Laura Young:

Welcome to the SAGES Climate Science podcast. I'm your host, Laura Young, environmental scientist and science communicator. And on today's episode we are going underground. We are thinking about what is beneath our feet, and I'm thrilled to be joined by two great guests who are going to have this conversation. The first is Dr Andrew Minto. And you are a lecturer at Abertay University, which is based in Dundee you graduated from the University of Dundee with a PhD in Geotechnical engineering. And you're research looks at the fundamental behaviour of energy geostructures, which are structures designed to capture and utilise shallow geothermal energy. I don't know anything about that, so I'm excited to hear more and you've developed this interest and actually you did some work with district heating networks working closely with Dundee City Council over the summer. It’s great to have you on the podcast.

Andrew Minto:

Thank you.

Laura Young:

Also, Brady Johnson is here who is a Hydro Nation Scholar and PhD candidate at the University of Aberdeen. Your research focuses on how groundwater can be used to mitigate the impacts of drought, specifically looking at private water users in eastern Scotland, developing more sustainable groundwater resources to think about that water scarcity problem that we have, particularly when we're thinking about frequent extreme climate events and prior to coming here to Scotland, to the University of Aberdeen, you worked as a hydrogeologist with the Department of Environmental Quality in the States and you're monitoring groundwater quality issues across the state and focusing on contaminants and transport of those with mining operations. Welcome to the podcast.

Brady Johnson:

Thanks for having me.

Laura Young:

You both work in the underground world. I mean, you actually work in offices, probably, but actually you focus on what's beneath our feet. And Andrew, I'm just

wondering to kick us off, thinking about Scotland, how can our underground environment help us when thinking about climate change and climate resilience?

Andrew Minto:

Yes. And so thinking specifically about geothermal energy, I think it's firstly important to distinguish between when we talk about geothermal energy between deep geothermal energy, which is probably what most people will associate with places like Iceland and shallow geothermal energy, which is typically the first 500 metres below ground level so shallow geothermal energy is not so location specific, it's something that can be utilised much more easily and it provides that sort of low grade heat which can be used for domestic heating and which is quite a big thing when we think about how much carbon is emitted from heat in our buildings, so heat in homes and commercial buildings and schools and churches and things like that. It's about 23/24% of the total carbon emissions is from that industry alone. It's only second behind transport in terms of its carbon emissions. So if we can decarbonize that sector, we can do quite a lot to try and meet our net zero targets.

Laura Young:

And when you talk about geothermal, so my basic brain that's you've got the world inside, you've got a really hot bit. And so if we get close to that bring up heat. But how does that kind of how does that?

Andrew Minto:

Actually it comes from two sources. It's comes from solar radiation. So just from the heat, from the sun and also from deep within Earth's cores and that sort of heat flux of heat moving through, moving through the soil layers and it's constant. The good thing about this heat is that it stays relatively stable in terms of its temperature, no matter what time of year it is. So outside of maybe the first, or the top 10 or 15 metres or so, which is influenced by atmospheric temperatures. So there's much more variation seasonally with temperatures in the ground, but below that we have a really, really stable temperature. So somewhere in the region of maybe 15° to about 25°C up to about 100 metres. We can then use that that low rate heat to heat buildings so not for direct use. It's usually something that's connected to a ground source heat pumps to heat homes, but it's something that is much closer to that target temperature that we want in our houses. So it's quite an efficient system.

Laura Young:

You just kind of drill down and use air, water, how do you?

Andrew Minto:

So yeah, there's different types of systems. We have closed loop systems and an open loop system, so close loop systems are much more. They're the things I was looking at really during my PhD. So these closed loop systems were buried inside of infrastructure. So if we have to use the foundations for example, piles, because we have either a really heavy structure or something that the ground at shallow depths is not particularly suitable for that for that load, and we need to use the foundation so we can bury pipes inside of these foundations. But there's also the option of just drawing a bottle and using pipes, and usually there'll be fluid through the pipe, so it's usually mix of water and a sort of antifreeze. So ethylene glycol or something like that to stop it from freezing. And that is captured or that that heat is captured from the ground and then taken to the ground then distributed around your building. But for loop systems, they're usually connected to like an aquifer or something like that. So if you have the geological conditions that suit that, you can connect it to an aquifer, but you've got to extract and then replenish the water back into the aquifer.

Laura Young:

And is it aquifer? Just a kind of underwater? Pond, what is it?

Andrew Minto:

Aquifers are basically underground storages of water, essentially. Depending on the soil we have, we have some soils which are much more permeable than other soils, which means that the water can transport a lot faster through it than other soils. And if you have productive aquifers we can use, we can connect straight to the aquifer essentially, which will have some heat in it. And actually, if you can use those little systems out a bit more efficiently, close up systems because you tend to be able to pump the water at higher rates, which means you can transfer heat a little bit quicker. Yeah, these open systems are a little bit more efficient, but there's some other things to consider when it comes to open loot systems. But yeah, we can use open loop or closed loop systems and that sort of low grade heat to try and heat our homes.

Laura Young:

When we think renewable energy, one of the I guess worries is that the sun doesn't always shine or the wind doesn't always blow and to have that.

Andrew Minto:

Absolutely, yeah, yeah. It's always switched on. If you like. It's not. You don't need a particular windy day or you don't need you don't need sun. You don't need you don't need wind or you don't need wave energy. It's all stored and it's always there and ready to. And actually you can use it for the opposite as well. So and a lot of European countries at the moment, Central European countries in particular. There's a lot of focus on using the ground as a sort of sink so we can take excess heat from in summer months store it in the ground and then reuse it in the winter.

