COMMONWEALTH OF AUSTRALIA

Official Committee Hansard

HOUSE OF REPRESENTATIVES

STANDING COMMITTEE ON INDUSTRY AND RESOURCES

Reference: Development of the non-fossil fuel industry in Australia: case study into selected renewable energy sectors

WEDNESDAY, 20 JUNE 2007

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HOUSE OF REPRESENTATIVES

STANDING COMMITTEE ON INDUSTRY AND RESOURCES

Wednesday, 20 June 2007

Members: Mr Prosser *(Chair)*, Mr Hatton *(Deputy Chair)*, Mr Adams, Mrs Bronwyn Bishop, Mr Cadman, Mr Martin Ferguson, Mr Haase, Mr Katter, Miss Jackie Kelly and Mr Tollner

Members in attendance: Mr Haase, Mr Hatton, Mr Katter and Mr Prosser

Terms of reference for the inquiry:

To inquire into and report on:

The development of the non-fossil fuel energy industry in Australia.

The committee shall undertake a comparative study of the following renewable energy sectors: solar, wave, tidal, geothermal, wind and hydrogen. The case study will examine the relative state of development of these sectors and their prospects for economically viable electricity generation, storage and transmission.

WITNESSES

Committee met at 9.39 am

GOLDSTEIN, Mr Barry, Chairman, Australian Geothermal Energy Group, and Australia's Executive Committee Member to the OECD's International Energy Agency's Geothermal Implementing Agreement

TESTER, Professor Jefferson, Private capacity

CHAIR (Mr Prosser)—Welcome. I declare open the second public hearing of the House of Representatives Standing Committee on Industry and Resources: a case study into selected renewable energy in Australia. The case study was referred to the committee by the Minister for Industry, Tourism and Resources, the Hon. Ian Macfarlane, on 8 May 2007. The committee shall undertake a comprehensive study of the following renewable energy sectors: solar, wave and tidal, geothermal, wind, bioenergy and hydrogen. The case study will examine the relative state of development of these sectors in Australia and their prospects for economically viable electricity generation, storage and transmission.

The committee welcomes Professor Jefferson Tester from the MIT and Mr Barry Goldstein from the Australian Geothermal Energy Group to participate in the hearing today on the theme of geothermal energy. Do you have any comments to make on the capacity in which you appear?

Prof. Tester—I am a Meissner Professor of Chemical Engineering at MIT in Cambridge, Massachusetts.

Mr Goldstein—I am the Convenor-Chair of the Australian Geothermal Energy Group. I represent Australia at the International Energy Agency's Geothermal Implementing Agreement, and I am the Director of Petroleum and Geothermal in South Australia.

CHAIR—Although the committee does not require you to give evidence under oath, I should advise you that the hearing is a formal proceeding of the parliament. I remind you that the giving of false or misleading evidence is a serious matter and may be regarded as a contempt of parliament. I also remind you that the committee prefers that all evidence be given in public. However, at any stage you may request that your evidence be given in private and the committee will consider your request. The media is here today. Do you have any objection to the media being here? There being no objection, let us proceed. Before the committee puts questions to you, I invite you to make a short statement. I apologise for the proceedings of the parliament, but that is democracy for you.

Prof. Tester—I am grateful for the opportunity to speak with you this morning about the potential of geothermal energy in Australia. Along with my oral testimony I refer you to our recently completed assessment of the potential of geothermal energy in the United States entitled *The future of geothermal energy*. I think another copy of this is circulating. It is in two forms: one is the summary report, the shorter document, and then the full documentation in some 400 pages. I was honoured to be the chair of an expert interdisciplinary panel that conducted the assessment, which was released in January this year.

Geothermal resources are usually described in terms of the stored thermal energy content of the rocks and contain fluids underlying landmasses that are accessible by drilling. The US

Geological Survey and other groups have used a maximum accessible depth of 10 kilometres to define the US resource, although conventional hydrothermal resources are already being used effectively for both non-electric and electric applications in the United States and in many other countries. Currently, some 70 or so countries are active and will certainly continue to be developed. They are somewhat limited by their locations and ultimate potential. Beyond these conventional hydrothermal systems are enhanced geothermal systems, or EGS resources, with enormous potential for primary energy recovery, using heat mining technology which is designed to extract and utilise the earth's stored thermal energy. The EGS feasibility is a result of improvements in reservoir characterisations and stimulation technologies and in deep directional drilling that have evolved over the past three decades.

