Gemini

Geothermal Energy Momentum

Podcast transcript

Geothermal Energy, Dr Aoife Braiden in conversation with Dr Sarah Blake

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Aoife Braiden: This week I'm talking to Dr Sarah Blake, Senior Geologist with Geological Survey Ireland and leader of their Geothermal Energy Programme. She's also recently been dubbed “Queen of the Underground”. So welcome, Sarah.

Sarah Blake: Thanks Aoife, thanks for having me. I'm not sure about that interesting moniker. I'm not sure I deserve that!

AB: Before we get into details about your work, maybe you can tell us a little bit about how you got into geoscience, and geothermal energy in particular.

SB: OK, well, I sort of fell into a geology degree once I left school. I was always interested in science and really enjoyed geology. Once I got to college, I really enjoyed the applied nature or the applied side of things. So I ended up doing a master's in hydrogeology, which is the study of how water moves through rocks - groundwater. And from there, I just became really interested in the possibilities of using groundwater as a medium to extract heat. And that's how I ended up looking into geothermal. I did a PhD on Irish thermal springs. Yes, we have them!

And that's led me to my current role, I guess.

AB: And so maybe tell us a little bit about the Geological Survey programme that you lead there. What does that do?

SB: Geological Survey Ireland is the national earth science agency. We collate and store and make publicly available high quality data on anything to do with the subsurface. So that could be bedrock maps, groundwater maps, aquifer maps. We also do seabed mapping.

That's a major part of our work - and applications of that data to societal problems. And that's really where geothermal energy comes in. So the geothermal programme, which I lead, this is really our efforts to kind of better understand the geothermal potential of Ireland.

So what do these resources look like? How could they be used?
And also, we're trying to quantify the potential. So how much energy is there available to us? That's really what we're trying to do in a nutshell.

AB: Maybe you could give us an idea of how geothermal energy works. Most people here would think that, you know, we need a volcano. They think about Iceland or New Zealand or somewhere where we have very hot rocks available at the surface. How we get heat out of the ground?

SB: Okay, so you kind of said it there. Geothermal energy is the heat beneath our feet. The centre of the planet is extremely hot. It's actually as hot as the surface of the sun. The core of the earth is over 5,000 degrees Celsius. The heat comes from a little bit of the heat left over from the formation of the planet.

And then some of the heat is generated all the time through naturally occurring radioactive decay of certain materials in the mantle. That's the next layer out from the core. And the crust, which is the rocky bit at the edge of the planet where we live.

We also get a lot of heat from the sun. This is heat that comes and hits the surface of the planet. And it also heats up and is stored in the soil and the shallow bedrock.

Those three sources of heat combine to give us geothermal energy. The heat is constantly flowing from the centre of the planet out to the edges to the crust and in certain places around the world, the heat is flowing faster.

These places are usually where you have tectonic plates meeting or separating, where you have volcanic activity, as you mentioned: places like Iceland and New Zealand. In these areas, you can see with your eyes the heat leaving the centre of the planet. So, happily, since we as humans developed drilling technology a couple of hundred years ago, we're now able to drill into the earth anywhere on the globe, more or less.

And we're able to access that deep heat. We also have the technology to extract the heat and use it and get it into our buildings and into our pipes and our systems. It can be used for heating and used for cooling. If you're using very low temperature geothermal heat, you can also use it for cooling.

And it can also be used for electricity production - now, the electricity production is easier in places like Iceland and New Zealand and those volcanic regions. However, it can be done in other places, as long as you can drill deep enough to get the hot, really high temperatures.

AB: Okay, it's just to pick up on something you said there that we've been using it for a few hundred years - this is not new technology. This is not something that's very new and I suppose, risky and innovative.

SB: No, I think the new and innovative stuff is really how do we get geothermal energy to market and how do we make it economical for people? But that's another discussion. But yes, in terms of the technology itself, you know, humans have been interacting with and using geothermal energy for millennia actually. Even the Romans knew all about geothermal energy. So yeah, that's sort of using the thermal energy that's just available to you.

But then in terms of actually having to go and drill to get the energy, we can kind of see that starting to happen in the 19th century. This was when drilling technology evolved. By the late 19th century, I think we had our first geothermal district heating system in the United States.

And then in the early 20th century, in 1904, we had our first geothermal electricity project. And the first, that was in Italy, in a place called Larderello. So yes, the use of geothermal energy for, in a sort of a modern sense, that's been happening for over 100 years now.