Laura Young:

And Brady, Andrew introduced this idea of stuff underground in terms of heat, but also aquifers, which is water. And that's where your research is, is surrounding. But before we talk about groundwater, I wonder, could you just paint us a picture of actually, Scotland's Water and climate change how are those two things interacting?

Brady Johnson:

Sure. So I mean a lot of what's going on with climate change in Scotland, you really have like two different parts of the country. You have the West side, which is traditionally very wet. And the eastern side, which is much drier, so when you're looking at those two and looking at how it's going to change in the future, we're really expecting the western part of the country to get wetter in the eastern part to get even drier, which is also not good considering how the population is split here where more rural, less densely populated, and more population growth is occurring in the east. So that kind of sets the stage of the climate as far as groundwater goes. Groundwater probably has more resources in the eastern part of the country, which is good as we talk about resiliency, much kind of like the storage of heat in the ground. You know the water stored in the ground. That gives us, you know, the source that can provide water for us in kind of the off season times. Usually we have more precipitation in the winter time when we're not growing crops. When it's colder when we're not using water and less precipitation in the summer when there are agricultural uses, you know it's hotter, there's more evaporation going on, so the ground. You know, aquifers, underground storage of water, really, you know, has this resiliency against climate change, against extreme heat and, you know, changing conditions.

Laura Young:

I think that's a helpful picture to understand a bit about different times of year and different locations. I guess the question I've got is this is all about water. When I turn my tap on where is my water coming from? Because I guess we've got rivers, lochs, the ocean, which I don't think it'll come from there. Aquifers. So where does my water come from? Or does that vary depending on where I live?

Brady Johnson:

It definitely varies depending on where you live. The majority of people when they turn on their tap, it's going to be provided from Scottish Water. Scottish Water provides water to over 5 million people in Scotland. I haven't checked the total population, but that's the majority of those. About 200,000 people get it from their own boreholes, their own wells from springs on their property, but a very small amount. So for the people that do get it from Scottish Water. Only about 5% of that comes directly from groundwater. The rest of it's going to be coming from spring sources, lochs and surface water. That's kind of splitting hairs a little bit because. Probably 1/3 of river water is also groundwater. Groundwater supplies, rivers and particularly in the summertime, when base flows occurring in some areas of Scotland, particularly in the east, it's probably almost half groundwater, but we break down those sources depending on how they're treated. But for the 200,000 private water users, mostly rural, mostly agricultural type areas, they overwhelmingly use boreholes and a lot of that's in eastern Scotland as well.

Laura Young:

And whenever you talk to people about being from Scotland, or if anyone ever comes on holiday here, they talk about the rain and that's definitely a perception. And when we have conversations about climate change here, often we go to that wetter side and we talk about well, we've got so much rain and flooding is a big issue and that absolutely is. But do you think we're wrong to be assuming that Scotland always has rain and always has too much water?

Brady Johnson:

Well. Well, I mean, every time I go out to like, hike or something, I will complain that it's raining and there's far too much water, but. I think a lot of it, Scotland as a country has a lot of water, but it's not always in the right place for the people or it's not

always occurring at the right time. So we're discussing, I mean like a lot of that precipitation comes during the winter time. And the aquifers that we have, some of them have higher storage capacity, but a lot of them don't we just can't store all that excess water. So we have flooding and that's what a lot of I think traditional research comes. I think if you look at a lot of job markets, you're looking at engineers who are dealing with flooding versus, you know, water resources and trying to store that a lot of agriculture and previous work on farms. You know, we took these meandering rivers and channelised them so they could be able to move water off people's lands quicker to stop flooding. I think we're starting to move a little bit away from that, but we've dealt a lot with having too much water, but it's really, I think more of an issue of where that water is and what time of year it's occurring, you know and as climate change continues and as our summers get drier, I mean every forecast and predictions going off into the next 40 years are predicting you know more frequent droughts? That are more severe and that are longer lasting. So it's really that imbalance of when water happens and where it occurs in the country.

Laura Young:

And I think in the media as well, people are beginning to hear a lot more about low water and even stories of people having to get bottled water because, you know, literally it's run dry or it's got to a level that that's not sustainable. So in your research you're looking at groundwater. It wasn't a huge chunk of where we get our water now, what role does groundwater have to play when we think about resilient water supply for communities and how does it actually work? You know what, what would we be needing to see?

Brady Johnson:

Sure. Well, I mean, like you bring up kind of what to the public's eye, I mean, for the past, I think going back to 2018 was a pretty significant drought. The Scottish environmental or Environment Protection Agency produces water scarcity reports and I think for each one of those pass since 2018, there's been at least like a moderate level of water scarcity. And at that level they can actually stop abstract abstractions withdrawals of water to protect the resource. And then in going, I think like 2022, there was particularly in Aberdeenshire up to 500 people that actually ran out of water in their wells in their springs and had to request assistance from the government at a cost of I think about £500,000. So a pretty significant source. So I think that really kind of brings up the idea that you know we do have decreased water levels, be it within the ground or even that ground, that's supplying streams where people get their water for drinking.

Laura Young:

And in Scotland, are there specific pockets that you think could work quite well so, where you're doing your research is the locations that have got these great conditions or is that what you're researching?