One of the most interesting experiments that are now going on in Australia at Cooper Basin—and we are watching this carefully—is the EGS approach that puts geothermal on the map for potentially a much more sizeable energy resource in the United States, in Australia and in other countries. The EGS would operate in an environmentally-friendly manner, with a closed system where cool water is pumped deep into hot fractured rock reservoirs, where it would be heated and then returned to the surface to be used as an energy resource to generate electricity or directly for heating applications.

In our assessment of the United States's potential, we noted that the US geothermal resource is very large, well-distributed and provides a clean and indigenous energy supply. Widespread deployment of geothermal in the United States would have a very positive impact on energy security, on our environment and on our economic health. Based on what I have seen so far in Australia, similar statements could be made about the potential of geothermal energy here. But there has been one big difference in recent years: while Australia has been actively engaged in supporting geothermal development—notably, at the Cooper Basin site, at a number of locations in South Australia and elsewhere in Australia—the US geothermal program has been stagnated and undersupported by our federal government. Regrettably, geothermal has been ignored as a portfolio option for widespread deployment in the US, even though the US is currently the largest worldwide producer of electricity, with about 3,000 megawatts of capacity. Although this is only a small fraction of the current US generating capacity, which is roughly a terawatt, the actual potential for geothermal energy is substantially greater, as recently pointed out by the MIT-led assessment that I chaired, by the Western Governors Association analysis and by the National Renewable Energy Laboratory in the US. For example, our analysis suggests that our focused and aggressive national research demonstration and deployment program could enable US geothermal capacity to reach 100,000 megawatts in 50 years. That would be comparable to the current capacity of all our nuclear power plants and all our hydropower plants.

In addition, to achieve such levels, a capacity and natural transition across the geothermal continuum, as we call it, would have to occur, from the country's high-grade hydrothermal systems in use today in a few states in the west to the massive EGS resource available in all 50 states over a range of grades. This would need to occur in increasing amounts towards the EGS reservoir for the next 50 years. You may recall that the early migration in the United States went from east to west. The geothermal migration will go in the opposite direction, from west to east.

Fortunately, the Advanced Geothermal Energy Research and Development Bill 2007—H.R. 2304—was introduced by the United States House of Representatives on 14 May this year to direct the Secretary of Energy to conduct a national program for geothermal energy. If this bill is enacted and supported with a multiyear commitment at the levels recommended, which are of the order of $90 million per year, it will completely reactivate an important national scale effort and will pay substantial dividends.

I believe that Australia’s current leadership in EGS research has been important in influencing this change in direction for the United States. Specifically in our detailed analysis of the technical compound that is needed to make EGS work on a commercial scale, we found that the Cooper Basin field program is providing essential information regarding the ability to characterise and engineer suitable reservoirs in hot rock.

I wish to make three observations that I think we could apply both to the United States and Australia. We recommended that the federal government support geothermal resource characterisation and assessment as an important first step to enhance the quantitative assessment of the US resource on a site-specific basis. We have not looked at this seriously for 30 years. An aggressive, sufficiently supported multi-international program is needed to quantify and refine the resource base and determine what the recoverable fractions might be. Although much has been accomplished regarding the technical feasibility at the major field operations—Cooper Basin; the Soultz project in Europe; the Rosemanowes site in Cornwall, England; the Fenton Hill site, which was the original place in New Mexico many years ago; and a number of other areas of fieldwork around the world—there is still a need to get into the field with projects to demonstrate and validate that reservoir stimulation and drilling technologies can be repeatedly and reliably implemented in the field to produce commercial scale geothermal systems. This is exactly the goal of major field efforts that have been proposed and are going forward. This is a big part of the US plan if the bill is enacted. It will bring down the risks and uncertainties to levels that will enable full private investment without government cofunding.

There is enormous leveraging potential for the US and Australia to collaborate together in EGS technology development and testing. This would probably be a good place to stop. I would be happy to share with you the major findings of our report and recommendations. They are documented pretty fully in the report, but maybe we should stop here and take your questions.

CHAIR—I thank you for that, given our limited time. Barry, did you want to make a short opening statement?

Mr Goldstein—I will give you a precis of the national outlook. I have tabled some information. In effect, the Australian sector, all of the companies exploring, all of the state and Northern Territory governments and the federal government agencies with a focus on resource development and, in particular, geothermal resource development have all joined together with the vision that geothermal resources can provide the lowest cost emission-free renewable baseload energy for centuries to come. The terms of reference of the Australian Geothermal Energy Group are to provide support for international and national collaboration and to seek to commercialise geothermal resources at maximum pace and minimum cost, through information sharing and cooperating on research—basically rowing the boat, all hands on deck, in the same direction.