AB: So, say in Ireland, if we don't target electricity, but we're more interested maybe in the heating side, what kind of temperatures are we targeting and how deep do we need to get to get those temperatures?

SB: Okay, so geothermal for heating, even deep geothermal energy for heating, we should absolutely be doing that in Ireland. Just to give you an example, in France, in the Paris basin, they're using geothermal energy from a deep aquifer. So this aquifer or reservoir, it's about two kilometres below the surface. And out of that reservoir, they're getting geothermal heat for about a quarter of a million homes in the Paris basin. I'm using that as an example, because that is not a volcanic area. That is not an area with elevated heat flow. In that sense, it's broadly comparable to the Irish geothermal setting. And it shows that we don't need to be Iceland. We don't need to have volcanoes to be able to use geothermal energy in such a way.

The kind of temperatures that we'd need for geothermal district heating, we'd probably need to be getting around 60 or 70 degrees at the surface. There would be a natural bit of heat loss as you pump the water up through the system, so we'd want to go a bit higher than that in terms of our reservoir that we're tapping.

Based on what we understand, we think we're going to have to go about two kilometres into the subsurface in order to get those temperatures. But I think it's very possible that we'll find that in Ireland.

AB: So this is where the geology and geoscience and hydrogeology piece comes in: it's about figuring out what's underground so that then the engineers can take it and do their job on the surface, I guess.

SB: Exactly. There's a lot of different disciplines involved. At this exploratory stage we'd be working with structural geologists and hydrogeologists and trying to figure out where are these cracks and fractures concentrated. To do this, we'd use a couple of different methods. We can use geophysics - that'll give us like an x-ray or a CAT scan. It's kind of a non-invasive way of looking into the subsurface. We can also do drilling.

And then you collect really detailed samples all the way down your drill hole. And then from all these different strands of information, we can piece together and come up with a really good 3D concept or a conceptual model of what's going on beneath the ground. At that point, then we'd bring in people - a lot of skills actually would come across from the oil and gas industry, people like reservoir engineers. These are the people that really understand and model how the fluid is going to flow through the system. And then, of course, you've got your drilling and your drilling engineers and your well engineers, the people who design the boreholes and the infrastructure that's going to actually suck that water out of the ground and re-inject it.

So yeah, that's all on the subsurface. That's even before you talk to your buildings engineers, the people building the district heating systems. Lots of really different disciplines involved.

AB: Zurich recently hosted a large geothermal conference and there were lots of presentations and discussion about large scale geothermal systems and geological heat storage and the different types of applications. Can you maybe give some examples of how we might use geothermal heating and cooling in Ireland?

SB: Yes, absolutely. I suppose we go in order from small to large. The kind of smaller scale use of geothermal would be for housing. So, once off housing or even a housing estate or an apartment block, these would be able to use shallow geothermal energy with a heat pump to provide their heating and cooling needs. For the shallow geothermal energy, commonly we're talking between zero and two hundred metres below the ground. It could be something like a trench collector, which looks like a slinky loop and that's buried very shallow, maybe two metres down. Or you could have a series of boreholes that are drilled to maybe 200 metres. So, yeah, you could do this for a single house or a housing estate.

There's also something called a shared collector array, which is a very interesting way of doing it, actually. It's where you might have a housing estate. And if you think under the car parks or under the green spaces, you could have a series of boreholes so that all of the houses around the boreholes, they would share that collector. And then in each house, they have a mini heat pump. So each house is able to control their own heating, should they wish to. But then that everybody is sharing this one collector. That's kind of a scaling up of the single domestic system.

AB: Sorry, just for those ones then, something like that is you're bringing in some base load heat into the network or into the building, into the homes. And then, if necessary, you can top them up. So that's why you might have a very shallow system that's only a few metres deep. It might not be very warm, but it's like putting warm water into your kettle and then boiling your kettle. You're just adding the extra bit on top.

SB: Yeah, that's what the heat pump is for. It's no different in that regard to any other heat pump. Basically, you take the free heat or the ambient heat from the environment. Whether that's from the air or from the ground or from water, and then you boost that with electricity through your heat pump. The great thing about geothermal heat pumps is they are the most efficient heat pumps out there. So, for every unit of electricity that you use, you're going to get about four and a half units of heat if you use a geothermal source. It is really, really efficient and you save a lot of electricity compared to other heat pumps and other methods of heating. Also, you can have cooling because, as you mentioned, the shallow subsurface is not that hot. It's maybe 10 to 12 degrees, maybe up to 15 if you're lucky.