Brady Johnson:

Yeah. So we're looking for that. There are some areas and kind of what Andrew your talking about, you know the different conditions for ground that are more you know beneficial for geothermal that can transmit more water. There are some areas, Dumfries, is a great example. A lot of groundwater down there, it's in sandstones. The sandstones have a lot of porosity, so the water, you know, a lot of water, being able to store between the grains in there and also transmits that are pretty high level. So you can really pump them hard, there's some sandstone up north. Scottish Water has some production wells that, you know, supply people through our taps. So those are some known resources, a lot of what I'm looking at too is getting into what Scotland's kind of known for in geology, which is a lot of metamorphic rocks, igneous rocks, very hard rocks, not typically known for their porosity, but they also fracture. So when you fracture, it creates this pore space in there which holds water. In a lot of areas in there too, these very hard rocks, these very dense rocks. They also weathered throughout their geologic history, so they get kind of crumbly. A lot of times that goes very deep to 10/20/30 metres throughout Aberdeen, so those represent very like a lot of potential for more groundwater storage. These won't be areas that are going to supply. You know, a town of 1,000,000, but they can supply farmers. They can supply small hamlet groups of, you know, 20 households. That kind of, you know, distributes our pressure on the aquifer system into these smaller ones that are, you know, hopefully more resilient than the burn that runs through your backyard.

Laura Young:

Think that's helpful to think about who can, who can be supported by this. But you were talking about what is underneath our feet and Scotland is absolutely world renowned for geology people come and do Geo tourism and we were speaking about that as part of one of the other episodes. And it's interesting to know why actually, what is underneath really matters in terms of what can be. Andrew for geothermal, does it matter what the material is or their pockets of Scotland that are better suited to what you're trying to do?

Andrew Minto:

Places are better, cities and that will have more advantageous geological sort of materials that we can work with. But the heat is always there, so the heat is there. It's just about if you can heat and meet the demands. I mean, that's the other thing. But a lot of these district networks rely on that sort of density of demand, if you like. But yeah, you can use it anywhere, but there are definitely places that we've talked about these sort of more impermeable rocks, for example. But even looking at superficial deposits. That you know you have these sand and gravel there's for example, there will be quite productive aquifers, and they're definitely much more seated because when we talk about thermal conductivity of soils, it's there's two ways that that thermal well that heat can transfer through soils. It can either transfer through particle to particle contact or it can transfer through the water in the pore spaces. So if you have saturated soil, if you have a lot of groundwater flow then that's obviously going to mean much, much higher thermal conductivity which means it's going to be much more efficient system and but the geothermal design can take into consideration if you don't have those. Really sort of advantageous geological materials that are available, but yeah, there's definitely places that will be much more suited than others, but it can be. It can be done anywhere. It just means that you might need other sources to meet the same demand. If you if you like. And it's part of a lot of studies. So there's been quite a few case studies. That even on sort of citywide skills. So I was at a conference in October 2023 and there was a lot of people that were looking at city-wide district heating and the potential for city by district heating and somewhat presented a case study in Cambridge, and they were looking at well, boreholes and we can look at the demand first and see if there's a possibility to meet the demand and averaged out around about 90% of heating demand could be met just through geothermal. And there's a standard deviation of about 20%, but there was actually places where there was more than 100% of demand. If you know potential capacity. So yeah, it's something that is probably with the underutilised, I think in the UK between deep geothermal resources and shallow geothermal resources, we're still only using less than 5%. Or it supplies less than 5% of the overall sort of thermal energy, which is really, really underutilised. And considering how available the resources. So it's something I think really if we're looking at potential for decarbonizing the heating grant is something that we really need to look at and get that into the mix for as one of our options.

Laura Young:

Are there any places Andrew around the world that do geothermal really well?

Andrew Minto:

There's a few places that is quite location specific, because you need to have that geology for it. But when people think about geothermal energy, their mind automatically goes to Iceland. All these, you know, warm places you can swim in. It's really quite nice.

Laura Young:

The Blue Lagoon.

Andrew Minto:

That's it. I knew there was a name for it, but yeah. So Iceland, they they've done geothermal energy for a long time. And I think it's about 25% of their energy production comes from geothermal energy. But that's not just direct use for heating. That's also for generation as well. We've talked about the obviously the Eden project down in Cornwall, and actually there's a lot of interest in the East African Rift Formation, which is sort of the Horn of Africa, if you like. Kenya, Ethiopia. We're going to have this, this very specific type of geology that allows them to capture deep geothermal energy at commercially available depths, which is, which is another country that has quite a lot of energy. Production, you know, quite a high percentage of their of their total usage coming from geothermal energy.

Laura Young:

And you have done some work in Dundee going wider, but maybe speaking about Dundee, are there any places in Scotland that use geothermal?

Andrew Minto:

There is, there's quite a few case studies, so, and they'll sort of two different sources, which is quite nice actually. The V&A Dundee is founded on geothermal piles. So there's the drill piles for the foundation. But they fitted these piles with pipes so they can extract and heat for, for supply and heat to the to the museum. Also the Caird Park Regional Performance Centre, which is a regional performance sports centre that was built in Dundee quite recently. That's part of the district in network. So that's the same thing. It was founded on geothermal piles and they can use those piles to then supply heat to home surrounding Caird Park. When we did our analysis, we had an intern working over the summer, which was great and we looked at those two

schemes and we looked at demand across Dundee to see where it might be more suitable. We identified I think six or seven locations in Dundee where there would be the sort of enough demand to justify that kind of district eating network. But there's other examples of other types of geothermal energy. So I think I don't know where it is exactly. In in the central belt. But there was old abandoned mines that are now flooded and we can connect pipes to those and extract heat from those and then and use that for heating. But I think it's somewhere in the South of Fife probably and that's probably. And I also think there might have been an example of a similar scheme in Glasgow. Where we're using old, old abandoned mine. So across the central belt there is a lot of abandoned mines that could be used and also the benefit of doing it in the central parts that you have that population density. So you have that heat demand. Those are considered as to be made about how sustainably you can use it, because you need to think about the permeability of the rock. For examples that you'd extract in that water out of the flooded mine, you need to either replace it or you need to have enough or high enough permeability that the groundwater recharges itself. But it's. Part of the geothermal design, or part of the part of the design of the heat pump and design of the system.

