**So, here’s our planet as most of us are used to seeing it. Not rotating next to me above my desk, obviously, but you get what I mean.**

**What we don’t see all that often is the stuff going on inside the planet. The bit WE all live on is this tiny crust on the outside, and although it can be as deep as forty kilometres in places, it’s still barely noticeable in the big scheme of things. Underneath the crust there’s nearly three thousand kilometres of mantle, which is made up of silicate rock and minerals. It’s still a solid layer but it’s bloody hot. The bit just below the crust can reach almost 900 degrees Celsius and the deeper it goes the hotter it gets, until down here it’s well over two thousand degrees C.**

**Then you’ve got about another two thousand two hundred kilometres of outer core made up mainly of molten iron at anything between three thousand and three thousand eight hundred degrees Celsius.**

**And right in the centre there’s this solid iron core which is hotter than the surface of the sun, at six thousand degrees C. And why is it solid when it’s at a temperature that’s far higher than the melting point of iron? Well it’s pressure isn’t it. There’s so much pressure from the layers surrounding it that the molecules in the core literally don’t have the room to move around in a liquidy kind of a way, so they stay firmly compressed together as a solid.**

**Anyway, I digress. The point is, there is a lot of heat energy captured inside our planet. Its been there for billions of years and it’ll most likely be there for a few billion more.**

**And that heat gets into our skinny 40 kilometres of crust as well. The bit we stand on is the same temperature as the air around us, but it gets warmer and warmer the deeper you get until you reach the base of the crust which is at the same temperature as the mantle it’s touching – nearly nine hundred degrees Celsius. So, there’s a lot of heat available just below the entire surface of the planet. It’s what we all know as Geothermal Energy and in theory we ought to be able to tap into it to provide a virtually limitless supply of heat and power for the entire planet with almost zero carbon dioxide emissions.**

**So why haven’t we done that then?**

**Hello and welcome to Just Have a Think**

**The golden poster child of Geothermal Energy is of course Iceland.**

**They’re a long way north, only about 250 kilometres away from the Arctic Circle with typical air temperatures that are often only just above freezing, and yet they get much of their electricity and heat from Geothermal Energy.**

**So how come Iceland have been so successful compared to most other parts of the world?**

**Well that skinny crust I mentioned earlier is broken up into 12 tectonic plates that can move more or less independently of one another. Anyone living on a fault line will know what it feels like when two adjoining plates push against each other until something gives. You get an earthquake. Iceland straddles the Eurasian and North American tectonic plates. Those two plates are actually moving slowly apart and that’s allowing huge amounts of heat from the mantle below to escape into the upper regions of the crust under Iceland’s land mass. Most parts of the earth’s crust get about thirty-five degrees Celsius hotter for every kilometre you go down, but if go down a kilometre below Iceland you hit temperatures of about 200 degrees C. That powers the famous Icelandic volcanoes and the hot steaming geysers, and it also provides geothermal heat very close to the surface that can be so easily tapped into that Iceland has really got more than it needs. They’ve built themselves seven geothermal power stations to generate electricity from the energy underground. They still do it by driving a turbine to rotate an electrical generator, just like a traditional fossil fuel or nuclear power plant, but they don’t need to burn coal or gas or fire neutrons at radioactive material to provide the heat to convert water into steam to turn the turbine. They use a fairly straightforward system called Flash Steam. A bore hole is drilled about three kilometres deep and cold water is sent down into it. The water gets super-heated by the geothermal temperatures and expands into steam which then comes hurtling back up the other side to drive the turbine. It doesn’t rely on weather conditions, it’s always on, so it can be used for constant and predictable baseload power and it produces negligible CO2 emissions. All that cheap electricity has allowed Iceland to develop a thriving aluminium industry that now accounts for about 40% of the islands exports turning Iceland into one of Europe’s richest nations.**

**They also pump geothermally heated water all over the island in a network of heavily insulated pipes to provide district heating for homes and businesses and greenhouses that supply a rich variety of healthy food for the population. They’ve got so much spare hot water that they can afford to heat outdoor swimming pools all year round and even pump some of it into freezing lakes to keep bits of it warm enough for the fish to survive through the coldest months of winter!**

**But on a global scale Geothermal Energy only accounts for about one percent of total electricity capacity. So why aren’t we embracing this seemingly inexhaustible carbon-free natural resource more enthusiastically?**

**Well, the answer is that some countries ARE going for it, but most of them are located on or near to the fault lines where tectonic plates butt up against each other. Geothermal energy is easy to access in those places because it’s literally bubbling up to the surface, so you don’t have to try very hard to scoop it up.**

**Of the twenty or so countries currently generating geothermal power, the United States is the largest, producing about 2.5 gigawatts worth in 2019, with 725 megawatts coming from the world’s largest geothermal plant at the Geysers located in the Mayacamas Mountains about 30 miles north of Santa Rosa in California.**

**Then comes Indonesia, The Philippines, Turkey, New Zealand, Mexico, Kenya, Italy and Japan, all of whom generated more geothermal energy in 2019 than Iceland.**

**In 2018 The International Energy Agency predicted growth of as much as 4.5 gigawatts in geothermal energy production in the five years from then until 2023, which would have equated to about 5 percent growth per year.**

**But their latest tracking report, released in June 2020, found that growth has only been about three percent per year and that geothermal energy is not currently on track to reach the Sustainable Development Scenario, or SDS, which the IEA published as an outline of how to meet the energy-related components of the United Nations Sustainable Development Goals.**

**To contribute to hitting those goals alongside other renewables like solar, wind and hydropower, the IEA say that geothermal energy production would need to grow by more like ten percent per year between now and 2030.**