However, the benefit of it really is that it's a constant temperature throughout the year because it's not dependent on weather or seasons. You know, there's no fluctuation there, you can depend on that constant input of heat.

And then also you can increase the efficiency of your system by having a cooling element to it as well. If you think in the summer your building is hot, you can take heat

from your building and actually store it underground. This concept is geothermal storage and it'll just heat up the rock slightly below your building or whatever. And then that heat will stay there. So it's quite efficient at storing the heat. And then in the winter when you need it, you can abstract that heat and use it to heat your building.

Things like this really enhance the efficiency of geothermal systems in general when you're talking about heat pump applications. So, yes, so we've got heating and cooling.

I guess we've spoken about the sort of residential side. You can really then just keep scaling up. So whatever your building requires in terms of space heating, if you need more heat from the ground, you just put a few more boreholes onto your array. A good example is Ikea, actually, in Dublin, where a lot of people will have visited, I'm sure. The first car park, the first outdoor car park as you come into Ikea in Dublin, it's got an array of boreholes underneath it that's providing most of the building's heating requirements.

AB: I'll look at it in a whole new way the next time.

SB: Yes, you wouldn't even know it's there. That's another benefit of the geothermal: that it's not obtrusive that way. You don't see it.

The installations themselves, they have a really long lifespan. Normally we think on a 50-year lifespan, and it could be as much as 100 years that these things will just be there quietly, not bothering you underneath the ground. And they require very little maintenance as well. So I guess the drawback to all of this is that you need to have that high initial investment because drilling boreholes, even shallow ones, it's an expensive endeavour.

AB: I guess this is partly why we don't have a lot of these yet in Ireland - that there's been cheaper options up until now? Or options that we were maybe less bothered about the security. It's become a bigger issue for us now.

SB: Yeah... yeah, it is. And I think the geothermal heat pumps -it's hard for us to tell because there's no central registry of information - we don't actually know how many systems are out there. But best guess, best estimate, is that it's just 3% of the heat pump market. So the air source heat pumps are currently much more popular. And a lot of it is to do with the high upfront investment that you require for geothermal. Geothermal heat pumps are a superior product, but they're still quite niche because you do need to have that extra bit of cash to go after them.

AB: So then it might be that this is taken up by places like hospitals or manufacturing or something with a high heat demand and maybe have that way of investing upfront... that might be a target market for this kind of heat source in Ireland?

SB: Yeah, I definitely think when we think about who geothermal is for, or who can benefit most from it, like you said, any of those organisations that can take a really long-term view. Because the thing about the geothermal systems is they have very low operational costs. So if you can overcome the initial spend, they've low operational

costs, and they've a very long lifetime. If you can absorb that upfront cost, then it becomes an asset. And also, it's like, let's say you have to use a heat pump, you're still going to pay for electricity throughout the lifetime of the installation. But it just offers you that much more security and stability in terms of pricing.

Take, for example, social housing, something like that, where if they could overcome the initial upfront cost, they could then guarantee the price of heat for decades for their tenants. You know, things like that.

AB: You're not relying on international suppliers or any kind of geopolitical issues that might happen around the world.

SB: No, exactly. Obviously, you still have your electricity bills to pay - we're all open to that shock - but yeah, because it's such an efficient system - like if you've got a coefficient of performance of four or five on your system - you know, your electricity is just 20% of that. In terms of security and stability, that is a really important benefit. I think that could influence some organisations to go for geothermal. The stability and the security is very important for hospitals as well.

AB: Of course, with 24-hour heating and cooling needs as well.

SB: Yes, yes. And so then the scale up beyond that would be your kind of district heating networks.

AB: And there was a recent announcement that Ireland is going to invest in some infrastructure for district heating. But this is quite common across Europe. I mean, we're a little bit behind the curve here, right? And can geothermal energy be used as a source, as a heat source in that mix?

SB: Yeah, that's what we're hoping. We've a project on at the moment, focusing on Grangegorman in Dublin 7. So this is part of the Gemini project. We're working with TU Dublin and the Grangegorman Development Agency and we're trying to answer just that question.

They have a district heating network. It's run off gas at the moment. It's quite a high temperature network. But we're looking to see, can we decarbonise that district heating network using geothermal energy? The signs are good. So far, we've drilled one hole to one kilometre: we got 38 degrees at the bottom of the hole. Our next step now with the Gemini project is to drill an even deeper hole. We want to go to two kilometres. And we want to really try and find those zones of permeabilities. You're just trying to find those areas where the water will flow. It's still to be proven but I think all the signs are saying that it's possible. And again, I hark back to the example of the Paris Basin. That's really ... they've got 10s of doublets feeding geothermal heat to a quarter of a million homes, we just want one in Dublin to prove the concept! A doublet is a pair of wells. For the Gemini project, we're going to drill the first of a pair of wells as part of a multi-million euro project.

