event transcript

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Universal Geothermal Reservoirs - The solution to the world's insatiable appetite for energy may have been under our feet all this time!

Dr Jefferson W. Tester, H.P. Meissner Professor of Chemical Engineering, MIT

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First of all I'd like to thank everyone including [Petratherm] and others who have brought me here to this fine country. Let me share with you a little bit of my own journey that I've been on. It seems like my wife continues to remind me. She said you've been working on geothermal for as long as I can remember you, which is fairly a long time at this point. Our anniversary was yesterday, our 40th wedding anniversary if you can believe that and she said, "Well you work on something for 35 years and you're an overnight success." But really this journey has taught me a lot.

I started out working as a young engineer with the Los Alamos Project back in the early 1970s and migrated back and forth between Los Alamos and MIT for a while but it hasn't been really until the last year or so where I've begun to fully appreciate the impact of what's been going on in the rest of the world with respect to geothermal development and in particular what we now call enhanced or engineered geothermal systems. And I've been lucky and I'll share with you just a little bit of the last few days of this, or last few weeks.

I started out a few weeks ago in Cambridge, Cambridge Massachusetts that is, and headed out to Iceland at the invitation of the President of Iceland, President Grimmson, for the first time I've been to Iceland if you can imagine that too, to see the transformation that that country has made in the last 50 years. A transformation from a country that's been essentially fully dependent on fossil fuels and imported oil for all of its energy needs, to one that uses geothermal quite extensively as many of you know, providing all of its space heating needs and 20 per cent of all electricity and hydro power providing the remaining 70 plus per cent.

And they are quickly moving away from being dependent on any way on imported fuels for transportation by considering the hydrogen economy that would use geothermal. Particularly very hot geothermal and electrolysis to generate that hydrogen to be not only carbon free but fully indigenous and what they consider to be fairly energy secure. And since that time, since my Icelandic trip I have been to Reno, Nevada to look at a new geothermal plant there built by Ormat that uses no water at all. It totally reinjects all its fluids. It uses no water for cooling. I think something like that could be quite attractive in a country like Australia where water is another primary and important commodity and then back and forth to Washington and as part of my preparation for what I'm going to face here in the next few days in Australia.

I've had an opportunity to speak to the US Congress on 4 occasions now in the past 4 months. Something that I think has never happened before in the history of at least the energy work in the US, that I find now that there is much bipartisan and apolitical support, general support for getting serious about making an energy transition and there are a couple of large bills that are in place right now. The Authorisation Process is under way both in the House and approval in the Senate and I'm optimistic, quite optimistic for the first time that we'll have chance to take our current geothermal budge, R and B budget which is zero right now in the US and to re-energise it and revitalise it.

We have to catch up to the Australians because they're way ahead of us now in many ways and I think it's important that I appreciate that. But my journey also takes me here and I've learned a tremendous amount as part of this assessment study and I'd like to share with you some of the result s of that. I realise that this is a US centric presentation so you'll have to bear with me. Our language also has some dissimilarities to it as you know but I think in the end you'll see there is a lot of commonality to the whole geothermal area, and this is not just about what country does this first or develops and deploys geothermal to a large extent versus one or another in competition. I think this has potential to really help out a situation in the world that we're going to face and see the development of energy demand.

So let me try to share with you a few of these things and we'll see how this presentation works. So the original title of the presentation today was called Universal Geothermal Reservoirs. I'm not sure exactly where that came from but we are going to stay on the earth for this and not move off the earth for the immediate future but this is what we're really talking about which was the title given eventually to this 15 month assessment that we carried out and interestingly enough this hadn't been done in the United States for about 30 years and it gave me and my position at MIT an opportunity to do something to bring other people together and we put together a panel, an 18 member panel that was focussed on two different goals.

The first was to provide a truly comprehensive and independent assessment or evaluation of what we're calling EGS. It started out as Hot Dry Rock. Parts of Australia might be referred to as hot fractured rock but what this is, is it's not a separate entity in the geothermal domain. It's a transition strategy to take us from the high grade systems that we have today to the very lower grade systems that we might find in many parts of countries where the geothermal gradients are lower and you have to drill deeper and other attributes aren't present as they might be in a good hydrothermal system.

The other part and this was the part we never imagined would have the impact that it seems to be having, is to really inform the policy makers in the United States as to what it would take to take the current level of support which is pretty easy to define as zero, being zeroed out by the Office of Management and Budget and if you wanted to make a difference. If you really wanted to see an impact of geothermal lets say in half a century, and this is not just about tomorrow or next years funding. It's about a multi year commitment. That's what we were hoping would be a result of this.

