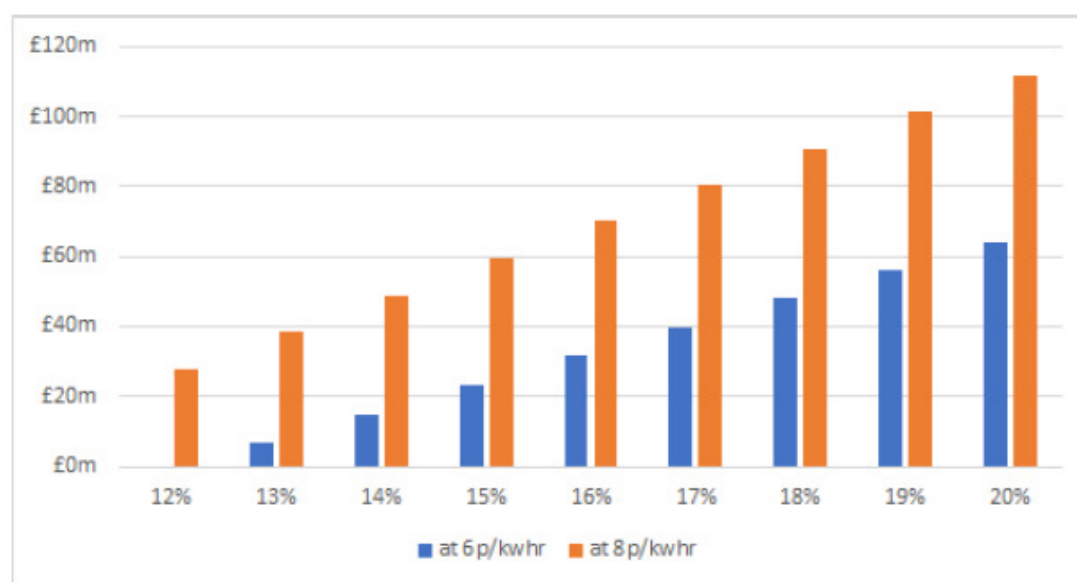
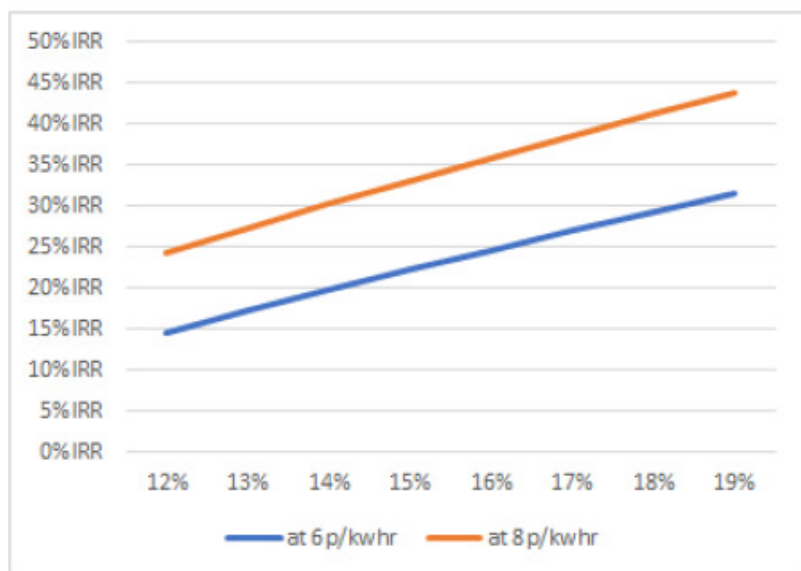
Some other variations

- Differing temperatures result in different surface equipment and capex
- Differing depths alter the drilling timetable and costs
- Alternative uses – drying, industrial, agriculture may add further revenue
- Availability/capacity/costs of grid offtake versus direct local use vary between sites
- Speed of development of EV/HV will impact local demand at sites
- Hydrogen electrolysis demands power so merely changes the off-take possibilities not necessarily the economics

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Sensitivity to Conversion of Heat to Electric

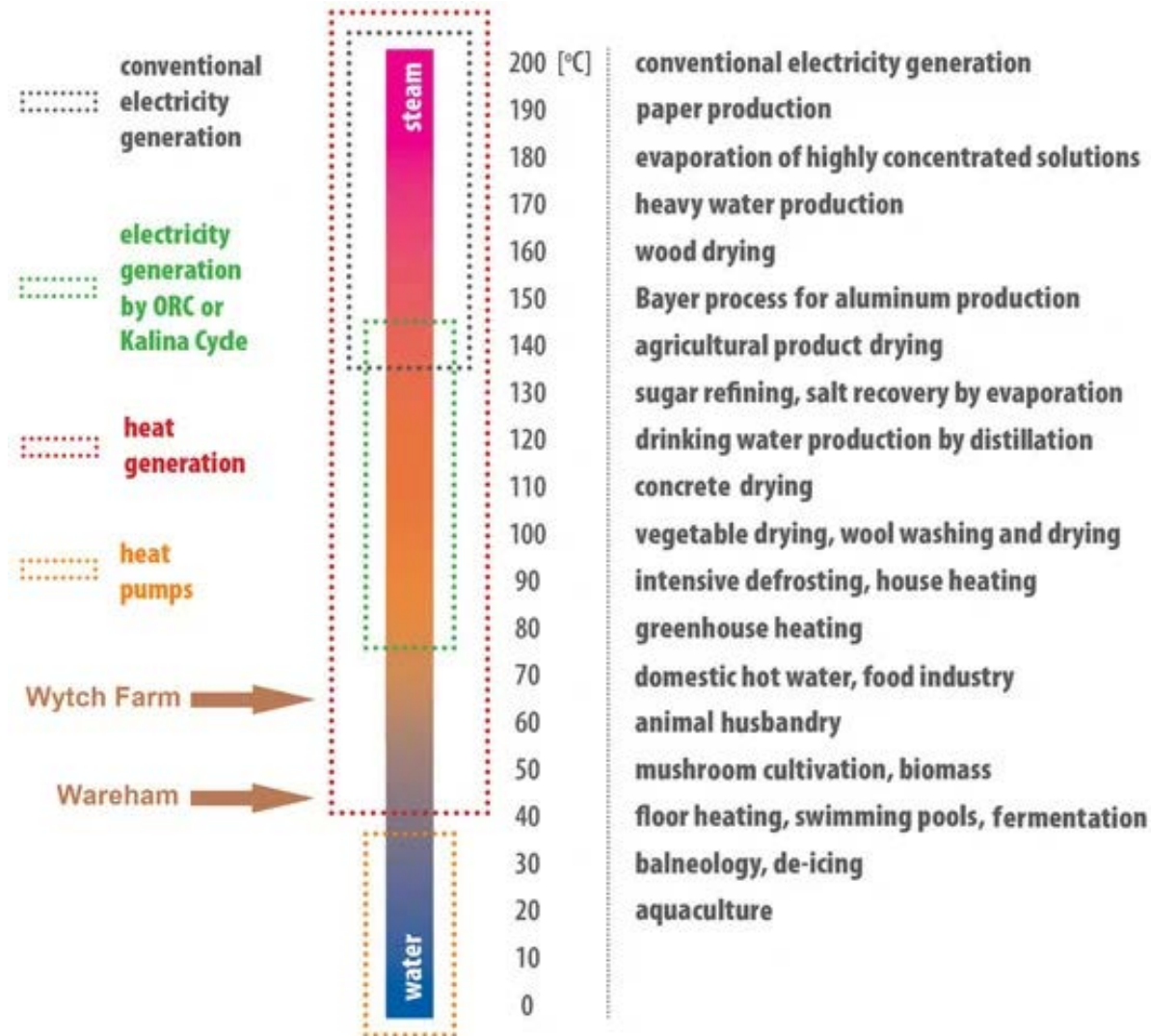
In addition to being highly sensitive to wholesale electricity prices, the cashflows are exceedingly sensitive to conversion efficiencies. The Company is actively engaged in the development of well and turbine design to improve these efficiencies from the 12% conversion base case.