It's still research, it's still exploration. But the hope is that we just show that there's enough resource potential to drill the second one and hopefully get enough heat. Now, if the resource potential.... if we don't find those fracture zones, there's always the option of geothermal heat pumps. That is something that is on the table for Grangegorman. Absolutely.

AB: Okay. So there are options there once you have more information about the site itself.

SB: Yeah, exactly. But the doublet is what we really want.

AB: I know that at the conference in Zurich recently, there were lots of examples of different types of organisations or users or suppliers that are using geothermal energy. So, for example, this can be used for things like agriculture. Is that something that we could do in Ireland?

SB: Yeah, yeah, certainly. I mean, once you know the heat is there and it's economical to abstract it, yeah, any process that involves heat, you could build a plant wherever you find the resource.

AB: Yeah, we've seen some examples of breweries and...

SB: Yes, geothermal cheese in the Netherlands... and sometimes it's quite nice, it gives your product a bit of a USP, geothermal beer. But yes, horticulture, anything that requires heating, greenhouses.

One of the first big successful deep geothermal projects in the Netherlands was actually a horticultural project. And it was driven by the growers themselves. And they organised themselves into sort of a community and they secured funding from many different sources. And they drilled this doublet, and they were able to operate in what's called a geothermal cascade, which is where the person with the highest heat needs takes the heat first, and then the slightly cooled water moves on to the next person and down the chain, and then it's recirculated back into the reservoir. So yeah, there's a lot you can do with, even with quite low temperature geothermal heat. You could still, you know, you can always stick a heat pump on it if you need to boost it. It just comes down to, I guess, the economics, whether that works.

AB: And maybe just to go back for a minute to the cooling that you mentioned. Most people, when you're talking about geothermal heat and abstracting heat from the from the ground... how do you cool something? If you're taking heat out, then you know, intuitively, you think that you're, you're bringing heat up and putting heat into a building. How does that work? If you're trying to cool something?

SB: Yes, well, if we're talking about shallow geothermal energy, which is the top 200 metres, like I mentioned, you've got a constant temperature of 10 to 12 degrees, something like that. That's quite a low temperature... If you're a manufacturer, and you're operating up at 30, 40, 50 degrees, and you need to cool something - maybe you

need to cool milk, or you need to cool any sort of process, or a building - and so what you do is you run a heat pump backwards, basically. You're taking heat from the air in the building or off the milk or whatever, and then you're just storing it under the ground. So you run it through the heat pump, and you store it under the ground. And then that storage is really efficient. And it means that you can actually access the heat later on in the year when you need it most, we're talking about seasonal cooling

AB: So, if you're putting heat into the ground under your building, it could be that the neighbouring building needs it only in the winter. And so they take it out then and can use it in their own time?

SB: Yes. Or I'm thinking there's a nice example I came across in Canada, actually. It was a dairy farm, a family business. And they were situated in the middle of nowhere. Anyway, there, they couldn't get gas because the pipeline didn't go as far as their farm. So they started using geothermal energy to cool the milk, that was the initial ask. And then they were able to store that underground and use it to heat a swimming pool. Not, I'm not sure if the swimming pool was for the humans or the animals! But yeah, I mean, there are lots of different permutations to this application. But it's... I guess that's just an example of how versatile it can be.

The other big application that I'd love to do a bit more research into for the Irish context is data centres. Yes, we all know they need a humongous amount of cooling. And in some cases, they vent heat. So that can actually be used as waste heat. And there's the example in Tallaght, where we've got waste heat from a data centre going into a district heating network - things like that can be quite beneficial. But yeah, the idea of geothermal cooling for a data centre: I think there's an example where this is being done in Italy.

AB: That's right, yes, in Bergamo.

SB: So I'd love to look into that and see what those conditions are. And if we have a geological match here and just where that could be done. I just think it's another interesting application of geothermal.

AB: I feel a field trip coming up.

SB: Sign me up!

AB: So that means then you could, if you have, for example, a data centre, if your neighbour doesn't need the heat all year round, it means that you can temporarily store it underground. So you don't always need to go straight with a pipe directly from the heat provider to the heat user. They might not need it all year round. So it gives you a little bit more control about when you might use it and how you might use it.