**But to reach that target, geothermal energy needs to be adopted on a truly global basis, which means finding ways of tapping into our planets energy in all the other countries of the world that aren’t fortunate enough to be located above fault lines.**

**A system called Binary power is an alternative to the more traditional Flash Steam system. In a binary system hot water from a naturally occurring underground aquifer is pumped up into a heat exchanger where it gives up its heat to a secondary fluid that has a much lower boiling point. The secondary fluid then turns to vapor to drive the turbine. The beauty of this system is that it only needs the water to be at about 100 degrees Celsius so in theory you don’t need to drill so deeply to hit the right temperature. And that makes it a system that could be used by many more countries regardless of their location.**

**But you still need to get at the hot water, however deep it may be, and you still need to ensure that the supply doesn’t run out**

**And that brings us to the increasingly contentious subject of Enhanced Geothermal Systems, or EGS.**

**The United States Office of Energy Efficiency and Renewable Energy offers this neatly sanitized explanation of how EGS works**

**“The EGS concept is to extract heat by creating a subsurface fracture system to which water can be added through injection wells.”**

**“Rocks are permeable due to minute fractures and pore spaces between mineral grains. Injected water is heated by contact with the rock and returns to the surface through production wells, as in naturally occurring hydrothermal systems. EGS are reservoirs created to improve the economics of resources without adequate water and/or permeability.”**

**Does that remind you of anything?**

**Sounds a bit like fracking doesn’t it? And although the liquid injected down into the fractures is just water and not the nasty concoction of chemicals and abrasives that get shoved down the fracking lines, and even though it’s at a much lower pressure than hydraulic fracking, it is still designed to open up natural rock fractures to create underground reservoirs of water, and there are plenty of geologists and geophysicists who think that increases the risk of earthquakes in those areas.**

**EGS has been linked to a 5.5 magnitude earthquake in Pohang, South Korea in 2017, causing seventy-five million US dollars of damage.**

**In an interview for this 2020 article at Yale’s Climate Connections website, Joern Ole Kaven, a research physicist with the US Geological Survey explained**

**“These faults are going to slip eventually, but EGS can certainly speed up the clock”**

**But of course, all the other environmental, climate and energy security benefits of geothermal are extremely compelling. According to this 2017 study, The energy reserves in the upper 10 km of the earth's crust are approximately 1.3 × 1027 J, which probably means as little to you as it does to me, but the study says those reserves could potentially supply all our global energy needs for approximately 217 million years.**

**So the motivation to get these EGS systems set up around the world is very high. As the director of the Geothermal Resources Council, Will Pettit, puts it**

**“You can effectively put a power plant anywhere. All you have to do is drill deep enough and you will find hot rock.”**

**So maybe with the right regulations in place, we would still have a workable solution right?**

**Well possibly, but even if that were the case, there remain some fairly big technical and economic obstacles in the way of geothermal progress.**

**Drilling is very expensive and there’s no guarantee of success when the pressurised water starts getting pumped in. You might not open enough decent fractures to make the project economically viable, in which case you’d have wasted a lot of time and money. Try selling that concept at an investor pitch presentation and you’ll find your audience thinning out quite quickly.**

**There are also minerals like quartz and limestone in the rock formations which are already saturated into existing aquifers or can contaminate new water being pumped in. These sorts of minerals can cause scaling and fouling that can lead to failures in components like pumps and heat exchangers. That causes expensive delays which again hits the economic viability of a project.**

**So as the prices of solar panels and energy storage have tumbled over the past decade, so large corporate investors have found themselves much more inclined to put their money into that technology instead.**

**Nevertheless, at the COP21 climate conference In Paris in 2015, the IEAs sister organisation, the International Renewable Energy Agency, or IRENA, was instrumental in forming The Global Geothermal Alliance, or GGA.**

**GGA is a coalition for action to increase the use of geothermal energy, both in power generation and direct use of heat, calling on governments, business and other stakeholders to support investment in geothermal energy’s potential. The goal is a five-fold growth in installed capacity for geothermal power generation and more than two-fold growth in geothermal heating by 2030. There are currently 46 member states from all over the world and the alliance aims to support those countries with five key strategies –**

**1, Foster an enabling environment to attract investments in geothermal energy;**

**2 Provide customised support to regions and countries with geothermal market potential;**

**3 Facilitate the exchange of insights and experience among key stakeholders in the geothermal energy value chain;**

**4. Identify and promote models for sharing and mitigating risks, in order to attract private investment and integrate geothermal facilities into energy markets.**

**5. Help to streamline outreach efforts to give geothermal energy greater visibility in the global energy and climate debates.**

**Just like all other renewable energy sources, Geothermal energy will be a major element of many of the Nationally Determined Contributions that participating nations are required to present at COP 26 in late 2021.**

**If the safety of the systems can be properly assessed and regulated, and some of the technical challenges can be overcome, then perhaps this ancient energy source, first tapped into by the Romans in their hot water spas, could become a major player in our 21st Century transition to a more sustainable, carbon neutral future.**

**That’s it for this week, but before I go I just want to let you know about an initiative called The Google.org Impact Challenge on Climate. It’s a ten million Euro fund to support bold ideas that aim to use technology to accelerate Europe’s progress toward a greener, more resilient future. Selected organisations may receive up to two million Euros in funding and possible customised post-grant support from the Google for Startups Accelerator to help bring their ideas to life.**

**They’re looking for ideas that address topics like increased access to or use of renewable energy, decarbonisation of transportation, improvements to air quality, natural resource planning and protection, and circular economy and design.**

**Applications are open now, but the closing date is November 6th, so if you’ve got a bright new idea that needs some funding then go over to the address below to have a look at the entry criteria. And I’ll leave a clickable link in the description box below as well.**

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**As always, thanks very much for watching, have a great week, and remember to Just Have a Think.
See you next week**