Graphs of sensitivity to different efficiency of conversion of the heat into electricity expressed in terms of pre-tax equivalent IRRs and £ Net Present Values calculated at 10% (a now very high discount rate historically used to value oil and gas assets).

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Offtake Possibilities



To which we add Green Hydrogen

- Electrolysis is a very well worn technique. Large scale applications were in place in the 1950s in the nuclear industry.
- During the 1970s Hydrogen and Oxygen fuel for the Ariane rocket programme was produced in MW scale with alkaline cells at 120C and 30 bar.
- Typical electrolytes include potassium hydroxide and sodium chloride. Our own fluid is likely to be heavy in NaCl.
- Further advances in recent years have included High Temperature Electrolysis of steam which is potentially well suited to geothermal application.

Alkaline water electrolysis is a well established technique for hydrogen production. Scaled, tried and tested facilities exist for production of 500 Nm³ H₂/hour at an energy cost of c. 4 kwhr/ Nm³ at 70 deg C +.

Such a facility would use approximately 2MWe (out of expected site power generated of 5MWe) and could be expected to yield c. 360,000 kg of H₂ per annum.

Those 360 tonnes of H₂ would be worth about £720k at £2/kg *. The same 2MWe sold into the grid at a spot wholesale price of 4p/kwhr would yield approximately £700k

Thus in a low wholesale price environment hydrogen production could be a competitive alternative to grid sales and a mobile one - liberating the Company from local grid capacity availability.

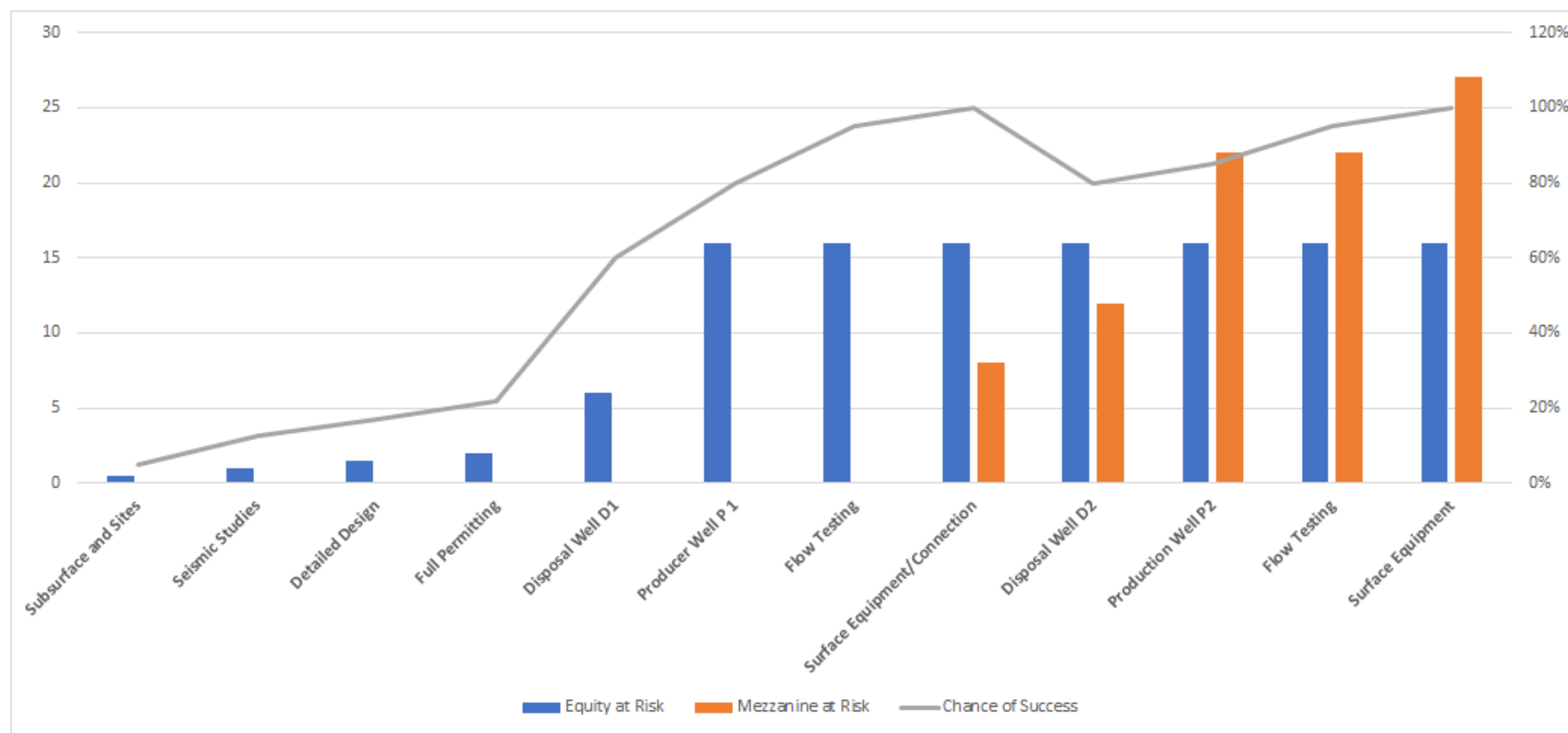
* assumes that carbon capture and auto-generation costs of \$1.20 are added to the existing steam reformed, grey, hydrogen price of approx \$1.50/tonne.

Target Roll-out of Producer & Disposal Wells

- Four Doublets (Producer/Disposal wells) per Site – 20MW
- Four Sites in 8 Years – 80MW
- Year 1 – Site Acquisition, Planning, Design
- Year 2 – Initial P(roducer)1 and D(isposal)1 well drilling, flow test
- Year 3 – Connection Generation, Sales, P2+D2
- Year 4 – P3, D3, P4, D4, Second site P1, D1
- Year 5 – Second Site P2,D2,P3,D3
- Year 6 – P4,D4 Total Output 40MW, Third Site etc
- Risk reduces with each passing Producer Well on a given fault system but increases as new fault systems are addressed by new sites

Evolution of risk-to-capital of a 2-doublet programme

Chance of success improves radically on the drilling of the shallow disposal well for c. £4mn making the deeper producer well a better risk reward proposition. Subsequent wells within the same fault system present significantly lower exploration risk.



