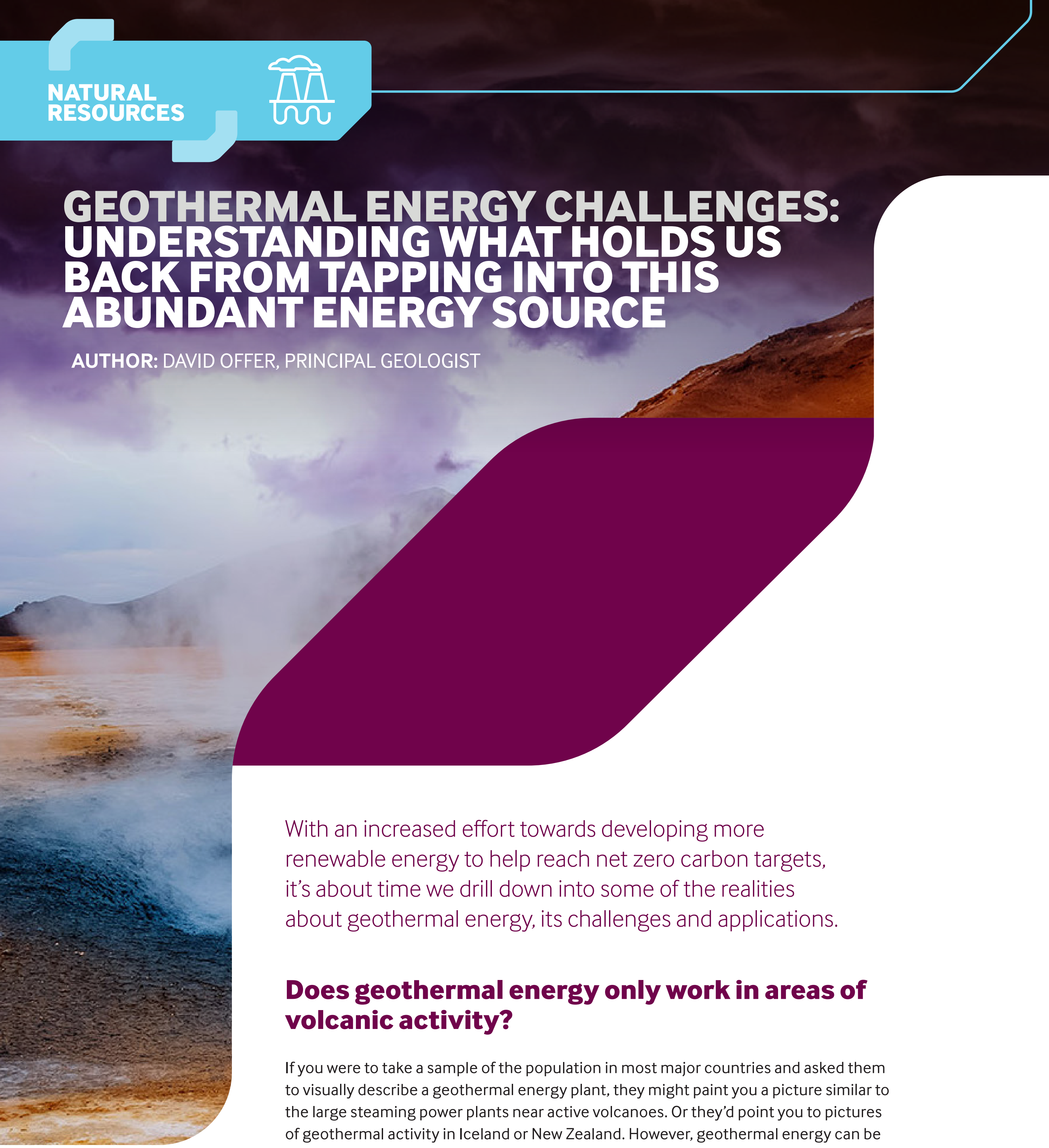

NATURAL RESOURCES

GEOTHERMAL ENERGY CHALLENGES: UNDERSTANDING WHAT HOLDS US BACK FROM TAPPING INTO THIS ABUNDANT ENERGY SOURCE

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With an increased effort towards developing more renewable energy to help reach net zero carbon targets, it's about time we drill down into some of the realities about geothermal energy, its challenges and applications.

Does geothermal energy only work in areas of volcanic activity?

If you were to take a sample of the population in most major countries and asked them to visually describe a geothermal energy plant, they might paint you a picture similar to the large steaming power plants near active volcanoes. Or they'd point you to pictures of geothermal activity in Iceland or New Zealand. However, geothermal energy can be found in many parts of the world, not associated with volcanic activity.

