How to make geothermal businesses work

Report from Finding Petroleum webinar on May 28, "Geothermal Success"

Geothermal businesses do not need high temperatures to be viable, but get easier with higher temperatures, if the well is already drilled, and if you have the right sort of regulatory support, we learned at a Finding Petroleum webinar

In this report:

Note: a video of the webinar this report is based on, including slides, is available online here

Geothermal businesses, selling the heat from the earth, can be viable with downhole temperatures of as little as 65 degrees C.

But it is easier to make them viable with higher downhole temperatures, wells which have already been drilled for other purposes, and a regulatory environment which supports risks, provides data, enables construction and more, we learned at a Finding Petroleum webinar on May 28, "Geothermal success".

Kalahari GeoEnergy, based in Zambia, believes it can build a viable business, based on the results of its exploration wells, producing 4.5 MW from 2 production wells, 500m deep.

Rob Westaway, Senior Research Fellow at the University of Glasgow, calculates that hot water produced from the Wytch Farm oil field in Dorset, UK, could provide 90 MW of heat.

But the development would be complicated by restricted planning rules in the region, as a designated Area of Outstanding Natural Beauty, which would probably make it impossible to (for example) send the heat to the nearby town of Bournemouth by pipeline, where it could be used to heat buildings and hot water.

The environmental credentials of geothermal energy are extremely good. Jon Gluyas, Director of the Durham Energy Institute at Durham University in northeast England, points out that geothermal energy could be developed

nearly everywhere on the globe. So it meets the UN Sustainable Development Goal of reducing inequality, as well as being low carbon.

Professor Gluyas has formed the Geothermal Energy Advancement Association, together with Chris Sladen, who has worked for many decades in the petroleum sector.

The Association aims to promote investment and drive awareness in geothermal, across academia and business. It advocates greater support from Governments globally and improved regulations. Ultimately the challenge is create geothermal investments at a similar scale to, say, wind or solar, in a world ultimately using less petroleum.

BP and Chevron are already involved in geothermal, through a stake in Canada geothermal start-up Eavor, announced in Feb 2021. Chevron has also been involved in geothermal in Indonesia for 20 years.

Where?

If you look at a map of the world showing where geothermal energy could be produced, including where heat is close enough to the surface, or where there are aquifers, volcanoes and granites, it includes a large proportion of the earth's surface, Professor Gluyas said.

Most people's idea of geothermal energy is to use it for power generation, Professor Gluyas said. The USA has the most geothermal power generation in the world. The first geothermal power plant in the world was built 100 years ago in Italy, and the next in New Zealand in 1958.

The Philippines was also an early mover. Other leading countries in geothermal power are Indonesia, Mexico, Iceland, Kenya, Japan and Turkey. Altogether 14 GW is generated in 27 countries.

Another application is using the geothermal heat directly. Here, "China and the USA are miles ahead of any other nation," he said. Other countries doing this are Sweden, Turkey, Germany, France, Japan and Iceland.

Iceland covers all its heating and power generation requirements with geothermal energy. There is potential for Iceland to use the energy to make liquid hydrocarbons using captured CO2, to power the transport system.

In the US, there are millions of onshore oil wells which could be candidates for geothermal, including 200,000 wells currently producing hydrocarbons at a rate of less than 1 barrel of oil equivalent per day,

"These are phenomenal opportunities, and we are only beginning to scratch the surface."

Where in the UK?

Two projects in the UK to use geothermal energy for power (electricity) generation are the United Downs Deep Geothermal Project and the Eden Project, both in Cornwall. "Both should see power generation in the next year or so," Professor Gluyas said. Although we should not forget to use the associated heat directly (such as for buildings).

Professor Gluyas was involved in a geothermal project in the Weardale Granite, in northeast England and in central Newcastle, drilling wells in 2010 and 2011. The granites contain uranium and thorium slowly decaying, which generate heat. The project generates 3.6MW of heat. There are deep saline aquifers in Cheshire, the Midlands and Scotland which could also supply heat he said.

Abandoned coal and metal mines could be suitable for geothermal. There are 23,000 in the UK, all now flooded with water, which ranges in temperature from 10 to 25 degrees C, he said.

A North Sea offshore oil and gas fields could be repurposed for geothermal. Some oil fields are already producing 10-20 times as much water as oil by volume, and most of the water is near or even above 100 degrees C.

Power from the water could generate 50 to 60 per cent of the energy needed to run the offshore platforms, he estimates, and could replace energy from burning diesel and gas.

Another business idea is that CO2 storage projects could be turned into geothermal projects, with a technology called "CO2 plume geothermal." Subsurface CO2 absorbs heat from the reservoir, rises to the surface due to its increased buoyancy, and is used to generate power.

One challenge in getting started is that you need to know the permeability of the rock, if the system involves separate injection and production wells. This is not always known, particularly for onshore systems, he said.

Role in global energy

At the moment, the role of geothermal in the global energy system "is about nothing," counting for 1 per cent of global power generation, while gas provides 24 per cent and coal provides 27 per cent, he said.