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Key is Derisking the Proposition for both Equity and Debt

- Increase the chance of success by better subsurface studies (see Part III)
- Reduce the cost of failure by reducing drilling costs (see Part IV)
- Organise the programme for lowest capital at risk
 - drilling shallower disposal well first
 - modular addition of surface generation equipment
 - lenders have access to secure cashflow from one doublet before second doublet is addressed
- In the event that precise target conditions of temperature and pressure are not met then all is not lost for equity
 - Downhole technologies to improve heat conversion exist. The company is in discussions with Ceraphi to explore use of their downhole heat exchangers
 - Improve conversion rates through other downhole measures - the Company is engaged in a thermodynamic analysis of heat flow within the well with a University
 - Improve conversion rates through surface equipment modifications - the Company is reviewing the ORC offerings in EU
 - Utilize alternative technologies to broaden off-take possibilities - e.g. steam produced hydrogen - the Company is actively researching this technology with a view to obtaining grant funding for a pilot project

Role of Government

- Most deep geothermal to date has enjoyed considerable upfront grants as well as ongoing support.
- Presently an enhanced grid offtake rate per MWhr is available through the annual CfD auction.
- Additionally a range of grants are available for research purposes and in recent weeks, for direct sales of heat and we will make claims under these where appropriate.
- Our own favoured approach is for a government backed well insurance programme for deep geothermal drilling funded by contributions from participants. Over time this should be a net neutral scheme for the taxpayer.
- Additional preferential entry rights into local/national grids for green power over other forms of power



Further Progress

- Three fault systems identified
- Full field survey completed
- Well design and rig analysis progressed
- Developing research programme with a university and turbine manufacturer
- Discussions with offtakers inc. DNO, and NG initiated
- EA preliminary discussions
- Equity and debt partners approached with tabled MoU.
- Heads of Terms under discussion with three landlords.
- Three other sites identified



Note that the Company has no firm rights over any new brownfield site as present nor does the Company as yet have any committed financing secured for any of these projects

How long can it last?

- Piero Ginori Conti's monster is still breathing after a century



III: Be sure of the reservoir

Deep vs shallow capex

Know the Reservoir in detail

Target largest fault systems

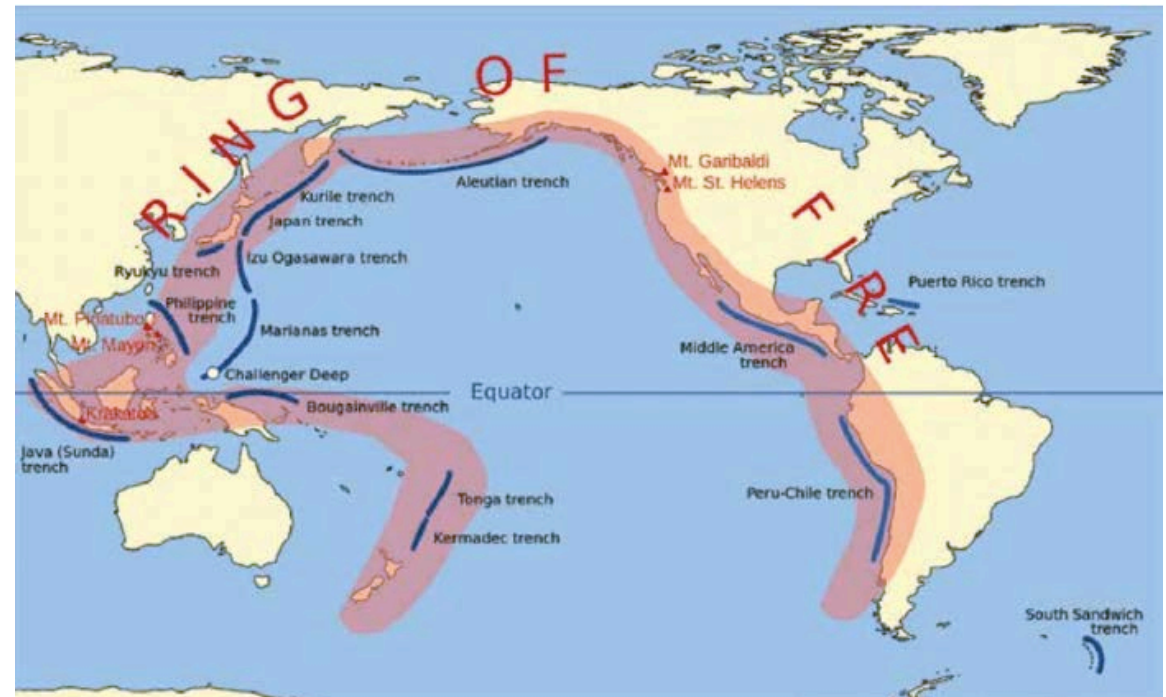
Find best fracture & heat zones

De-risk Seismmmcity

Improve conversion of heat

Shallow Reservoirs

- Shallow Geothermal tracks volcanic activity closely. Depths of as little as 100 metres
- 14 GWe of Installed Electrical Power
 - 3.8 GWe USA (from 1960)
 - 1.9 GWe Philippines (from 1979)
 - 1.9 GWe Indonesia (from 1923/83)
 - 1.0 GWe Mexico (from 1959)
 - 0.9 GWe NZ (from 1958) – 17% demand
 - 0.8 GWe Italy (from 1911)
 - 0.8 GWe Iceland (1947/87) – 26% demand
- Still only 1% of global electric demand



Deep Reservoirs



Deep Reservoir Economics

Getting to the energy

- Drilling deep means more time with rig and crew
- Material costs – 3km (EU) to 5 km (UK) of steel pipe rather than 0.5km
- Volume of waste cuttings to dispose of
- Heavy (expensive) rigs are traditionally thought necessary