Laura Young:

I think that even just hearing that is just a nice use of old minds, right? Like what? What are what good use of something that that brought some really, you know, hard times obviously it's good. We're moving away from coal and other intensive mining and for a district heating.

Andrew Minto:

Yeah, absolutely, yeah.

Laura Young:

You know, Brady was talking about how many people could rely on a groundwater pump, but actually for a heating network, how many people or how many houses could you maybe get on a basics sub, you know, a sort of system?

Andrew Minto:

I mean. That would really depend on the space that was available, but for example, you can definitely do it in the centre of Dundee. For example, it could. It would more than be feasible. There was a study done from there was a case study and I think it

was in Slovenia or may have been Serbia. There was 2 case studies where they looked at District Heating networks and they sort of worked out that for the district heat network to be viable, you need to have a sort of aggregate heat demand of about 300 MW hours per hectare. Something like that. So it needs to be quite densely populated.

Laura Young:

How many people?

Andrew Minto:

Yeah. So yeah, it needs to be quite dense and populated, but and a lot of urban locations, you do have that population density which and it's not just homes, it's obviously businesses and schools and things that are all using that that heat demand. So it definitely has potential you can easily do it on quite a quite a large scale.

Laura Young:

I think that's so interesting. And really the, I mean the only thing I know about geothermal is a conversation that happened with Eden. Actually the one that's down in Cornwall, obviously Dundee is getting an easing project, so we'll see what happens there. But the Eden project in Cornwall, we're talking about their biomes, these huge greenhouse structures were all heated with the.

Andrew Minto:

Absolutely, yeah, yeah.

Laura Young:

They've got there and it was just interesting. Fascinating to hear about it. And actually, I've been to the site, so it was kind of nice to know that that's how it was getting powered because you can only imagine how much energy.

Andrew Minto:

Yeah, I mean, it's also the that project is quite fortunately, it sits in probably the only place in the UK that's got commercially viable deep geothermal energy. So then in the Cornwall area you've got you've got hot, dry rock that you require for deep geothermal energy. Commercially available depths, which is about 4.5 kilometres, it's quite deep. But yeah, so they they're hooked into that deep geothermal energy. But the benefit of that is that you don't just get, you can use direct heat. So you don't need a ground source heat pump because it's already hot enough. But you can also generate steam because you've got. Greater than 100° so you can generate steam which can you be used to power turbines which can be used to generate out as well. And that's what you have in places like Iceland. And we actually don't really know enough about the geology in Scotland to know if there's anywhere that has potential for. There's some thoughts that might be some good places in the North East might have this potential, but we don't really know enough about it. Or enough about the geology to know if it's possible yet. But. Yeah, it would be quite nice if it was.

Laura Young:

An opportunity for more research, there we go.

Andrew Minto:

Yeah, yeah, absolutely, yes. But with Eden project and Dundee, I think there really is an option, an opportunity there for at least shallow geothermal energy. I know that there's some initial discussions with Scottish Water actually, who because you can get heat sources from elsewhere. And actually in urban locations, that is quite, something that a lot of people are thinking about trying to incorporate what we call anthropogenic heat sources. So an urban areas, you have a lot of this, you call it the subsurface urban heat island effect where infrastructure has been built, so people's basements, underground railway systems, or sewers, or some anything that's sort of infrastructure that generates a bit of heat that increases the temperature of the ground and the shallower depths where we have that variation normally. So in the shallow depths we have a lot of variation because it it's more effective by atmospheric temperatures. But between urban locations and rural locations. The temperatures in the subsurfaces you know, maybe between 5-10 metres depth it's about 60°. Maximum difference, which is quite significant. It's quite significant, so it varies between maybe 2° and six degrees, but you know that that that's quite a big that's a significant heat source that we're not using and actually that Cambridge study that I was talking about earlier, they were looking specifically at anthropogenic heat sources. And they calculated that you can get about an extra 1700 kilowatt hours per year. Of thermal energy.

Laura Young:

What's that? Give me English.

Andrew Minto:

Of thermal energy to spend to supply heat to it's quite a lot. Yeah, to feel the significant amount of feeling of an amount and with the Eden Project in Dundee, there's a sewer quite close by. And also there's, I would imagine that the building or anything that's built there, visitor centre or something like that would be built on foundation piles. So there's opportunity to maybe fit these piles with heat exchanger pipes that we can then use to extract shallow geothermal energy. And I think as the, you know, the Eden image. Always about sustainability and using sustainable resources and that would be a really good selling point for bringing it to the people of Dundee.

Laura Young:

I think you have talked a little bit about what I think is right is underneath almost like the pavement in these urban areas because something that cities have to deal with is with climate change and increasing temperatures, we get this thing called the urban heat island, which is on top. So you're walking through a city. And if there's no trees, it just feels unbearable during the summer months. But you're talking about something that's actually happening under our feet, is that right?