With that as an introduction to the fact that the sector, which is not very old—it is new—is actually acting rather mature early by gathering together and having a common vision, Australia’s vast hydrothermal and hot rock energy resources have the potential to become a very significant source of safe, secure, competitively priced, emissions-free renewable baseload power for centuries to come. This potential, combined with the evidence of risk posed by climate change, is stimulating growth in investor interest in this particular area. Most of the investments are in fact focused on enhanced geothermal systems—that is, hot rocks which are susceptible to fracture stimulation or engineering to make them sufficiently permeable to allow high rates of heat to surface flow. This can be used for power generation.

At this point in time, and it is in evidence in the document that I tabled, there are in fact 27 companies Australia wide—16 of those are in South Australia—who have applied for 149 licences in Australia, 125 of which are in South Australia. For the aggregate guaranteed and non-guaranteed work programs, out from 2002 to 2012, both what has already been spent, which is about $100 million, and what is forecast to be spent just for drilling deep wells to find out if there is a geothermal reservoir and then fraccing and flow testing but not drilling a second well into the fracture network to demonstrate that you can flow power to surface—that is a second step on the conveyer belt for geothermal activities that you need to demonstrate the resource is present—the forecast investment is $656 million across those 149 licences. Of that, $526 million is in the 125 licences in South Australia. It isn’t that South Australia will remain unique; the inner two-thirds of Australia has a great geothermal resource for which there is very little data.

Mr KATTER—Why?

Mr Goldstein—The answer is that only in the basins where there are oil wells have wells been dug deep enough to know. Wherever you do not have an oil and gas province, you do not have wells to 4,000 metres, and where you do not have wells to 4,000 metres you just do not know. So all of our maps are very uncertain.

One of the particularly valuable by-products will come out of the onshore energy security program that Geoscience Australia are undertaking, because they will be remapping and determining where we have good prospectivity but little data and where we can efficiently get the best bang for the buck in terms of data acquisition. The companies are also going to be doing that by drilling their wells. They need help. So far, there has been $28 million in state and federal grants, mostly from the federal government—$27 million from the federal government in ready and similar grants. South Australia has provided about $1 million so for. I am sure the other states are going to come to the party.

The issue is that there is a conveyor belt of activities. You need to drill at least one deep playmaker well to find out if there is permeable rock that can flow heat to surface at an appropriate rate, then fracture stimulate, then drill a second well into that, then fracture stimulate and then test that you can inject in flow to surface. That is the proof of concept. Geodynamics is heading into that in this calendar year. The rig will be on site in July. We expect to see the first proven geothermal reserves in South Australia this year.

Mr HATTON—Enhanced geothermal systems—it looks like a new steam age. There is a fundamental use of fractured rock. What problems are related to that in terms of geological stability? For instance, with a place like Yellowstone, which is a giant caldera, it can go up.

Prof. Tester—First of all, let me be absolutely clear: no-one is advocating going into Yellowstone. Yellowstone is a protected area. It is a sacred site, if you will, for geothermal advocates. When we go deeper into the domain of the six- to 10-kilometre regime, the United States begins to look like Yellowstone in terms of the temperature and heat flow that we see—certainly the temperature distribution. The major focus by far of the effort is on exactly the point that you are making—characterisation of what nature has given us at depth in terms of the stress situation, the compliance, of the rock itself. Some rocks may be open naturally—as they found at Cooper Basin, with high permeability—but the other experiments at Soultz, Fenton Hill and Rosemanowes required hydraulic pressurisation essentially to open up the permeability of a sealed natural fracture system against that stress field. Once that happens, there appears to be a common phenomenon of slippage of these natural planes and propping of them, keeping them open, for circulation. But that is the focus. We define it as connectivity—establishing connectivity between these injection wells and production wells. That is the engineering side of it. It will be different in different settings. That is why we are recommending in the US program that we have multiple field efforts underway and a strong international collaboration. With more knowledge and experience, we will come down the learning curve in a very positive way. So what happens at Cooper Basin is just as important to us in going forward in a new program.

Mr Goldstein—Australia has a comparative advantage. The continent is under compression—under tectonic scale—which promotes horizontal fractures, so there is a very high chance that all hot rocks will be naturally horizontally fractured.

Prof. Tester—Which is a big advantage—

Mr HATTON—There is a tyranny of distance problem here. Cooper Basin is in the middle of Australia. You need to build infrastructure. You have attenuation in trying to transmit the electricity to places where it will be used. That puts it in a similar situation to places that have a lot of wind energy.