Getting the energy back to surface

- Lifting 25,000 – 40,000 barrels per day against a 4km gravity gradient

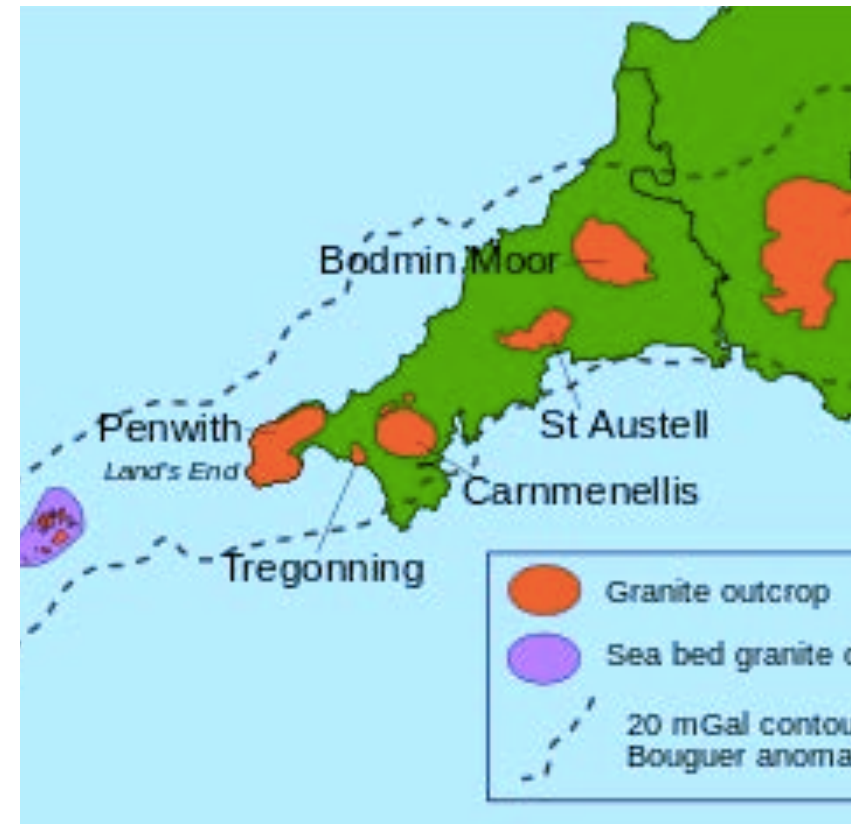
Using the heat

- In Europe the temperature won is nearer 150C than 200C and lends itself to Organic Rankine Cycles (where an intermediate fluid is required for electricity generation)
- This method, common on the continent, is more expensive than Flash generation where the reservoir fluid is allowed to expand to steam



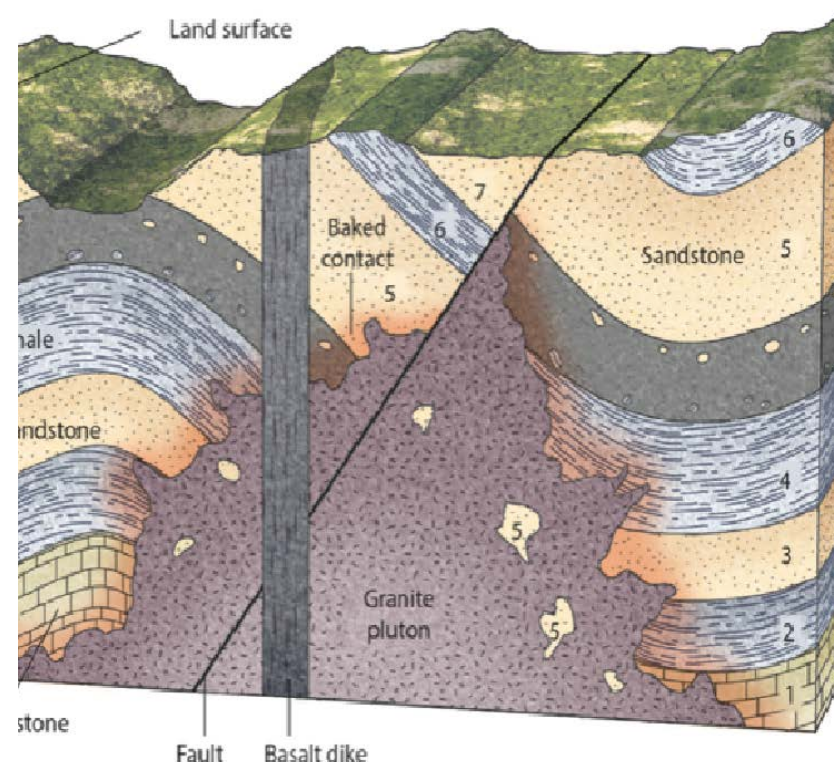
Our Deep Reservoir

- We want >> 1 GWe from the Cornubian batholith lying between Dartmoor and the Scilly Isles.
- A huge stretch of magma-formed granite out of which certain outcrops or “plutons” emerge
- Dartmoor, Bodmin Moor, St. Austell Moor
- The plutons contains high concentrations of metallic and radioactive elements which, in addition to sheer depth, assist in heat flow and heat generation
- Such elements also assist us in the detection of heat rich zones within the reservoir - which will not deplete significantly with time



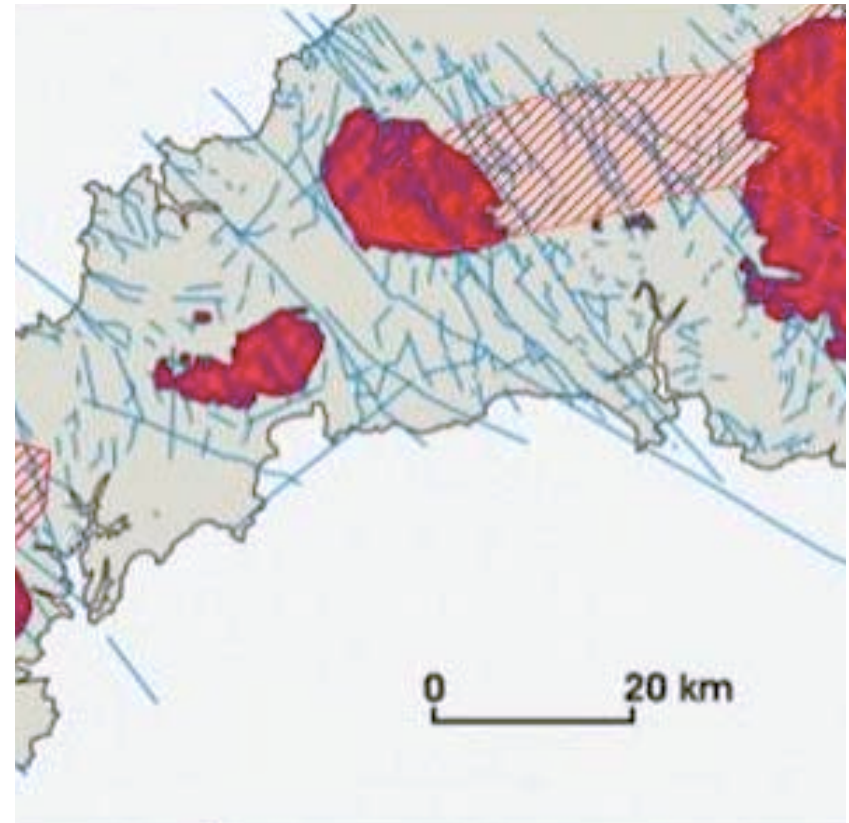
Target Zones

- The granite pluton or Cornubian Batholith – marked 3 opposite – can vary in thickness and geometry.
- During the formation of these bodies, at extreme temperatures, heavier elements tend to be thrown to the periphery of the plutons.
- This means we can detect the shape of the pluton with radiometry (for the radioactive elements), magnetometry (for the metallic elements).
- Additionally, gravimetry, seismic and old fashioned survey geology further refine the target zones.