Andrew Minto:

Right. That's right. That's right. Yes. So we have the term for it is actually it's, it's almost like underground climate change. So we have this pattern where we have an increased temperatures underneath the ground and that comes from infrastructure, but also comes from the heat island effect you're talking about there, but it feels warmer in cities. If it's warmer in the atmosphere, it's going to be warmer underneath the ground as well because direct sort of interface between them, but yeah, but we have infrastructure, particularly pave surfaces. You have really, really high temperatures in the summertime, especially if it's direct sunlight. You end up with, you know, asphalt, for example, really attracts heat, and you could end up with pavements. It might be 4 to 50, even 60° and really hot weather and that. A direct interface with the with the surface and then obviously that heat is stored. We have and there's quite a lot of environmental impacts that come with that, so habitats are

being lost, certain insect species, groundwater quality, is something that's a concern as well. If you have increased temperatures so that subsurface urban heat, urban heat island effect, we can use it. We can utilise it for geothermal energy, but it also has negative impacts as well.

Laura Young:

That it's important as well, because actually a lot of urban areas that have the densely pop are densely populated is where you need to more think about retrofitting and you need to think about solutions and I guess I'm imagining you can't put a ginormous wind turbine in the middle of Dundee. I think enough people would be annoyed with that and there is an annoyance about pylons, about wind turbines. Obviously. I think they're beautiful, but not everybody does. But I think I've heard that actually geothermal on what we see on top of the surface is about a shipping container size. What do we see when you have a geothermal?

Andrew Minto:

For geothermal energy, yeah, that would be something like shipping container size. It's not particularly, it doesn't take a massive footprint, but for geothermal energy. Actually, you don't really see anything because it's the borehole that's buried and you know it's buried underneath the ground. So it's drilled into the ground surface and you might have some pipework connecting it to a heat pump. But apart from that, that's all you would have for geothermal energy. So it's not something that's visually intrusive if you like. It's something which you don't really see, which I think is probably beneficial for that sort of community acceptance, if you like, which I think is really important.

Laura Young:

If we were looking at a community and you've done all the right research, you work out actually, there's a great opportunity to do groundwater. What would you see on the surface? Is it a big, intrusive piece of infrastructure? What change would need to happen at that surface level?

Brady Johnson:

So usually for boreholes, I mean you're looking at a small shed essentially that's going to contain a small pipe that's coming up off of the ground, which is your borehole and maybe some sort of pump. And that's a pretty significant, I mean for

Scottish Water and very small shed and enclosed for individuals, I mean oftentimes, for better or worse, it is a pipe sticking up out of the ground in a field with nothing else around it. So very little infrastructure, very little footprint. Yeah, it's it's not much. I was kind of thinking particularly with kind of small differences in geothermal, you know, like one of the uses for groundwater kind of in like an industrial sense and like a lot of distilleries is for cooling and just kind of when you mention that small temperature difference, I wonder how much cause a lot of times in the cooling process for distilleries, they will extract groundwater because it's had a constant temperature to cool, and then that water is, you know, could be discharged into a stream. But it's a slightly higher temperature re injected. It would be interesting to see if there is enough of difference to where you could really get some benefits for.

Andrew Minto:

Yeah, I think it would be interesting to find out actually something I don't know enough about, but yeah, it would be interesting to see if it could be done.

Laura Young:

I think it's all these little opportunities, right and actually looking at things differently and working, how we can do together. And I think with both water and energy, you know with water we take for granted that we can pull all of something that we can see, whether that's with energy we used to just have one source right fossil fuels, but actually, as we've journeyed, we've realised for climate resilience we need water from lots of different sources because actually our water landscape, the water cycle is changing. And so we need groundwater along with surface water and other aspects. And the same is happening with energy, right? We don't, we don't want to use fossil fuels, we want to move towards. But actually there is no like for like we need to do a bit of wind, a bit of solar, a bit of geothermal, a bit of, you know it's a mixture. But I guess I'd love to ask you about how this fits into people in communities because we can get excited in the science of where water or energy comes from and get discussing the technology, but ultimately it's people at the end of the day who get to use this resource. So for both of you. But maybe Brady to start. What impacts or benefits would groundwater bring to the communities that they would be suitable for?

Brady Johnson:

Sure. I think what we're really looking at in groundwater is security. You know, it's that diversification of a resource, you know, we can look at locks that are, you know, big storage of waters and we can see those water levels decline. The water levels do

decline in groundwater, but it's very much buffer. Do you know there's not the direct evaporation recharge doesn't necessarily have to occur right there within that loch. It could be, you know, 100 kilometres away up in the hills where you're actually, that water's flowing through the ground to where you would extract it so. You're getting water from a larger area. That water is typically of higher standards as far as quality. You think about water that's applied to fields that you know, picks up certain nutrients, has pesticides or anything that's coming off, road waste and oils, I mean that's as it moves through the soil that gets diluted concentrations decrease, you know, so typically a higher standard of water, but it's really. Yeah. Security, like a more reliable resource for people.

Laura Young:

And I think that's yeah, really important, particularly as we move away from this perception that we've got endless amounts of water, right. We need to be concerned. And for you, Andrew, thinking about energy. We are in a cost of living. The energy market is wild. You know, it's really volatile and there's lots of factors that impact that. And there's the stuff that we're talking about. Stuff's just controversial, OK, but pylons went to our bines like big structures, big industry. How does geothermal come into play when it comes to community? Or do we even know like is it too new that we don't know or?