There are direct connections between geothermal and hydrocarbon, coal and nuclear power, he said. It was the heat in the Earth which enabled coal and hydrocarbons to form. The heat in the earth comes from the decay of uranium and thorium.

For the question of how long geothermal energy can go on for, scientists estimate that 15 per cent of the heat generating capacity of the Earth that is available has been produced over the last 4.5bn years. "We don't need to worry about next week," he said. "It is sustainable as far as any reasonable description of humans as a species go."

The risk of geothermal projects is not the failure of heat in the Earth, but getting the reservoir engineering wrong. "It is possible you can mismanage a system, inject cold water and get cold water back."

"The important point to note is that margins on geothermal are always going to be modest," he said. "There's just not the energy density in a barrel of hot water compared to a barrel of oil."

"Stacking" geothermal

Professor Gluyas envisages a future where heat is used through multiple levels.

If dry-steam is produced at 200 degrees C, and used for power generation, the waste "wet steam" remaining could then be used for food processing, drying timber, "a whole array of industrial applications."

Water at under 100 degrees C can be used for hone heating – this is done on a big scale in Iceland. While lower temperature water can be used for greenhouses and fish farms.

"You stack up your projects and keep taking energy out of the system," he said.

Repurposing UK wells

Rob Westaway, Senior Research Fellow with the University of Glasgow, led research into the potential for repurposing hydrocarbon wells in the UK. The work is funded by the UK's Engineering and Physical Sciences Research Council. Industrial partners are oil services company Schlumberger and oil and gas operator Perenco, operator of Wytch Farm, a strong candidate for geothermal repurposing.

The study found that the "vast majority" of UK onshore wells with potential for geothermal energy are in England.

Dr Westaway's team did a screening survey, to identify the most promising oil and gas wells in the UK for geothermal production.

OGA's well database has 3 categories of well abandonment. Phase 1 means a permanent barrier is placed between the reservoir and the well bore. Phase 2 means zones in the well have been isolated, such as with cement in the well. Phase 3 means the well head, conductor and all surface equipment are removed.

Of these categories, only phase 1 is reversible, meaning the well can be used for geothermal, Dr Westaway said.

This means there are 560 possible onshore wells which could be repurposed as geothermal, of which 293 are currently operating, 83 shut in, 163 in abandonment phase 1, 20 categorised as "plugged". Only 1 of these is outside England.

The key parameters for site screening are the bottom hole temperature, and the formations which a well connects with.

There were 17 wells out of the 560 with an estimated bottom hole temperature above 80 degrees C. They were all in either the East Yorkshire / Lincolnshire basin, or the Wessex basin, which includes Wytch Farm in Dorset.

It is possible to aggregate all the candidate wells in a field, to calculate how much energy each field could 'produce,' if their hot water streams were comingled.

On this basis, Wytch Farm is overwhelmingly the field which could produce the most energy in the UK.

The Wytch farm field is mainly offshore, to the South of Bournemouth, but accessed through onshore wells. The reservoir temperature is 65 degrees C.

The field is in a part of the UK which has the same environmental protections as a national park, as a designated Area of Outstanding Natural

Beauty. This means it is unlikely planning permission would be agreed for new infrastructure, such as pipelines to carry heat to nearby large towns to be used for heating.

“If the field was in a less protected area, much more could be done with the heat.”

The value of the energy in hot water produced today at Wytch Farm could be equivalent to a third of the total energy produced in the hydrocarbons, if (for example) the water replaced heat from burning the gas in a power station, he calculates.

Still, the value of heat is much less than the value of the hydrocarbons. This means that many technologies which are viable in producing hydrocarbons may be too expensive to use on geothermal wells. And geothermal projects need very careful consideration on costs, otherwise the initial drilling costs will never be recovered.

Ultimately, Dr Westaway calculates that Wytch Farm could generate a thermal power output of 90 MW.

The second most viable fields in the UK for geothermal purposes, Stockbridge and Welton, could yield thermal power outputs of 638 and 251 KW.

Legal complexity

The UK Oil and Gas Authority (OGA) does not have any system in its regulatory framework for hydrocarbon wells being used for geothermal, either alongside hydrocarbons or repurposed for geothermal after hydrocarbons are depleted.

It does not have a simple mechanism for a hydrocarbon operator to pass ownership of the well to a geothermal operator.

“The OGA expects every well to ultimately be decommissioned and expects the owners to commit to doing that. If the liability of decommissioning is transferred to some new operator, there needs to be some framework which ensures they [actually do it],” Dr Westaway said.

Another reason why OGA is reluctant to allow repurposing of wells is concerns raised by environmentalists that conventional hydrocarbon wells might be converted to shale gas wells, and so create a UK shale gas industry by stealth.

The Netherlands has a more favourable regulatory environment for geothermal including a government scheme to provide insurance for drilling risks, he said.

In the Netherlands it is possible to get a license for geothermal drilling in a certain area. In the UK, you would need to take out an exploration license, and then apply for an oil and gas petroleum production license, in order to have exclusive access to an area for geothermal use.

All subsurface data in the Netherlands is publicly available. In the UK the British Geological Survey makes databases for its internal use, but does not provide access to anyone else, he said. If the data was made available, it would be easier to find targets for geothermal wells.