The term **geothermal energy** refers to any heat derived from the ground, whether that's a few metres (shallow geothermal) or a few hundred kilometres (deep geothermal) below the surface.Let's understand a little more about each of these concepts.

MAKING COMPLEX EASY

Shallow geothermal energy

Shallow geothermal energy, or low-grade ground-source energy, comes from heat absorbed from the sun by the earth. Developing shallow geothermal energy normally requires a heat pump to help increase temperatures to levels we can use to heat buildings. One example of shallow geothermal energy in the UK is the reuse of the country's historical mine sites (that have long since been disused). Mines used to require constant draining of wastewater to avoid contamination of rivers and potable aquifers. This 'waste' water is warm and having absorbed heat from the surrounding rocks, is now ready for repurposing to warm buildings. It's estimated that ¼ of the UK's population **lives above abandoned mines**. These mines have the potential to generate 2.2 million GWh of heat which could keep approximately 18 million people warm and cosy with no associated greenhouse emissions.

Deep geothermal energy

Deep geothermal energy **is defined by the UK government** as sourced from more than 500m depth. The heat is generated partly from primordial heat left over from when the Earth was formed, and partly from heat generated from the normal decay of naturally occurring radioactive minerals. There are many forms of deep geothermal energy, some that produce water that is hot enough for heating and others that produce steam, which can be used to generate electricity and heat.

The UK has been using deep geothermal energy since the times of the Roman occupation, in areas such as Bath in Somerset where the water naturally flows to the surface at approximately 45oC. More recently (since 1986) heat and with the addition of biomass heating, electric power has also been produced in Southampton. This has helped to save 10,000 metric tonnes of CO2 emissions from the port and surrounding municipal buildings every year.

More excitingly, in 2020 steam was produced directly from deep well bores at the United Downs Industrial Estate, near Redruth in Cornwall. A power plant is currently being constructed that will generate 65 MW of electrical power, with hot water being used to supply heat to a rum distillery and the local community.

Geothermal energy is being explored across the UK and in many other parts of the world. As our understanding of the related/required geology and new technologies to extract heat evolve, the prospects for geothermal are definitely increasing.

Kamojang Geothermal Power Plant, Garut, West Java / Indonesia

If the upfront cost of geothermal energy is high, does that make it unfeasible?

To answer this question, let's begin by defining the risks clearly. In a geothermal energy project, before any plans for drilling wells or constructing pipelines are made and before a plant is built, analysis is first carried out to understand the potential of heat generated from specific locations. In other words, the theoretical heat potential and the flow rate that exists deep underground needs to be proven. In many cases, this will require a well, which is an expensive upfront cost.

Early risks will naturally be closely followed by early costs. For example, the US Department of Energy (UoE) estimates that **the initial cost for the field and power plant could be around $2500 per kW installed**. While that is not something to scoff at, it's important to remember that the return on that investment could be much faster than you might expect.

So where would the cost savings be? Carbon taxes would be the first and most obvious example associated with a new geothermal energy plant. Exploration costs could also be reduced by increasing the publicly available geological data, (although this often requires mandatory regulatory compliance). Access to old mine records or previously drilled wells would help to further reduce assessment costs, streamline the permitting process and regulatory compliance. With robust cost modelling, a geothermal project can be planned in such a way as to reduce upfront spend, mitigate and, in some cases minimise the risk of well exploration. Subsidies from governments, incentives that include risk insurance, shared costs of drilling between public and private sectors are just some of the other ways to mitigate initial capital risk.

Reusing existing infrastructure can further decrease both risks and costs. By repurposing existing heat, such as re-using disused mine waters (already produced to mitigate against potential water resource pollution) can be an effective way to heat spaces. A great example of this is the **Seaham Garden Village** in County Durham, UK. The other return on investment is, of course, the benefits in supply. To put some numbers in perspective, typical coal power plants have average availability of 75% (i.e. producing energy more than 75% of the time) or thereabouts. In comparison, geothermal plants are closer to 90% and are available 24 hours a day, 365 days a year!

Are investors really interested in geothermal energy projects today?

If you were to turn the clock back even 20 years ago, investors might have been sceptical about setting aside capital and resources into geothermal projects. Geothermal energy at the time was seen as a niche, geographically limited energy source that could not be scaled easily and therefore only likely to produce low returns on investment.

However, public awareness of climate change and the requirement for a continuous renewable energy source, (especially for areas that are hard to decarbonise such as space heating for domestic housing), has created greater market awareness and reignited an interest in geothermal investment.

The scalability and profitability of geothermal projects is now being reassessed with the advance of hydrocarbon industry technology. Horizontal drilling or HPHT (High Pressure and High Temperature technology) is one such example, as it can be used to drill deeper, and access hotter geothermal fluids. This would make previously ignored locations, geothermally accessible and worthy of investment. Also, our geological understanding in several areas has increased, ironically brought on by the shale boom, a facet of the hydrocarbon industry that has been historically controversial. It may still hold some of the answers to support de-risking geothermal project investment.