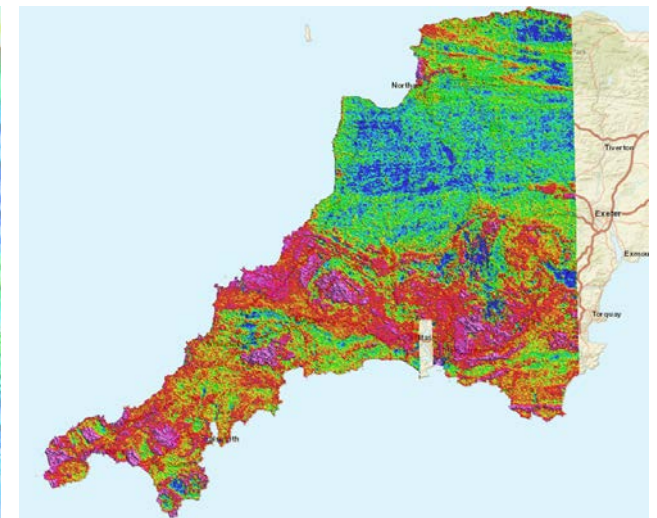
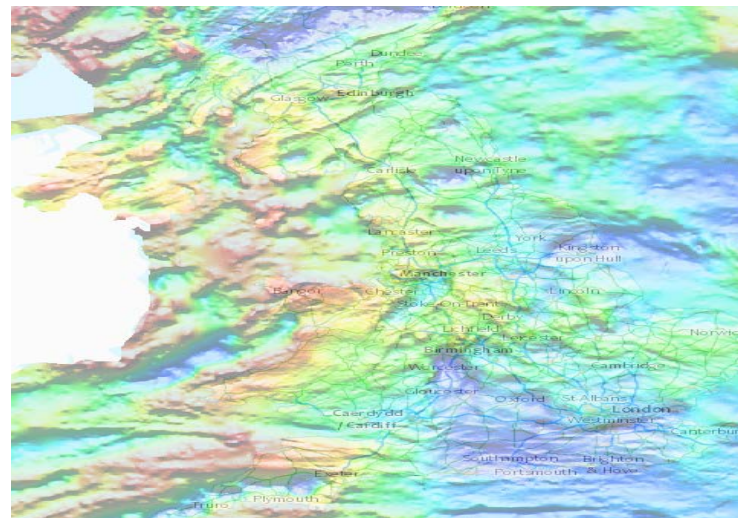
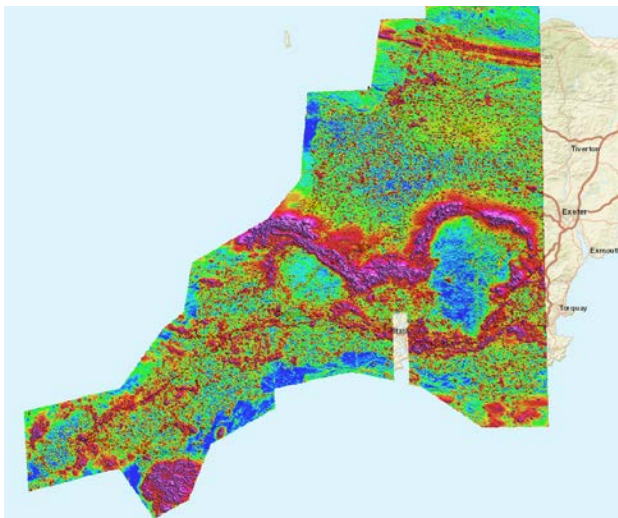
Faults and Fractures

- If the plutons were sheer granite welded into outlying country rock, there would be no fractures and therefore no water and geothermal wells demand > 25,000 barrels per day circulating
- In practice the target zones are areas where large fault systems have displaced the granite resulting in abundant open fracture systems – some extending to the surface and visible as valleys or other features
- The associated fractures nearly always contain water at high temperatures – 160-220 degC – and high pressures – up to 500 bar
- Good fracture systems allow for both production of water and reinjection within 1-3 kilometers of each other – keeping pressure at equilibrium

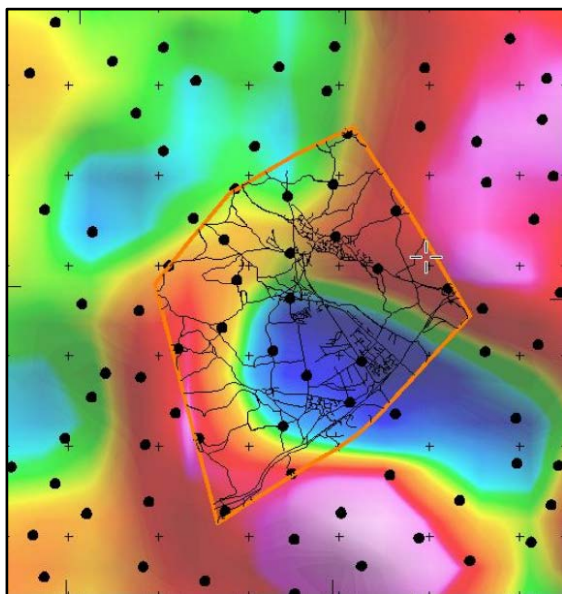


Existing Datasets

- The BGS dataset comprises gravity observations over onshore Great Britain. Most of the surveys were carried out by the BGS but the dataset includes data originally acquired by other organizations.
- The Tellus SW project acquired airborne geophysical data for the counties of Cornwall, Devon and Somerset during the second half of 2013. The survey comprised of a high-resolution magnetic/magnetic gradient survey
- The Tellus SW project also combined this with a multichannel (256 channel) radiometric survey.