Prof. Tester—Again, I would like to look at this as a pathway towards gaining the engineering knowledge you need to proceed. Looking at the Cooper Basin experiment, initially it does not matter where it is. The first thing you want to do is show that you can engineer the reservoir. As I understand it, there is quite a bit of demand locally on site and nearby with the binding and excavation work that goes on. Building long transmission pathways will have to be done in many cases. We have hundreds of thousands of miles of them in the United States. We bring hydropower from the far reaches of northern Quebec into New England and other parts. So it is improvements in that, reducing the losses. But certainly this is an appropriate area for federal and state participation in developing that kind of infrastructure. You are absolutely right. The US has the problem with wind in North Dakota, offshore wind, but it is just part of the mix. It is part of the things you are going to have to do.

Mr KATTER—Earlier you mentioned the amount of 5c. How do you know that? Is that the actual operating cost?

Prof. Tester—That is the actual cost of approaching 3,000 megawatts of geothermal power that has been on-line. The US production of geothermal electricity started in the 1960s at the Geysers field north of San Francisco. That is the largest field in the world. At its peak it was producing over 2,000 megawatts. With the exception of old existing hydro, the hydro that was federally put together in the Bonneville power project and TVA, it was the cheapest electricity we had in the United States for a long period of time. I think that a similar story would be echoed if you looked at the northern Italian fields. It has certainly transformed, with a similar low-cost price situation, the Icelandic economy, and there are good examples of this. Small countries in Central and South America are deploying geothermal, hydrothermal resources in a cost-effective way to provide and distribute power. There is enormous growth in Indonesia and in the Philippines. This is a very diverse resource in some ways, because it is already in developing countries. It is in highly developed countries, but that is conventional. Those are real costs. With all of the costs that we discuss in this study in looking at EGS we are, admittedly, looking at something that has not yet been done in terms of producing commercial size systems. But it is easy to establish the goal. You drill holes and you have power plants in all geothermal systems. The costs of those are known. What is not known is whether you could produce a reservoir with full commercial production for long periods.

The base case that we started our economic analysis with was to assume that we could emulate the conditions of a good hydrothermal reservoir. The costs are already known—real costs at 5c a kilowatt hour. So I think it is a good starting point. But any economist will tell you that that is partly speculation, so we did a full sensitivity analysis around that. You can look at where research investments could help reduce costs. You have asked the two most critical questions, which is how do the costs relate to the engineering of the reservoir. That is what all this research is about.

Mr KATTER—How deep down were those holes drilled in New Mexico?

Prof. Tester—Interestingly, in the seventies, when I was a very young man working on the project, the deepest holes were drilled to over five kilometres. The deepest holes in the Soultz project in France—most recently—under European Commission support are also in the five-plus kilometre regime. We know where Cooper Basin is, 4.2. They are going to look at the reservoir they have there at that depth; that is already a very high-grade system. The Icelanders are now drilling deep into extremely hot rock because they want to increase the efficiency of generating electricity. They have an enormously ambitious experiment to produce water at super critical conditions, above its critical point, to make hydrogen efficiently in an electric power conversion cycle. One of the limitations for making electricity out of geothermal power is that you have to live with the temperatures that you might produce a fluid at, which typically would be between 150 and 250 degrees centigrade in today’s hydrothermal systems. The critical point of water is about 370 degrees centigrade, and the properties change drastically as you go into that regime. If we had Iceland in the United States, it would be like Yellowstone. They can afford to go deep and go above the critical point. That will give them, if this works, a very high efficiency conversion to electricity and will help improve the economics of making hydrogen. We are watching that. There are other experiments that are going deep, such as the Basel experiment in Switzerland. The Landau project we do not know much about, but they are certainly in the regime. The Landau experiment in Germany is in the Rhine Graben in the same way that Soultz is. I suspect they are at a similar depth.

Mr KATTER—Can you use explosives to increase your permeability of the rock fracturing, to induce fracturing?