So the next part was to assemble this panel and I'm not going to go through the qualifications of this group but this represented not only a lot of different disciplines but a tremendous amount of experience over this 30 year odd period or so that we've been working on EGS and there were a lot of new people that came in that initially were quite sceptical and they didn't have the advocacy position on geothermal that some of us had. And it was the dynamic of this and watching this process go on for 15 months was an education to me in itself. And what I'm hoping to do is to highlight just a few of the key results that we found and to encourage you if you haven’t had a chance to read this report, to take a look at it. We've tried to write it in a range of forms, ranging from a 60 page summary that has a front end synopsis that almost anyone can understand of just a few pages, to the full documentation. A 400 page report and there are other appendices available and I'll be happy to get into that if we want to in the discussion to show that this is not just a sort of a once through over pass at a very high level. It had a lot of detailed work, a lot of new work that went on. Some of it in particular was associated with assessment of the resource base in the US but a lot of it was concerned with dealing with the status of technology, both for drilling, reservoir stimulation, surface plants and conversion technology, to the economic aspects of this and how it might fit into an overall strategy for the country.

Now what was behind this, at least in the US right now is the, lets say the vulnerability of our US electricity supply system. Now this is a set of curves that were put together by the agency, the part of our Department of Energy that is focussed on predicting the future and statistically representing the past, and it was what was available to us at the beginning of the study. So if you take this vertical bar, everything to the right is the future and everything to the left is the past. So this is all speculation to a certain degree and notice the natural gas line for generating potential here for electricity and coal. Natural gas could never grow to this level of producing primary electricity without importing a lot of natural gas.

If you were to go to the EIA website today, you would see a much different picture. One that shows a change in derivative of nuclear where it’s slightly positive now. This is only a 20 year period. Coal going up perhaps even a little faster but gas being relatively flat. Much slowed growth and renewables playing a bigger role. How will those renewables actually be put together in a portfolio particularly when you're talking about, and remember the US has a few more folks than Australia, about 300 million. We just passed that threshold last year and in addition we also passed the threshold of having now one terawatt of electrical generating capacity and if you want to count the number of wind mills you might need for this that would be one way to do it but I think it’s going to be clear that this cannot be just a singular solution. A good portion of the US capacity is in coal right now. We have 100 plus nuclear plants that are getting older and older. So there are many, many reasons why we should be concerned. And here’s a summary of a few of them.

So the state of the US energy supply system, in the next 15 to 20 years we have 40 gigawatts, 40,000 megawatts of sort of old coal fired plants that are at capacity that are operating that don't meet today’s emission standards. This has nothing to do with carbon. It has more to do with particulates and [nox] and sulphur. So something’s going to have to be done about that or they’ll have to change the regulations and in addition we have this aging fleet of nuclear reactors and certainly within the next 25 years some 40 per cent of our nuclear capacity, 40,000 gigawatts, 40,000 megawatts, 40 gigawatts will be beyond what we would consider even the most generous relicensing procedures. We haven’t built a new nuclear power plant in 30 years.

The availability and limitation prices and increasing prices for natural gas, I've mentioned that. So that has to be dealt with. There still is a lot of public resistance to expanding nuclear power in the US, although now there seems to be orders and increased interest, I think partly driven by the fact that we have to get more carbon free and as a future nuclear would have a role in that, but also just a change I think in the public attitude about trade offs between nuclear versus coal.

And if we're going to go to nuclean coal, no matter how we define this clean coal, if carbon sequestration is part of this these are going to be incredibly expensive plants and they don't represent a permanent solution for sure. They represent a transition to how we might evolve to a more permanent solution and all of this particularly in our country where putting in power lines and other energy carters is a big deal will require that and where this fits into the funding and support is a question of importance.

So let's talk about geothermal for a moment here. Is this in fact a missed opportunity for the United States? We are producing the largest amount of geothermal generated electricity in the world but not much growth has occurred in recent times. We're roughly at 300 megawatts capacity, 3000 megawatts capacity now but the plan is and the strategy behind this assessment was could we grow to 100,000 megawatts by 2050. If that did occur geothermal would all of a sudden have the same presence in the United States as our nuclear reactor part. It would have the same presence as all the hydro in the US including primary hydro as well as pumped hydro and that would make it a real player and that was what we thought would be a reasonable backdrop.