New Gravimetric

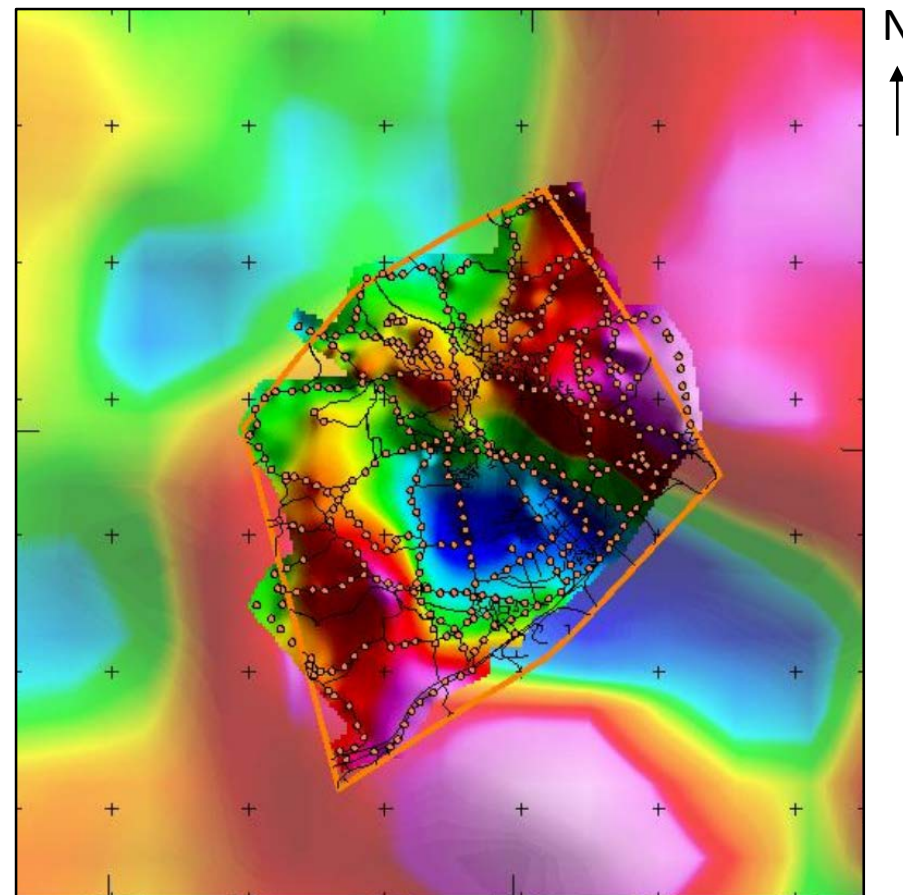


Existing Dataset

Austinbridgeporth in conjunction with Imperial College successfully carried out a land gravity and radiometrics survey over a 35km² area of interest in July 2021

The gravity data was recorded at 200m intervals along the survey lines with spacing of 250m and a total of circa 700 stations were acquired.

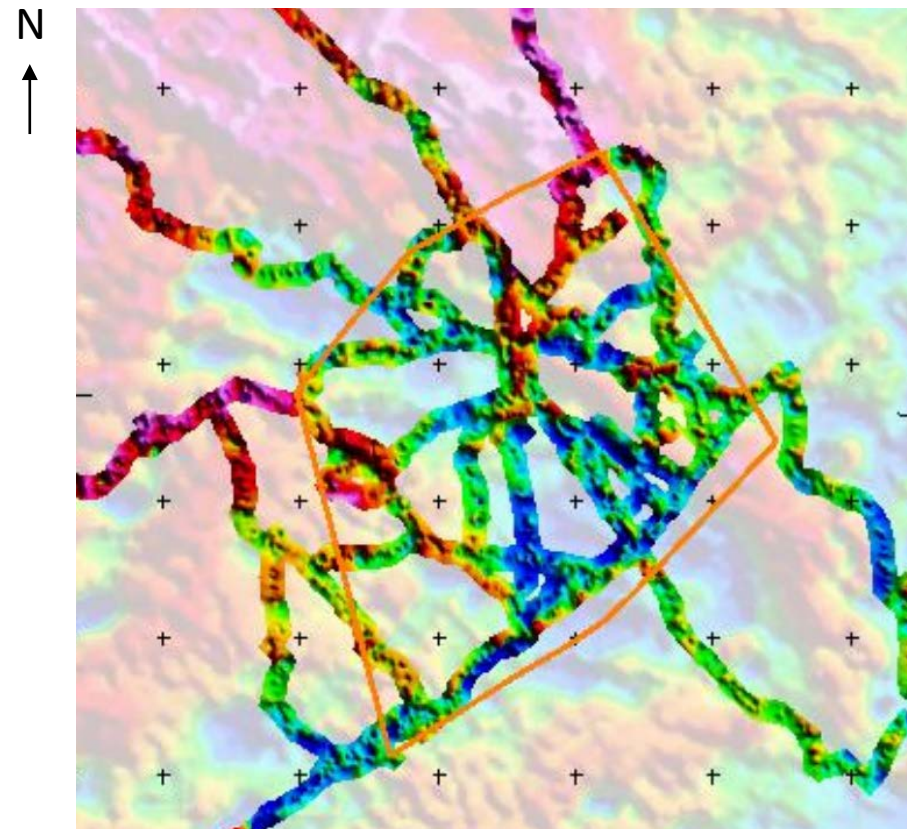
The newly acquired data has an increased coverage of data points compared to the BGS data and therefore a more accurate representation of the subsurface.



New Dataset

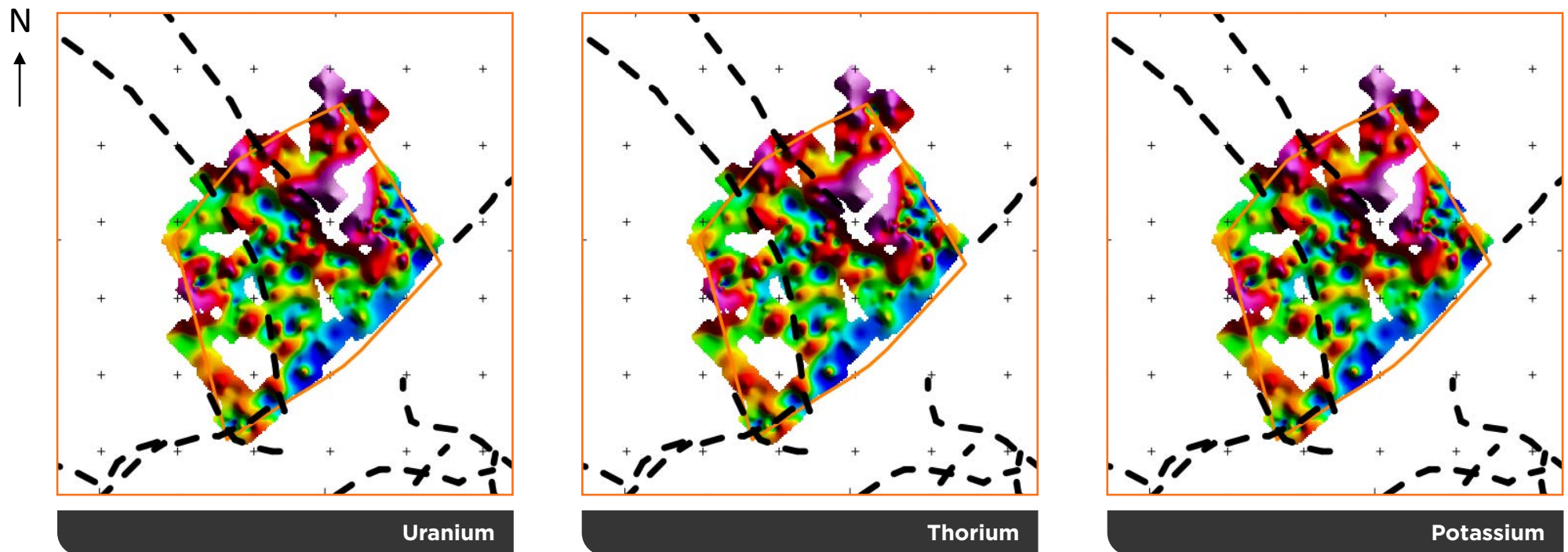
New Radiometric

- As previously mentioned, radiometric data was acquired over the area of interest
- This shows the extent of this data overlain over the legacy Tellus SW dataset.
- The better the radioactivity the higher the heat source