Professor Gluyas added that the Netherlands has a requirement that oil and gas operators evaluate any failed oil wells for geothermal potential.

CeraPhi Energy – a single well model

CeraPhi Energy of Great Yarmouth, UK, has developed a geothermal technology which requires only one well

CeraPhi Energy of Great Yarmouth, UK, licenses a geothermal well design it has developed which uses a single vertical well. So the water is both injected and produced in the same well (but through different piping inside it). This means there is lower exploration risk.

This system can be retrofitted into an existing oil and gas well, to turn it into a geothermal well, said Andy Wood, subsurface manager, CeraPhi.

The more common geothermal configuration is to have two wells, an injection well and a production well, with water flowing through the reservoir between the two wells, being heated as it does so.

Misconceptions of geothermal

There are many misconceptions of geothermal energy, Mr Wood said.

Many people believe that projects need to be close to volcanoes (as in Iceland). But anywhere in (for example) the UK is capable of having geothermal wells which could create enough heat for district heating (buildings and water), and much of the UK can hold geothermal wells which could be used to generate electricity.

Many people are concerned that the pumping of large volumes of water into the subsurface can cause small earthquakes. This did happen in Basel, Switzerland, in 2006, when an earthquake with a magnitude of 3.4 was triggered by water being injected at high pressure into the ground. But in reality, geothermal projects do not necessarily need hydraulic fracturing, or cooling the subsurface with injection of water, which is what caused the Switzerland earthquake.

There is a perception that the wells need to be very deep, but actually it has worked with wells of "very modest depth," such as with the Zambia example also presented in the webinar (see below).

There is a perception that subsurface uncertainty adds to the risks. But this is only a factor if you go for a two well layout, one well for injection and one for production, and the communication between the wells is not what was expected, due to a failure of reservoir characterisation. The CeraPhi design (described above) avoids this.

There is also a perception that geothermal energy is very expensive. Mr Wood believes that geothermal energy is already "competitively priced" with today's renewable energy, and the costs will reduce further over time.

The biggest risks are probably in drilling, but the enormous amount of expertise in the oil and gas industry can mitigate this, he said.

It is interesting to consider how much of all energy consumption goes on heating, including heating buildings and domestic water, and heating industrial processes – including drying, cooking, curing, washing, sterilising, distilling, brewing.

In a decarbonised society, it would make far more sense to use heat from the earth for this, rather than generate renewable electricity, he said. And unlike renewables, geothermal energy produces continuously.

The biggest environmental impact of the geothermal project is probably the "well pad," the area of land where you drill, typically 100m x 100m, holding the drilling rig, equipment and vehicles. But after the drilling is done, this can all be replaced by a well head and production system, small enough to conceal within a domestic building.

Oil companies could also plan an oil well which would later be used for geothermal production after depletion of the oil reservoir. Or they could have geothermal energy from the start, producing hot water from a side-track well.

Kalahari GeoEnergy – building a business in Zambia.

Kalahari GeoEnergy plans a commercial business in 2022 in Zambia, with 2 production wells 500m deep, expecting to produce 4.5 MW of geothermal energy, following the drilling of 21 experimental wells

Kalahari GeoEnergy plans to have two wells in commercial production in 2022 in Zambia, producing 4.5MW of power in total.

The company was founded by Peter Vivian Neal as an independent sustainable power producer in Zambia. Mr Vivian Neal is a former mining explorer.

The company is currently doing a feasibility studies. It has already drilled 21 wells, 6,100m in total (so average 290m each). These are "slim" wells with 3 inch internal diameter.

The best two of these wells are proven to be able to produce hot water with 500 KW of heat. They will be used for a demonstration plant.

In the subsurface, the fluids move upwards from 10km depth through permeable rock, with sedimentary basins forming a caprock above. The wells are drilled through this caprock. There is some additional heat from radioactive granite intrusions. So there may be fluids at above 150 degrees C, at around 1km depth, Mr Vivian Neal said.

The highest temperatures encountered so far are 112 degrees C, at 200m depth.

Mr Vivian Neal believes that 120 degrees may be a good minimum temperature for a commercially viable project.

The demonstration will also show how the heat can be used for growing plants and fish farming.

Some helium is also produced, comprising 2 per cent of produced fluids, coming from deep in the earth's mantle.

Zambia

Today Zambia gets 70 per cent of its primary energy from wood and charcoal, and in chopping down this wood, it has the second highest rate of deforestation in the world (after Brazil), Mr Vivian Neal said. 96 per cent

of the rural population has no access to electricity, and about the same number have no sanitation (drinking water /sewage disposal).

There has been some hydrocarbon exploration, but it found that the basins had been too hot, so outside the oil window. There is some interest in solar energy, but no commercially sized storage facilities, or grid management system, Mr Vivian Neal said.

However Zambia has less restrictive regulations than the UK on geothermal projects. It does not have any regulatory restrictions on “independent power producers,” you just need to find a creditworthy customer, he said.

“I do think perseverance and enthusiasm are the drivers which will make this work,” he said.