Prof. Tester—Let’s put it this way: virtually every technique was thought of and tried. I often find in scientific adventures that I have been on that somebody probably thought of this idea a few years back. The British, in their initial effort at the Rosemanowes quarry in Cambourne in

Cornwall—with the Cambourne School of mines taking the lead on it—initially proposed to use near well bore stimulation with explosives, and they did some explosive testing. The problem with that is not that you cannot fire off explosives in a well bore and fracture the heck out of the rock near the well bore, but we have to produce large systems, systems that go deep into the medium. Water pressure and sustained pressurisation is a much more effective way to do that. You do not get the attenuation that you do because you can drive against the stress field over long distances. Remarkably, the New Mexico experiments, the Rosemanowes experiments, the Japanese experience at Hijiori and Ogachi, and the more recent experiments at Soultz and at Cooper Basin all produce stimulated regions that have roughly the same characteristic of being of the order of a cubic kilometre or so in volume.

Mr Goldstein—Habanero stimulated a four kilometre by two kilometre area that was about 800 metres.

Prof. Tester—You could never do that with explosives. That would take nuclear explosives, and we are not proposing that.

Mr KATTER—Why aren't we looking at places near volcanoes where the heat and the magma come much closer to the surface?

Prof. Tester—We are doing about. The original Fenton Hill site is in one of the largest relatively recent calderas on the rim, the western flank, of the Valles caldera in New Mexico—a massive volcanic area, about a million years ago; even some activity maybe 50,000 years ago or so. The reason they drilled there was that it was close to infrastructure, there was an electric co-op nearby, there were roads in place and it was on a site that had been burned over by a forest fire, so the environmental impact statement was pretty easy. Most importantly, the heat flow was high—because it was near that caldera. The temperature gradients there were a factor of two higher than they would be more regionally in the New Mexico-Colorado plateau.

Mr KATTER—How deep do you have to go there?

Prof. Tester—To get to 300 degrees centigrade, which is approximately what they got to, they are at five kilometres—so the average gradient is 60 to 70 degrees per kilometre.

Mr Goldstein—Scope Energy is exploring in the Mount Gambier region, near the relatively youthful volcanoes that are in south-east Australia.

Prof. Tester—Many of the areas in the US that we evaluated have been either classified as truly volcanic EGS—you will see a category in the assessment—or on the margins of volcanic areas. You are right: this is high grading, it is exactly what you would do—get the drilling costs down. You know a lot about those resources—presumably, even hydrothermal resources may have been developed inside of that active region. So an excellent question; thank you.

Mr HATTON—Going back to Yellowstone, it is an immense caldera and a very active one. It is 650,000 years since it has blown. It is very geo-thermally active. Why aren't people looking there? Is it simply the status of it?

Prof. Tester—It is the protected aspects of it. It is a national park. We do not have to go to Yellowstone. Yellowstone is an area that provides the kind of information that we need to understand the regional geology, but the margins outside of Yellowstone are enormously high grade. One of the things that enlightens some of our western senators and governors in this review by the Western Governors Association in recent interest in geothermal in the US is that there is an enormous potential just nearby in the state of Montana, in other parts of Wyoming and in Idaho, which all sort of border into Yellowstone. On our maps you will see this big caldera region sticking out, with a high grade, but it was not included in any of our assessments. We took that off all national parks. There are a few others in the Pacific North West that also are volcanic—Mount St Helens and others that I am sure you have heard of. Those were all removed because they are protected areas. You would probably have similar cases. The Costa Ricans have that situation with volcanoes in national parks. I think that would be the desperation move and, fortunately, for EGS and geothermal we do not have to do that. There is plenty of it outside of those protected areas.

Mr Goldstein—The Australian Geothermal Energy Group—and it is in the evidence I have tabled—has formed 10 technical interest groups which are different key aspects that entail uncertainties, problems we are solving, on the pathway to commercialising hot rock energy. In effect, we are trying to get to all of the universities in Australia, which have a tremendous amount of competencies, and which are not now focused on geothermal, to make them aware that these are some of the problems we are solving in geothermal. So we can get the mechanical engineers, the chemical engineers, the geophysicists, the geologists, the mining people in our universities and in service companies focused on geothermal which is brand new. We have to bring the right people to the right problems. So we are trying to work on that. Eventually we envisage some kind of national cooperative research organisation that would make sure that we are all rolling in the same direction from all support parts of Australia.

CHAIR—We are out of time. Thank you for appearing. Are you intending to table that hard copy?

Prof. Tester—I would be happy to give that to you.

CHAIR—It is proposed that the Australian Geothermal Energy Group vision statement and the document *The future of geothermal energy*, provided by Professor Tester and Mr Goldstein, be received, taken as read and incorporated in the transcript of evidence. Do members have any objections? There being no objection, it is so ordered.

Resolved (on motion by **Mr Katter**):

That this committee authorises publication of the transcript of the evidence given before it at public hearing this day.

Committee adjourned at 10.10 am