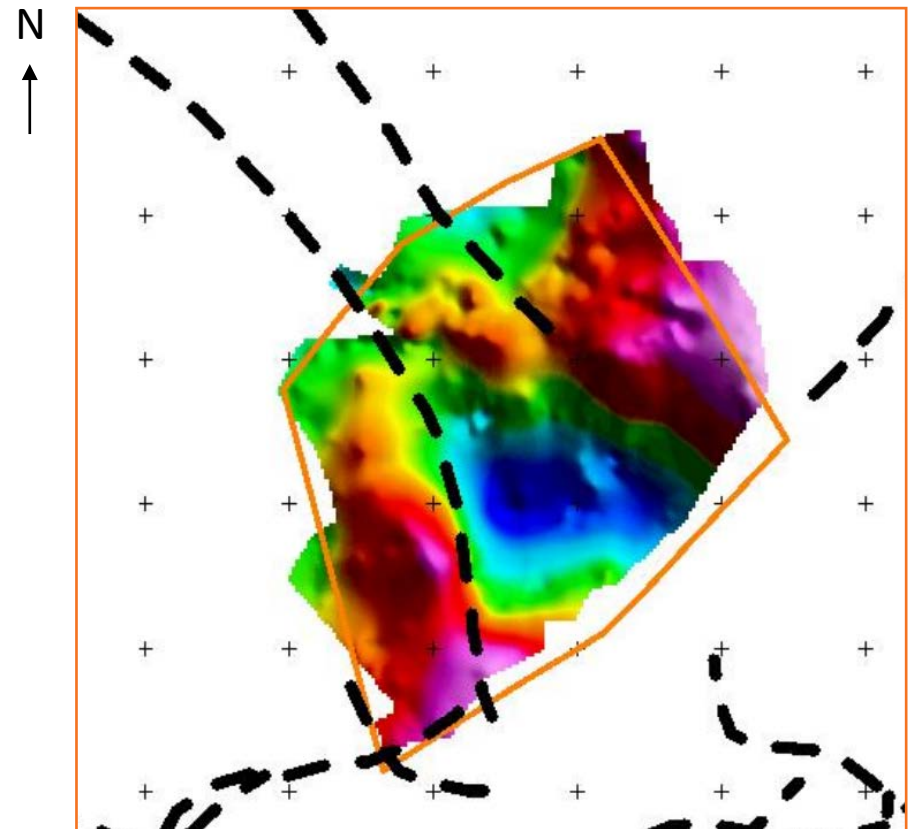
Radiometric - elements

Abrupt changes in radiometric data assist in fault detection



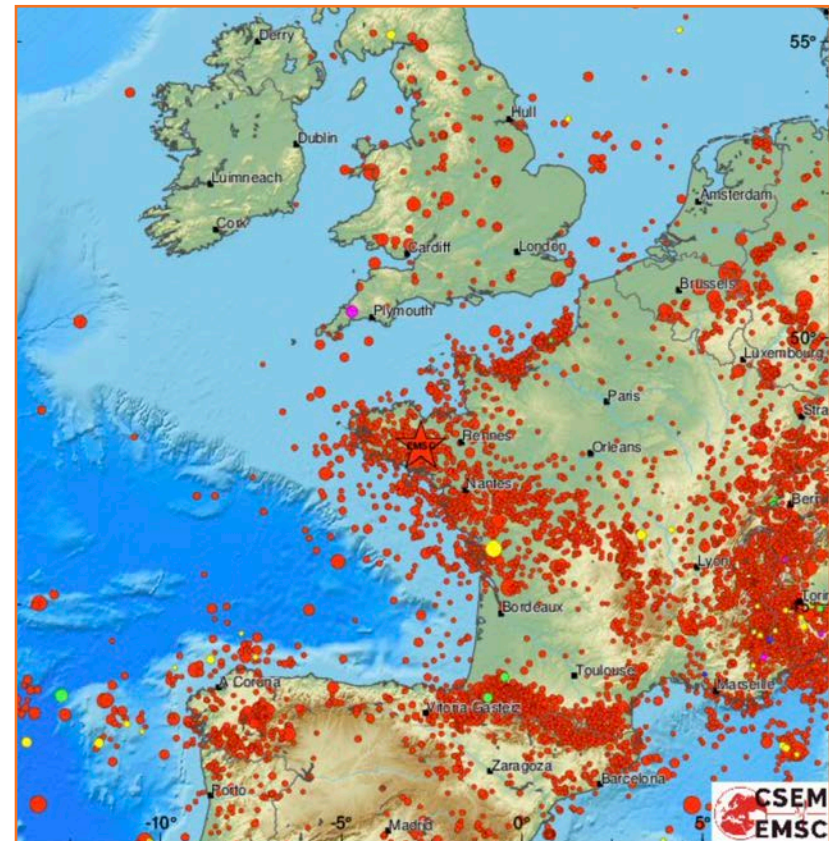
Fault finding

- The gravity responses and anomalies are representative of the density contrasts within the subsurface.
- Bringing together, gravimetric, radiometric and geological data, key structural trends such as faulting can be interpreted, and the boundary of the granite can be mapped
- This refines the drilling zones into small target areas.
- Seismic studies will complete the picture



Seismicity in Western Europe

- Seismicity in the UK is very light compared to continental systems
- Seismicity has caused issues for drilling in the Upper Rhine Graben (the intersection of France, Germany and Switzerland)
- We still need to be mindful of the fact that the UK's best fault zones are those most prone to seismicity, albeit mild



Source: European-Mediterranean Seismological Centre (EMSC)

IV: Getting Costs Down

Design for smaller rigs

Design for ease of service

Reduce casing volumes

Minimise well testing time/costs

Keep wells straight

Generate nearer source

Why costs have been high to date

- Drilling deep means more time with rig and crew
- Material costs – 5 km of steel pipe rather than 0.5km
- Volume of waste cuttings to dispose of
- Heavy rigs are traditionally thought necessary
- Pioneers tend to overengineer as they enter the unknown sometimes replicating features common to oil and gas even though the working material is neither flammable nor explosive
- Some drills encountered many down-hole problems and others induced seismicity



Reducing the rig requirement

- Using a simplified well design, whilst meeting safety and environmental needs, we can use smaller locally available rigs
- The simplified well design uses less steel casing reducing the cost of materials
- The well completion (the tubing used to produce the water from the well) is designed to be serviceable with a small rig for testing and maintenance