Andrew Minto:

Yeah, it's probably it probably on a community scale, we maybe don't know yet because there aren't many district heating systems that that are that are being used. I think from maybe from an individual consumer's perspective, you might have more security as well, thinking about lower energy costs. So with ground source heat pumps, you still require some electricity because you've got to increase that temperature that you get from the ground. It's, you know, it's between 15 and 20°. You might you for space heat, you want it to be a little bit higher than that. So you still need some just to input and depending on where that comes from, it might be still be subject to all these you know fluctuations in cost, but the actual, you know, there's that sort of security of the of, maybe more reliable, more efficient, more efficient heat system. So if you think about the efficiency of a boilers or something, for example. You can also, heat pumps are on average about three to four times more efficient. So you can do more with less essentially, so you may be able to reduce fuel bills in that way. But that obviously comes with the caveats that you don't have windows open etc, you've already all these things, but I think that comes with education and maybe understanding that it's a different type of heating. It's not something you can

just, you know, just don't just burn gas and get heat later, then it's something you have to build and something they have to be a bit. I don't know, maybe a bit more. A bit more planning in advance kind of thing, yeah. Definitely something that's maybe a little bit more reliable and more efficient. So in terms of loading bills, it could be a good thing.

Laura Young:

A helpful picture and I know what you mean about it because it feels new, right? I don't. I don't know much actually about growing water or about geothermal, but it's exciting to see it move forward. And there's one story that that I actually quite liked, which was when Eden were doing their geothermal, when they were actually doing the kind of consultation. And we're discussing with the community and there was a concern that you talk about we're drilling underneath the earth, that we're going to be pumping up all this stuff. This is a huge infrastructure project, even though it ends up being a little shipping container, the community we're concerned about noise. That was that was a big thing. And so one of the things that that Eden did was they said, OK, we're going to have recording throughout all of our process so that we can see if any things happen or if it gets too loud. And they said throughout the whole infrastructure building construction. The loudest thing that was picked up on the audio recorder was the dawn chorus. The birds. Actually I thought that was quite a sweet story though, but actually I think it was a helpful way to say, you know, here's a community's genuine concern. But let's actually figure out what the reality is and I thought it was such a lovely way to say actually, you know, it's not as intrusive as we maybe presume, but actually nature is taking over, which I thought was quite nice.

Andrew Minto:

Yeah, yeah, it's definitely not as intrusive as people may think. So that, that conference I was at in Delft in the Netherlands, they're drilling a geothermal well on campus. So they're using that to power or they're using it for direct heat, for the university buildings, but also for part of the city of Delft as well. And obviously, because the conference is over all geothermal, we're all geothermal people, they offered us the chance to go and go and see the drilling process, which obviously I was really excited about. We were standing with, you know, maybe 10 or 20 metres away from where the bore was being drilled and at that point they were about maybe two kilometres below the ground and you can speak like we're speaking now. There was, you know, it wasn't. It wasn't over overly loud and it was just like a normal sort of, I mean, I spent a lot of time on ground investigation sites stand around next to something that can be quite loud, but it wasn't overly loud and it wasn't something

that was really intrusive, you know, and it was quite a small site and they didn't have. It wasn't a say that, you know, it was over, you know, hundreds of years. It was just a small, almost like courtyard in the university where you can just go in and sort of stand there, watch while someone drilling and then and then leave again. It was really good fun.

Laura Young:

I think more examples of that are just helpful so that we can see right, like see what it is. And I feel the story kind of threaded throughout this, we've talked about how these aren't new and novel in in some ways technologies or ways of getting water. And heat in particular and I think there is a big role for local authorities, for the government to be investing and looking and investigating a role for researchers actually be working out where are the best spots, businesses as well as you say, if somewhere is coming and doing a big infrastructure project, looking at it, I feel there probably is also an important bit to talk about people because we are the end users of water and energy. And I guess Brady, do we do we use water wisely in Scotland?

Brady Johnson:

Probably not. OK. I mean, and I think that goes for most countries. Probably undervalue water because we probably don't pay the real value for it. It's readily available. We expect it for free when we go to a restaurant, we just don't put much of a cost on it. So I do think we undervalue. Scotland is the highest per capita water users within Europe, some of that relates to the infrastructure here, which is leaky and we probably use a lot more water through that. But yeah, I think kind of both the idea of being a very rich country probably goes into a little bit of that too.

Laura Young:

It's so helpful to know a bit about the Scottish context with water. Globally, how do we compare or are there ideas that are really? There are ideas that are really struggling with this, but I guess could you maybe give a bit of a?

Brady Johnson:

Global picture on water. Sure. So yeah, I mean Scotland definitely experiencing more drought, but drought is a little bit different in Scotland, you know, I mean, we have meteoric drought, which is often called, you know, this kind of a lack of rainfall with low storage aquifers. Even small amounts can have a pretty significant effect on

Scotland. But if we go to somewhere like the American West, where I came from and did research our annual precipitation was about 1/4 of what Scotland gets so. Much more reliant on groundwater. Everything was dry. All the farming was irrigated, so water's very important as you move through the Colorado River and the western United States. That water was allocated many years ago. Quite poorly actually, to where there was never enough water to actually meet the demands. But now, as you get growing populations of cities throughout there that are using more water that are trying to stake claim about how much water they should be using, which doesn't actually exist, and then you run into these conflicts between states and communities that are trying to get water, they think they're entitled to or have legal rights. This isn't there, and this is, you know, changing very fast, getting even drier, which is really leading up to. You know, probably some very significant, hopefully just legal fights, but a lot of conflict in the future and ongoing.