SB: Geothermal storage is a hot topic in Europe at the moment. But there are a lot of applications. You've got the low temperature stuff, which is for space heating that we've been talking about. But then you've got the high temperature stuff. So there are projects

where they're trying to store water of 70, 80, 90 degrees underground in aquifers and try and save the heat for abstraction later. There's many different examples.

AB: And you talked about the difference between the electricity and heating, or heating and cooling. But is electricity something that we can do in Ireland? Or are there different places around the world that you would do one rather than the other? And if so, why?

SB: Yeah, so electricity production from geothermal in Ireland is not impossible. It's certainly possible. However, because we don't have volcanoes, we don't have that easily available high temperature geothermal activity here. We have to put in quite a bit of effort to go and get the heat that we need to generate steam, to generate electricity. So the deep drilling that we're looking at in Ireland to get electricity, it's on the order of four or five kilometres, practically speaking. That's our understanding now. Nobody's done that yet. Not in Ireland anyway. And in order to drill that deep, it becomes a really expensive operation. So you need a lot of upfront investment. In order to make that investment available, you need to understand a lot about your rocks, which we don't yet.

And that is really what we're working on. There's a lot of researchers in Ireland working on this at the moment, just trying with the limited data that we have available, trying to really understand what is the geothermal potential and where are the best prospects for this deep, high temperature geothermal energy. So it's really a frontier of research at the moment.

AB: Great. Well, I think we'll take some questions. As you and I both know, children have the best questions. And we've both had some brilliant questions from little people that have come up to us over the years at different events and asked us great questions.

SB: I'm going to struggle now, I know.

AB: So these are questions that have come in to us from Laura, who's 10: *My dad told me the tomatoes in the supermarket are grown with geothermal energy. Is that true?*

SB: Okay, Laura. Yes, it would be amazing to go into your supermarket and buy geothermal tomatoes. So the way this works is tomatoes naturally need a lot of heat in order to ripen and become tasty. In places like the Netherlands and Iceland, actually, they're using geothermal water, so hot water from the ground, to run through their heating systems and heat up the greenhouses. So particularly in Iceland, they might not have a lot of sunshine, so they supplement it with geothermal water. So this creates a very nice, warm environment for your tomatoes to grow and get really tasty.

AB: Okay, that sounds great. Question from Amy: *Could geothermal energy be used to heat the swimming pool in our town?*

SB: Oh, good question, Amy. And yes, is the answer. And I even have some examples from Ireland, where that is happening. Sligo Regional Sports Centre, which is a big public swimming pool and gym. We are looking at decarbonising that: putting a

geothermal system in so that they don't have to use gas anymore, and then all of the heating of the swimming pool will be done from shallow geothermal energy.

AB: So if this works, you could do it in other swimming pools around the country as well?

SB: Yes. So there's SeaWorld in Lahinch actually partially heated with geothermal energy. And there's another example in Carlow. And there's another example in Mallow in County Cork... it's like this big energy secret that nobody's talking about.

AB: We'll have to put big signs outside them! A final question then from Conor: *If you drill down underground, does the heat from the planet not melt the drilling machines?*

SB: Great question, Conor. When you get down to four and five kilometres and beyond, the temperatures are well above 100 degrees, and the machinery can melt, yes! This is the subject of a lot of research on the technology side that is taking place in places like Iceland, a big project in Utah in the States, where they are looking at just this. What materials can they use in the drill bits and the equipment so that it doesn't just melt.

AB: But presumably that is only an issue if you go to 4-5 kilometres? For the kind of drilling we are looking at in Ireland, they are doing that in Europe already.

SB: Yeah, oh yeah. For the types of depths we want to get to for geothermal heating is in the order of 2-2.5 kilometres. Yeah, at those depths with Irish geothermal gradients we wouldn't be above 100 degrees and most machinery would be able to operate. There's also research into drilling with lasers.

AB: Oh, that sounds cool!

SB: Yes, so there is a project coming out of MIT, I think, the QUAISE project. They have developed a method where they use lasers to vaporise the rock and they claim they can drill very deep, so 8-10 kilometres. And not only that, they can drill fast which, again, makes everything cheaper. Lots of people working on this all around the world.

AB: Well, I think with that, Sarah, thank you for helping me with those questions today and for joining me and telling me all about geothermal energy. So, thank you Sarah.

SB: Thanks a million, Aoife, thanks for the chat.