Well location and profile

- Angus have previously mentioned their concept of drilling through the surrounding rocks for speed and only entering the granite at depth
- However, directional drilling is expensive and can be difficult in very hot wells
- By reverting to older simpler cheaper methods the same requirement can be satisfied but with reduced cost
- Shallower disposal wells alone knock out 25% of cost from the overall drilling programme



Drilling innovations for the future

- The method of drilling affects not only the size of rig used but also the rate of drilling
- There are existing drilling methods appropriate to brittle hard rocks that have been used primarily in the oil and gas industry that may be transferable to geothermal drilling
- Quicker drilling times and a smaller cheaper rig would have a large impact on cost
- The new casing design would also facilitate larger completions making high rate production easier



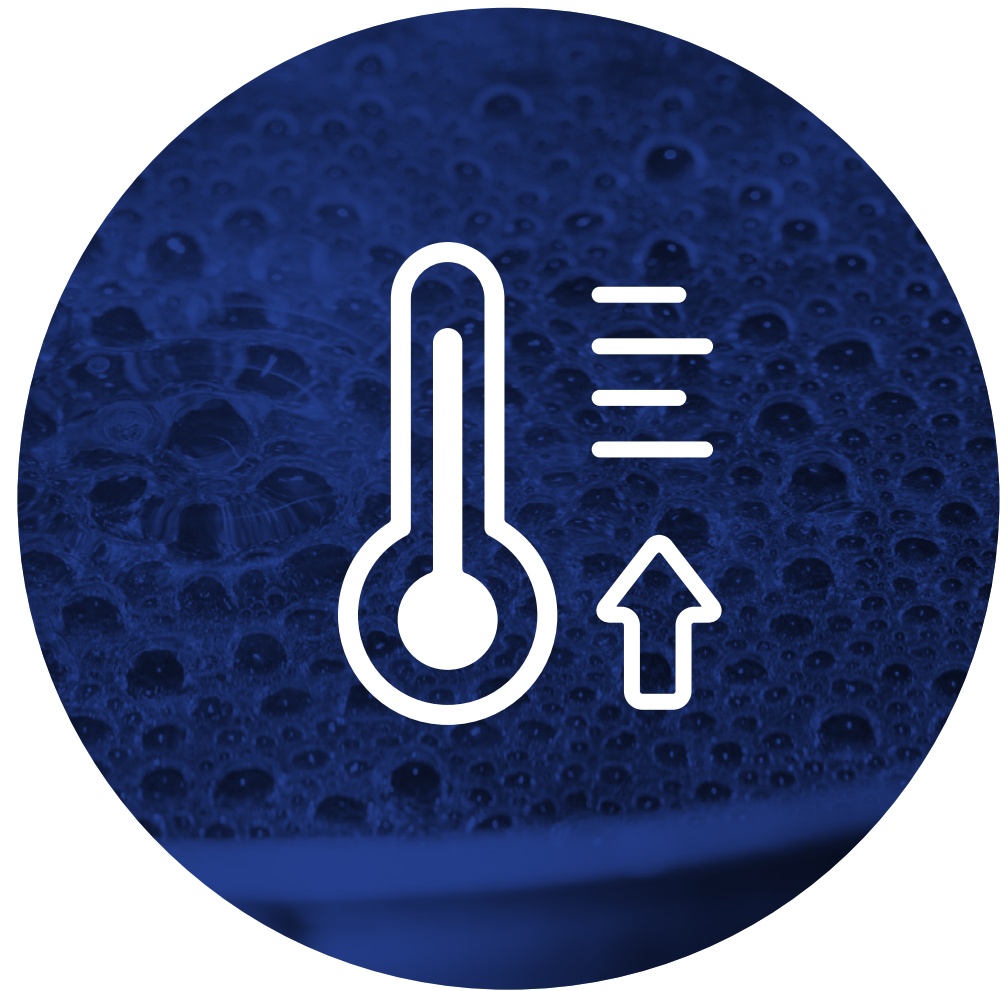
Well Testing

- The testing of a geothermal well can be a very expensive business requiring mobilisation of a large rig and a spread of equipment for a prolonged period
- Angus are planning to complete the well once in a way that enables changing out of the critical components with a small workover rig
- Extensive internal experience of well testing will we believe lead to lower testing costs.



Minimising Heat/Friction Losses in Well

- Geothermal heat should be converted with maximal efficiency or returned to source. There is no room or acceptance of waste in the current climate.
- Heat Loss in the wellbore can significantly reduce the energy available to convert to electricity or for other purposes.
- By designing the well completion to enable Nitrogen to be placed in the annulus between the tubing and the casing and by centralising the tubing the heat loss can be minimised using the same principle as a thermos flask
- This approach is possible because we are dealing with benign fluids.
- Additionally a range of high temperature low friction coatings are now available at economical costs.



Thermodynamic Engagement

- Angus are using an engineer with experience of steam generation and processing to examine the thermodynamics of flashing the steam in the well
- This approach may offer the possibility of avoiding or reducing the need for pumping by using the gas lift opportunity given by the evolving steam
- Taking this a stage further alternative methods of harvesting the energy from the well are under consideration which reduce the energy drag from lifting the molar mass of fluid 5 km against a gravity gradient estimated at 30% of power generation.



Lessons Learned from projects in UK and Europe region

- Wellbore T > 130°C costs rig time to **cool BHA** especially if it equipped with expensive MWD/LWD tools
- On high temperature wells tripping is **40%** of rig time
- Many days spent in pressure testing equipment
- **Poor bit performance** achieved drilling through hard rocks
- **Hole integrity** issues and **lost BHAs** while drilling through salts (anhydrite formations)
- Poorly organised well construction led to 21 days for well clean up, treatment and testing in one instance
- Liner shaft pump failed after 7 years of service because not all the components had the right **metallurgy**
- Illkirch project stopped after French government banned Deep Geothermal following the Vendenheim doublet test and subsequent **seismicity**
- **Corrosion** is more of an issue to the injector and to surface heat exchanger

Lessons Learned from projects in UK and Europe region II

- Design the **well trajectory** so there is no need for directional work beyond 130°C
- A good and **reliable mud cooling system** is a key to reduce rig time
- Prepare a drilling programme where minimum trips are required
- Equipment to be **pressure tested and certificates** in place **in advance**. Minimum testing will be necessary to proof pressure tight connections on site.
- Angus prepared a **drill bit analysis** from the drilling data of other deep geothermal projects and identified the most efficient drill bits for hard rocks, maximising ROP and drilling faster.
- **Geological prognosis and static geological models** are being prepared for the area of interest to avoid problematic formations that cause hole stability issues and require extra casing strings. This approach **decreases the drilling risk and material cost**.
- All liner shaft pumps components must be stainless steel to decrease the need for maintenance
- **Seismicity monitoring** shall be in place prior and during drilling operations to ensure no seismicity will be induced
- **Maintaining** correct P and T of the injection fluid in order to avoid corrosion, being always above CO₂ bubble point
- **Scale inhibitor** to protect all surface equipment

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