There are other new technologies also being constantly developed, many of which are in advanced feasibility test stages, leading to increased investment from large multinational companies. Technologies such as:

- Closed loop systems which allow the circulation of fluids with a higher heat absorption capacity rather than water, enabling the use of geothermal energy in areas previously considered as unfavourable.
- Repurposing of heat as a valuable resource, something that has previously been seen as a waste product. This is particularly interesting when combined with heat pump technology which allows low temperature extracted fluids to be increased to temperatures that can comfortably heat homes and offices.

A great example of this and the potential scalability within the UK, is the repurposing of disused mine discharge waters as described earlier.

The takeaway message here is one of technology advances, new thinking and scalability, all factors that tick a lot of ESG requirements, leading to a more buoyant investor potential. The numbers speak for themselves. In 2020, global geothermal investments **increased six-fold from the year before, exceeding $675 million**.

How could one negotiate the regulatory nightmare of geothermal energy exploration?

Exploitation of our natural resources is generally heavily regulated, and rightly so. To protect people and environment these regulations must be strictly enforced. Many regulations and permits differ from country to country, and in many cases, between regions in a single country. This can make the process complex leading to confusion, slowing down project delivery and in some cases cancelling a project all together.

What is needed here is clearly a process built on deep expertise, that makes the complexities of individual regulatory requirements easier to manage. With a 40-year history of successful projects completed within the energy sector, across both the **oil and gas** industry as well as **renewables**, we are best-placed to have these regulatory conversations with the right stakeholders. Our commercial and technical expertise can be brought to the fore against a geothermal project's unique permitting and regulatory compliance objectives. We understand subsurface geology and the field development planning that would go into a geothermal energy lifecycle and how to negotiate with challenging stakeholders.

Could geothermal power plants take up a lot of area?

Geothermal energy has the smallest land footprint of any comparable energy source in the world based on land use per gigawatt hours, making it perfect for urban areas, where instant constant dispatchable heat or power is required. As with everything else, size is relative to their heat and electricity supply requirements.

A geothermal energy plant in Indonesia

Consider the following scenario, as described by the **US Department of Energy (DoE)**. Let's assume you want to produce a single gigawatt hour (GWh) or one million kilowatts of energy for a single hour. A typical geothermal power plant would use the equivalent of 1,046 sq. km (404 sq.m) of land.

To produce the same GWh, wind energy would need 3,458 sq. km (3237 sq. m). A solar photovoltaic plant requires 8,384 sq. km (sq. m) while coal plants would use about 9,433 sq. km (3,642 sq. m).

What about the risk of earthquakes? Do they outweigh the benefits of geothermal energy?

One of the historic and oft-repeated challenges of geothermal energy is that it could trigger seismic events such as earthquakes. However, recent research by Caltech suggests that geothermal energy development could reduce stress and aftershocks and prevent earthquakes of a larger magnitude in the same area in the future.

Caltech's research is based upon the 7.1 magnitude earthquake that struck Ridgecrest, California, on 5 July 2019. The Coso geothermal field was located within 10km of the epicentre, yet, **seismologists and researchers from Caltech** noted that of the thousands of aftershocks recorded across the region, none were seen in the geothermal field. They concluded that the regional operations related to geothermal energy production over the last 30 years could have relieved the stress and lowered the risk of a more powerful earthquake.

Using a technique called synthetic aperture radar (SAR) interferometry, seismologists learnt that the Coso field had sunk by tens of centimetres since this technique was first deployed. This contraction could have relieved tensions underground. In other words, the smaller magnitude (approximately four on the Richter scale) tremors that could have been recorded by fluid injections may have prevented the region from experiencing larger aftershocks.

There is always some risk of earthquakes with the start of any geothermal activity and most modern developments employ a system of seismic monitoring to assess risk. However, the Caltech study is insightful. If we learn to suppress seismicity in a region over time, the risks of geothermal exploration warrant a second check. Further research in this area is both required and welcomed.

These are important questions and it's equally important that we tackle them head-on and carefully. Today, geothermal exploration is poised for a seismic shift both in how it's perceived as well as how it is project managed. The time for us to be taking it more seriously is well overdue, but there's no time like the present to begin to have the right conversations with the right stakeholders, and we would certainly be able to facilitate them.

RPS has a 40-year history of successful project delivery **across the energy sector**, in both oil and gas and renewables. Built on our deep commercial and technical expertise, we understand subsurface geology and field development planning and consenting/permitting required to successfully deliver a geothermal energy project.