Laura Young:

I think the difficulty is going back to school. The water cycle, right? We can't control it. It literally evaporates if we don't look after it, and we've got water that's locked away in frozen environments. That is melting because of climate change and it's moving, it's bringing water. But as you say, places that have maybe never had to think about it before are now having to think about it. And some places that have always had to think about it are now not. But they're actually getting flooded. And so water moves whether we like it or not. And so I think it's important. And I think that geopolitical aspect is important as well because it is. Of the only things we actually need to live. And so when it's scarce, that can obviously lead to a lot of conflict.

Brady Johnson:

Yeah, definitely. And there's also I think about that change in even places where water could be stored. I think of a lot of mountainous areas with snowpack. Snow is an excellent reservoir for water, you know. The wetter winters, you know, stores water in there and it's slowly released throughout the spring, providing water, filling up reservoirs through climate change. You're getting less snow pack. More rain events in the spring that creates these catastrophic events, which the infrastructure that was built in the time 50 years ago, can't store that water anymore. So even when we do have infrastructure in place, it's just not applicable to the current climate conditions, I mean plus I'm going for Scotland. We don't really use it in agriculture, which is a huge usage. If you go into other places that actually have irrigated croplands. So our personal consumption uses, you know, really get into those. Your showers, your toilets, you know, and there's a lot of ways that I think we can, you

know, reduce that on a personal level. But I think a lot of it goes to is holding the companies accountable. You know, really looking into those leakage rates, the leakage rates for Scottish Water for public systems is on the high side of in Europe. And one of the highest in within the UK. That's almost 25% of the water that Scottish Water supply is leaked before it ever gets to. That is before. Yeah, their supplies before it gets into your house is lost.

Laura Young:

That's nuts.

Brady Johnson:

That's higher than a lot of other water providers. It's not outrageous outlier, but that's a significant amount that we should really, you know, be holding people accountable for as far as investing in infrastructure. Aside from what we do personally, but also investing in the future to bring that down.

Laura Young:

So do we have to get used to a bit of disruption while we fix that, I guess I'm wondering where is our water infrastructure is beneath roads, so is that I guess as us do we have to maybe get ready to see change if we're asking for it.

Brady Johnson:

Yeah, I mean I think so. I know there's a lot of kind of work looking at when new infrastructure projects are going in place, whether it's new construction to kind of reassess what that existing infrastructure is, particularly for water, and being able to do upgrades during that to minimise it. I mean, I advocate that as far as the common sense, I've realised there's a lot more planning that goes in there that's outside of my realm, but it's probably.

Andrew Minto:

Yes, that's an engineer. It's another engineering challenge. Yeah, actually that's I've had no idea that was that was as bad as 25%. That's really. Yeah. Yeah, that's really not something I expected to hear. So yeah, when you see people ripping up roads, it's usually to get to the infrastructure. That's bad. It's probably underneath. It's a bit

of a pain because, you know, you try to go to work and you turn up and they've not told you that the roads closed and you have to turn around and go elsewhere that feels. At the moment that almost every second road is either closed or there being resurfaced or something like that, but yeah.

Laura Young:

When they're doing that, we're hopefully dealing with a lot of issues and actually our water infrastructure not to try and promote it, but actually it was amazing, you know, when it was first built, we've just maybe not given it the attention that it's needed recently and maybe and taken for granted. Actually both water as a user and the structure I think.

Andrew Minto:

I think they definitely did take it for granted. I mean, I know myself. I definitely take it for granted, you know, with.

Brady Johnson:

Oh, absolutely.

Andrew Minto:

With a sort of climate conscious mind, I want to use less, but it's so hard to actually use less, you know. Even. Yeah, it feels like everyone can definitely do more. It's not something that may be doing well in the country. We definitely can do more, I think.

Brady Johnson:

Yeah. And I mean there has been change. I mean, if you look over the past 20 years, I mean I think Scottish Water is pretty much cut in half their overall leakage rates from pipes. I don't know how much of that's concerted effort to fix it versus going in. But I mean if you kind of think about two all of the connections and I mean, distributed people are that are on Scottish Water. There's a lot of pipe, there's a lot of ageing infrastructure, there's a lot to go after and a lot of it has improved. But I still think we have the ability to do more.

Andrew Minto:

That there has created a big link between what was talking about live with that subsurface urban heat island effect. So in urban areas when you have this. You know, shallow, shallower soils or. Yeah, just below the ground. That is an impact infrastructure. It definitely has an impact on infrastructure. You know all materials expand and contract when they're heated and cooled. So if you've got significant differences in temperatures between seasons in the shallower ground where all our infrastructure is buried, then you're bound to have material fatigue and you know, things start to come loose and you know, start to leak and so that. It's obviously making it impact. Yeah. And it probably doesn't help.

Laura Young:

When people flush oil down the toilet. They make these big fat bergs that yes, no wet wipes, no tampons, no fats, no oils down the drain. You need to get the plug in every time you can, but I guess Andrew for you energy, we are the end users and I guess energy leakage, maybe you told that story of, you know don't put.

Andrew Minto:

No, that's it. Oh, yeah. Nothing. Yeah, yeah.

Laura Young:

Then open windows but.

Andrew Minto:

Absolutely, yeah, yeah.