So when we look at geothermal across the country this is just one example of considering the near surface geothermal gradient. We could look at heat flow. We could look at identified reservoirs. We have to recognise immediately that we have a range of grades just like any other mineral that we might be dealing with. There are going to be extremely high grade regions. Those primarily as many of you know are associated in the Western part of the US. There are 4 or 5 Western states that have been the active players. California with the lead but Nevada and Utah and others are developing their geothermal resources.

But what about the rest of the country? Last week I was in Texas as part of this journey I've been on speaking to the oil and gas community about the use of low grade geothermally heated water that's co-produced during the production of oil and gas, and this represents not necessarily a massive thermal resource in the long term but in the short term would have immediate impact particularly in this mid Western if you will corridor where you have a lot of hot water and it has to be dealt with both in environmental terms as well as to utilise some of the heat. So that too is placed in this continuum if you will.

When we talk about enhanced geothermal systems there are many cartoons we can draw and all of them sort of give the same message. That what we are trying to do here is to engineer systems in a manner that they can emulate what nature has provided in these rather few instances around the world. So we're talking the need to increase connectivity and permeability, porosity, however you might want to define it, to add water if it doesn't exist in place in the reservoir and to manage that water in terms of recirculation and in places where we have to go deep we'll have to develop the technology to do it and in places where we don't have to be so deep we'll take advantage of the economic gains of that.

And so again to get back to this continuum idea, if you look through our report you'll see that we're really talking about not only today's hydrothermal systems but also the bigger stored amount of thermal energy that's in conduction dominated EGS particularly in deep crystalline rock but as well in deep sedimentary basins. The co-produced fluids example that I just mentioned associated with oil and gas production and geo pressured which are located in the Gulf Coast region where we have natural gas, high pressure and relatively high temperatures all simultaneously represents some interesting challenges to the reservoir management side as well as to the energy conversion side.

And again this has produced one of our groups that was heavily involved with the study of Dave Blackwell and his group at SMU, Maria Richards and we were glad to have them because a lot of the data that is in this report is new, has not been considered. The US Geologic Survey which is the agency responsible for resource assessment in the geothermal area has not published a report on geothermal since 1979. So it's time they got started again and Blackwell's team is helping that along quite a bit.

These are 3 examples of different rock temperature slices into the lower 48 states where we can look shallow and features on here that you should think about. This little purplish dot up here is Yellowstone National Park. We're not advocating going to Yellowstone National Park but on the other hand it gives you a good index of a good geothermal system and as we begin to go from 3½ top 6½ kilometres you can see that the West is beginning to look a lot more like Yellowstone and if we can go to 10 kilometres which is what you would expect to do in sort of a long term scenario, going from high to low grade, and the whole country in a sense is at temperatures, particularly the whole Eastern part of the country where you could generate electricity efficiently, certainly have a lot of heat for heating, direct heating needs, but the whole West is a giant Yellowstone, just somewhat deeper.

This is another map that Blackwell's group has put together. It shows a slight different colour scheme but the same kind of idea and this is at 6 kilometres, which is much more the kind of depth which we're developing EGS today. This is the range of depths that we're thinking about that project forward from where you are now at Cooper Basin, where we have in the Salts Project over in France, European Union funded project. The Deepest Wells at Fenton Hill in New Mexico went to depths approaching that. So it is technically a viable range to consider for maybe the next generation of EGS and look at these temperatures. Anytime we get above 150C and upwards we have useable temperatures for generating power.

So as part of this assessment, taking these horizontal slices we can create a histogram of how much stored thermal energy, and this is the if you will, the secret and perhaps some of the misunderstanding that comes into geothermal. We're not talking about utilising the steady state heat flow that comes to the surface by normal processes. We're talking about mining if you will, mining that's stored down there as stored thermal energy and there's a significant amount of it. This scale is an exajoule so this is a million exajoules. The US alone as a country uses 100 exajoules, that's 100 times 10 to the 18^{th} joules per annum in all of its primary energy, and the similar unit is a so called quad. So you can think of an exajoule as being roughly equivalent. And so when we sum all those bars up you come up with this red bar which is a stored thermal energy in place over the depth range from 3 to 10 kilometres. What is technically accessible and sort of accepted as the US GS resource base for the country. And from that level you come up with 14,000,000 exajoules.

