RESUMED **[10.59 am]**

COMMISSIONER: It is 11.00 so we will resume. Professor, thank you very much for joining us from New South Wales. You have taken the oath. Mr Jacobi.

MR JACOBI: Mark Diesendorf is an associate professor in interdisciplinary environmental studies at the University of New South Wales, Australia. He was previously a principal research scientist at the CSIRO, a professor of environmental science and a founding director of the Institute for Sustainable Futures at the University of Technology Sydney, and a director of Sustainability Centre Pty Ltd.

Currently his principal research is on rapid mitigation of global climate change, and in particular integrating renewable energy on a large scale into electricity supply and demand systems. He's a member of the University of New South Wales Research Group modelling 100 per cent renewable energy in the National Electricity Market. His most recent book is Sustainable Energy Solutions for Climate Change published in 2014. He's also made a submission to the Commission which is available on the Royal Commission's web site. Welcome, Mark Diesendorf.

COMMISSIONER: Professor, can I start perhaps at the high level, to discuss the extent to which policy has an effect on electricity generation in Australia. In your view, how important is it that government policy is shaping our current system of electricity generation?

ASSOCIATE PROF DIESENDORF: Government policy is crucial in any system where there's a transition going on, and right now we're seeing a substantial transition happening with solar PV becoming very cheap so that residential solar PV is cheaper than buying electricity from the grid in most of Australia now. We're also seeing wind power becoming cheaper still but not at such a fast rate any longer as solar PV. Then we have the question of policy for climate change, which has been having its ups and downs, both at the federal and various state levels. So policy can influence very greatly the rate of change of the energy system. At this stage I think that some technological changes are unstoppable, almost whatever policy happens. So that rooftop PV is pretty close to being unstoppable now, although government policy, federal and state, can influence the rate at which it continues to grow. I don't think they can stop the growth.

So these are just some general remarks, but perhaps I should make some comments on policy with regard to South Australia. I guess the first thing that comes to mind is that business as usual - in other words, doing nothing - is not an option for South Australia right now because we have a situation where Northern Power Station and Playford B are likely to close very soon and Pelican Point Unit 2 is no longer operating under normal conditions. So we already have a situation where - and Torrens Island A is likely to be closed in 2017. So we have a situation where some of the major power stations in South Australia which are fossil-fuelled are going to be closed and in fact most of those stations have not been operating at full power continuously for the last few years. So just ignoring that situation isn't an option.

The result is that AEMO envisages that by 2019-20 South Australia will be in what they call a low reserve situation already. On a time scale of three to five years, it seems to me that the only options for dealing with that situation are new sources of renewable energy supported by some additional gas turbines if necessary, and possibly some enhanced transmission from Victoria. That's on that short time scale of three to five years. Nuclear energy is at least 15 to 20 years away, possibly even much longer than that, if it ever occurs. So it's not really an option in the short or even the medium-term.

Either by good luck or good management, South Australia has followed a pathway that actually, in the view of our research group at the University of New South Wales, is probably the best pathway for dealing with the current situation where it already has 39 per cent of electricity consumption coming from renewables; about 33 per cent last year from wind and about 6 or 7 per cent from rooftop solar PV. It's going to increase partly thanks to the ACT, which is going to build the Hornsdale Wind Farm of 100 megawatts. So South Australia is already proceeding on a renewable energy growth pathway.

In addition, the Heywood transmission link joining South Australia to Victoria is currently being upgraded and that's scheduled to be finished next year about 31 July, as I understand. So it's an upgrade of about 200 megawatts, which will also make it easier to handle the fluctuations in the growth in wind power in particular.

COMMISSIONER: We might stop there and dive into the detail I think, Mark.

ASSOCIATE PROF DIESENDORF: The point I'm trying to make is really that this transition can be assisted by good government policy at the state level and of course at the federal level if there are changes in the current policy in the future. Maybe later, if you want to, we can talk about the kinds of policies that would assist that transition.

COMMISSIONER: I'm sure we will.

MR JACOBI: In fact, Associate Professor, I think this is where I was going to pick up. Your submission refers from about page 35 in terms of achieving the scenario that you refer to, which is a high penetration renewable outcome, to a range of policies. Am I to understand that it would be necessary for those policy settings to be put in place to achieve the outcome you describe? These are the policies that are referred to as targets, incentives, certificates, options, capacity payments and an adjustment to feed-in tariffs.

ASSOCIATE PROF DIESENDORF: Some of the policies would be necessary to drive large-scale renewable energy because at this stage wind and solar PV and big solar PV are more expensive overall than coal and some gas. So there is a gap in the large-scale price, although the gap is closing. Now, I say that but I mean it depends how you do the economics. If you're taking into account the cost of the environmental and health and social damage of burning fossil fuels then it's very likely, depending on whose analysis you look at, that a hundred per cent renewables will be cheaper.