Laura Young:

Above what we all probably know already. You know, what role do we play in just helping? Because I think often when we talk about net zero, which is that buzzword of trying to bring our emissions down with a bit of balancing the scales to hit 0 or we'll talk about pushing to renewable a bit. I always feel is missing, always bringing down usage like we always keep going. How do we just swap?

Andrew Minto:

Mm hmm. Yeah.

Laura Young:

From fossil fuels to renewables without saying, but we actually use a lot of energy.

Andrew Minto:

Yeah, I think bringing down usage is it comes from, from properly insulating people's homes and things that's probably more impact than anything else. I think in terms of usage. Yeah, we definitely probably do have certain tendencies to not use a particularly wisely, but a lot of that again is that's proper and insulation will definitely have much more of an impact than Earth and individual consumer could do, I would imagine. I don't know if there's any studies on that would be quite interesting to see if, see if it is the impact of that, but it's the same as every type of energy source, but I think. Where we may see more uptake of things like geothermal energy or shallow geothermal energy and heat pumps is expensive. You know, for if you're installing one for your house, for example, it would be quite expensive. You're looking at thousands and thousands of pounds. You might have cheaper bills, but how long is that return period? Know that's the sort of looking at it from that perspective, it's not, and that's maybe why other renewable sources are maybe a little bit more and widely used like air, so she pumps it. You have to buy the heat pump. We don't need the infrastructure. You don't need to drill the 200 metre bottle in your back garden, you know. And yeah, that's it. Yeah. That's the cost of money to drill.

Laura Young:

It's a reality.

Andrew Minto:

So that that needs to be. But I think if you if there's more investment, I would say probably the local authorities are people are there and statutory body that you would look at to maybe make things a little bit cheaper or maybe to subsidise it or maybe to drill. You know, district heating system so that it's not on the individual person to actually purchase that themselves. And yeah, that will work where we have the population density to justify it. And in these urban areas we probably do and it's something I think that that would make it much more viable, make it much more

economically possible. Usually when we're assessing the potential geothermal energy, we usually break it up into sort of theoretical potential, which is. Basically just how much thermal energy is stored on the ground a lot. The technical potential which as well how much can we actually extract? And then there's the economic potential, which is how much can we, you know, how sustainable is it going to be and how long is the return period going to be? And that's what we have to think about. Anything that's where the local authorities or maybe its government. I don't know that it can come in and maybe make things a little bit cheaper so that people can actually use these.

Laura Young:

And maybe then there's an extra pillar that you need to think about, which is social benefit, right? It's not just like how much. It's like how much more dignity does this gives people who get to turn on their heating versus not.

Andrew Minto:

Absolutely, yeah, yeah. Yeah. I know that's true. I mean, especially now. Talking about the cost of living and how expensive things are that you know, everyone's eating those over the last year or two years have probably almost doubled. I mean, I know mine almost doubled or at least doubled. It's not sustainable. We can't keep going that way. You know, we need to look other ways of making sure we're not using too much energy. And if that is subsidised. First, systems are better insulation and actually to give Dundee City Council its credit, a lot of the Council housing in Dundee have they've had a big programme of insulation. Building insulation or putting insulation into people's homes to make them. More efficient, and I think that they need much more of that.

Laura Young:

And I think that's the key thing is that you know. And that's where I'm a campaigner at heart, right? So I'm thinking, what's the next campaign? But it is, you know, it is political decisions and you know, particularly thinking about where you've got rural communities that don't have many options for water or you've got people with dodgy landlords who don't have goods they don't have double glazing, they don't have insulation. Actually thinking of how do we policy wise kind of nudge it forward to enhance these things, I think yeah, it's really important.

Brady Johnson:

Well, and you start thinking things like that. I mean, as far as and I mean bring back kind of the thing that happened throughout Aberdeen, sure. Where you know, local governments where spending £500,000 to provide containerized water for people due to climate impacts, you know where that money is going to be better spent installing wells for people, for the geothermal part, for installing that rather than giving people credits to pay for higher energy.

Andrew Minto:

Yeah. Yeah, that's true. Yeah. Yeah. Let's be able to do that investment. You invest up front and then have, you know, the infrastructure in place for when we will need it. We'll definitely will need it. Or yeah, rather than that sort of reactive.

Brady Johnson:

I think there needs to be that investment in. I mean, and I see that becoming even more of an issue as far as climate change occurring with hotter times. I mean, the groundwater supplies, the water supplies in general, I mean are just going to become under more stress and I think heating is going to.

Andrew Minto:

Yeah, yeah, it's huge. I think. I mean, politically, obviously it's a political thing that where governments will have to spend money, of course they're going to have to spend money. But I think the cost of is higher and I think that's what. I don't know if the politicians realise it yet, but the definitive audio is it's in when things start to get a lot worse. The cost of an action is so much higher than the cost of action now, so it's just trying to make sure that that investment is here and it's not reactively spending in 10 years time when things are already. Starting to, you know, start to get a lot worse so.

Brady Johnson:

Yeah, absolutely.

Laura Young:

And I think that's that is a great place to wrap up because actually what we've done is, you know, discuss these two really exciting initiatives and spaces well both happening in the same space underground. But actually they have so much potential, but it is about raising awareness. Both for communities to be pushing for these kind of things or know about them, but also to give confidence that the research is happening, that we can embark on these journeys to help with climate resilient places that are also not costing a fortune to communities, whether it's with water or energy. So thank you so much for sharing all of your knowledge and being a part of this podcast that has been Brady Johnson and Dr Andrew Minto. Thank you very much.