Keep in mind that down here our one on this vertical scale is 10,000 times the annual US energy use. So when you talk about geothermal as a sustainable resource this is what I think provides a lot of strength to that argument. It's not about the local mining of a small bunch of reservoirs. It's about the sustainability of a long term strategy which goes after the stored thermal energy in the earth. So these blue bars represent different levels of optimism if you will, as to how much ultimately could be extracted and utilised subject to whatever economic and technical constraints you could come up with.

So even at a long term sort of 2 per cent conservative level, only the 10 kilometres and having a long period of time, centuries to develop this, there's plenty of capacity to lead to a very positive picture for geothermal essentially for the foreseeable future. The idea of this is that if you go after stored thermal energy, you will never be in a situation where you have insufficient energy in place to produce a primary energy, whether electricity or heat forever, and I think that situation is true here in South Australia. I think it will be true generally for the country as you begin to expand your database for geothermal.

Now again to do some, to fairness here, as you look retrospectively as we tried to do in this project. At the beginning of the assessment project Australia was starting to get very heavily involved in smaller projects that’s occurred in a great way here now, and I'm certainly happy to see that kind of growth, but the one major project that we examined in detail was the Cooper Basin Project, because it was active. It was doing real reservoir testing at depth and attempting to expand the horizon if you will of EGS to this very different stress regime. So we went backwards in time. The main blue boxes on here are the large projects. Of course in addition to this we had to deal with the Basel situation which had some interesting induced [seisnicity]. Just this past week we were fully briefed on that situation which tells you how important it is to deal with the public when you're developing EGS, but also these other experiments.

In Japan at the [Rosemenalis]] site and the Cornish Granite in South West England and at Fenton Hill, tell a similar story with respect to the reservoir itself, and we use this as a way to kind of frame the arguments around what is technically known and what has to be done. The critical challenge technically is unquestionably in this yellow box here. That you’ve got to engineer the system and engineering it has different aspects depending on what nature has given you at a given site but connectivity and connectivity here between a set of injection wells and production wells has to be achieved.

What we’re looking at is a micro seismic map, two dimensional projection of three dimensional micro seismic signals generated during hydraulic pressurisation of the Soultz Reservoir in France and you can see that this is an area where fluid is getting out there. It’s causing a lot of fracture re-opening and a lot of seismic noise but it’s not well connected to these other wells and that’s not going to probably be a good production system. So how we achieve that connectivity may require a variety of engineering tools and techniques that have to be applied and it’s the demonstration of this that has to go forward.

So what we summarised in the report based on these large experiments and a whole set of smaller ones, is a list of things we think we know how to do. Certainly we can do directional drilling to 5 plus kilometres. There's many, many techniques that are out there for understanding, characterising these systems, looking at thermal hydraulic behaviour etc. We can routinely now make extremely large systems that are active. Active in the sense that they accept fluid, they can circulate fluid and this is the size we have to be talking about in the range of a cubic kilometre or greater to sustain the productivity and to help offset the capital investment that’s got to be made in these systems.

We have injection production well connectivity but it needs to be at a higher rate and manageable and control of the water loss is a key part obviously to the geothermal story in regions where that’s important. Manageable and so seismic effects and subsidence effects and other important environmental attribute and we can achieve net heat extraction. The parasitics being accounted for and still get a significant amount but there's a lot of things left to do. Not a lot of things but a few critical things if you will. We have to be able to demonstrate commercial levels of fluid production for sustained periods and we want to be able to establish one of the beautiful features of geothermal is its modularity. That we can go from megawatt size installations to hundred megawatt installations and to group those together to produce the equivalent of large base load central station power in the order of 1,000 or more megawatts, such as we have at the geyser site in California. So modularity and repeatability of the technology over a range of US sites was viewed by us as a key to this and lower development cost for low grade geothermal systems. Ultimately not initially, start out at high grade like you would in any mineral extraction approach and work your way towards a lower grade.

The analysis that we showed and this is where the economists, resource economists and other people that looked at this on our panel very carefully, was that you can do this with a rather modest investment in research, development, demonstration and deployment in the near term, and there's a bit chapter in the report that has many, many graphs in it and I'm trying to summarise this in one so we can let you all eat here soon. This is the break even price of electricity that we calculated, levelised costs in US numbers, cents per kilowatt hour. So that’s shown by the blue curve as projected for EGS and this is a capacity scenario growth showing in the green line out to 100,000 megawatts in 50 years. This is what we were asked to do and the red line are the projected prices for electricity, commodity electricity. Clearly this is speculation as well but I don't think there is anyone that thinks this is going to go down and there will be lots of interruptions here that may drive that red line even further vertically.

But the point is, in a short period, a relatively short period of say from now up until a period of 10 to 15 years you reach a point where EGS could compete in the full competitive electricity market in the United States and another aspect of this, you’ve got carbon free electricity. We tried to show by this graph, this does not appear in the report but I’ll be happy to share it with you or leave it behind as to what different levels of EGS deployment would do to our carbon footprint. And these are gigatonnes, this is billions of metrics tonnes of Co2 per year and this is what we have right now, the current production due to electricity production. Stationary sources, not automobiles and this is the reduction levels that we would achieve by different parts of EGS. Unfortunately as we grow bigger and we hope we don't go up this curve too far. This is the constant growth scenario, the 2100, I think that would make an extremely poor example internationally of us and it’s more likely we’re going to see some growth. But that EGS and geothermal could be a big player in the carbon reduction domain.

So let’s just summarise things very quickly. This is a big resource. It’s well distributed and this is true everywhere, not just necessarily in the US. We've got this 14,000,000 exejoules of stored thermal energy. The key point, I said this once, extractable amount of energy that can be recovered is not limited by the resource itself and its size and availability. This fits in a portfolio of renewables. The organisations that are involved with renewable energy need to combine their alliances I think much better. This is what the ACCOR organisation in the US is trying to do. They’ve been often competing for resources in the RD support domain. So you have to look for complimentarity and in EGS and Hot Dry Rock geothermal compliments this. This is base load, continuous power. Very different than solar and biomass and wind of course, which can contribute and should contribute where the grades are high in the appropriate domains. This is an extremely scaleable technology with a lot of positive environmental attributes. No carbon, no emissions. Very small plant footprints. Most of the activity is underground.

Large scale wind has challenges in our country in terms of where it’s deployed, particularly if it’s near populated areas and they're seeing this in Europe too. But geothermal would not have this particularly limitation, t he technical feasibility. We’re focussed now on connectivity in all the field tests going on around the world and in proving that we can have sustained commercial production for the long term. The economic projections are favourable. Certainly you see this in the numbers that have appeared in this report but I think if you look to other countries, projections for Iceland that have had a long history of geothermal development. What's happening in Australia, in other countries such as in Italy, reactivating their interests in geothermal and the deployment costs and this is a critical area because you're going to need this in the early years. You're going to need both Federal and State participation in a big way, along with industry. We have a fairly fragile industry in many ways that will have to take the risk and uncertainty burden to some degree in the capital investments needed to get these field sites going.

So if we're going to get on a path to 100,000 megawatts we have to do it in a way where we have engagement for multiple years in the 10 to 15 year range by the State and Federal Governments. The supporting research costs are also relatively reasonable. For the EGS portion alone we're talking about $40m. Now when you look at these new Bills that are in front of US Congress right now, these are of the order of $90m to $100m per year committed as far as they can commit in 5 or 6 years into the future, which is a remarkable shift in strategy over what we've seen in the past. The recognition that this is the kind of resource where you can't just deploy a small amount here and there, you have to get involved with fairly large field experiments. So the recommendations we made and this is very important we feel. This is the first step. You've got to engage the US geologic survey. You've got to get back out there in the field. You have to continue this fine work that Dave Blackwell and his group has done but you have to get much more site specific about it and more detailed, and you can't just do one field demonstration anymore. We have a lot of those going on around the world. We did it once in Fenton Hill a long time ago. We have to have multiple field demonstrations. That's the only way the investment community we feel in the US is going to be brought in, in accord with the risk and uncertainty reduction. Develop shallower systems in high grade areas first along with the co-produced sites that I talked about in Texas and Wyoming and other places and in the longer term look towards these deeper resources that will require more costly wells and some more advanced technology at depths greater than 6 kilometres. Put the Federal and State policies in place. They will incetivise this and maintain a vigorous R and D effort which has not been true in the US in both sub surface science drilling and energy conversion and systems analysis and when you're all done with this you come up with an investment of say $300m to $400m total spread over 15 years and I think most of you know this. This is less then the price of one single commercial sized clean coal plant and certainly within the management range, the financial management range of the US Department of Energy and the Congress today.

So I'd like to thank you. Please read our report and I'd be happy to take some questions now or later.

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