In fact, in our scenario study for the National Electricity Market, which includes South Australia, we found that by taking the most conservative projections of costs of renewable energy and fossil fuels to 2030, which is the initial projection by the Bureau of Resources and Energy Economics, taking their projections - and I say they're conservative because their 2012 projections for solar PV made for 2030 were actually achieved last year, so they are in my view the most conservative - taking their assumptions then with a carbon price of $50 a tonne of carbon dioxide upwards, a hundred per cent renewables would be competitive now. In the absence of a carbon price, if we removed all the subsidies to the production and use of all fossil fuels in Australia, which are at least $10 billion a year, a hundred per cent renewables would be competitive now.

Now, that's taken the BREE projections of the economics to 2030, but if we take

Bloomberg New Energy Finance you probably wouldn't even need to worry about removing the subsidies from fossil fuels.

MR JACOBI: In your answer there you referred to there being a market price fixed for emitting carbon.

ASSOCIATE PROF DIESENDORF: Yes.

MR JACOBI: Coming back to my earlier question, do you regard that as a critical feature for the - - -

ASSOCIATE PROF DIESENDORF: It would be a very important feature in two ways, really: first, it's a way of including the environmental and health and social costs of burning fossil fuels and using fossil fuels in the actual price of electricity; but, secondly, it sends a message to investors that it would be financially very risky to invest in the future in more fossil fuels. So the carbon price, at times I've thought it's necessary but maybe it's only very strongly advisable because if we don't have a carbon price but we have other policies then there's a contradiction between the policies. But we do need some of the policies that are essential are to have targets for greenhouse gas reductions, state and federal for 2020, 2025, 2030, to have targets for renewable energy, renewable electricity in particular, again for 2020, 25 and 2030. I think we need the targets and then we need some policies to actually ensure that those targets will be implemented because if we leave it to the market it is going to take a lot longer.

MR JACOBI: I guess what I am getting at is, you started out by talking about the falling costs associated with generation - - -

ASSOCIATE PROF DIESENDORF: Yes.

MR JACOBI: - - - particularly from solar PV and wind and I am just interested to understand your view as to whether or not the economics alone will justify – will lead to a transition to the outcomes, the high penetration outcomes you describe, or whether it is going to need to be a combination of that and policy?

ASSOCIATE PROF DIESENDORF: There is going to have to be some policy at this stage until – particularly until wind and big solar decline in cost by several cents, up to four cents a kilowatt-hour at present. With roof top solar, at present, in many states and many electricity retailers are paying very, very small feed in tariffs already, in fact some pay zero, Momentum Energy pays zero cents a kilowatt hour going up to at most eight cents a kilowatt hour, compared with the price of – retail price of grid electricity which can vary upwards from 25 to 35, even to 55 at certain times of the day. So for businesses or homes that use significant amounts of electricity during the daytime, rooftop solar is highly cost effective now for avoiding buying electricity from the grid even if they get no feed in tariff. The problem is that, for many people are not at home during the daytime, for example, and so without battery storage the solar energy they collect effectively goes to waste in terms of reducing their household electricity bills and so those people in that situation will have to wait for battery storage to become more economical.

MR JACOBI: I just want to shift the focus of our discussion away from particular generating technologies to the system as a whole.

ASSOCIATE PROF DIESENDORF: Yes.

MR JACOBI: Now as I understand it, from your submission, your group at the University of New South Wales has undertaken a study directed at the directed at the technical, or at the first level, at the technical feasibility of a high penetration scenario. What was your conclusion with respect to its technical feasibility?

ASSOCIATE PROF DIESENDORF: Well, we conclude that a 100 per cent renewable electricity system in the National Electricity Market is technically feasible. We can make the transition now based on existing commercially available renewable energy technologies and we can achieve the same reliability as the existing mainly fossil fuel based system in the National Electricity Market. So the key first question is the reliability and we have no doubt that we can produce a reliable system. We have now analysed eight years of hourly data from across the National Electricity Market. That is hourly data on demand on wind and on sunshine and we can achieve a reliable system. Based - - -

MR JACOBI: Can I come back to reliability - - -

ASSOCIATE PROF DIESENDORF: Yes.

MR JACOBI: - - - because I - - -

ASSOCIATE PROF DIESENDORF: Okay.

MR JACOBI: - - - want to talk about that - - -

ASSOCIATE PROF DIESENDORF: So technical feasibility and reliability are closely related.

MR JACOBI: Sure.

ASSOCIATE PROF DIESENDORF: Sure.

MR JACOBI: I am just interested in understanding you have mentioned that it is based on a technology that exists now - - -

ASSOCIATE PROF DIESENDORF: Yes.

MR JACOBI: - - - in terms of the generators, am I right in understanding that includes concentrated solar thermal as well as biofuel driven peaking gas plants?

ASSOCIATE PROF DIESENDORF: Yes, the role of the biofuel gas turbines is now tiny. In our latest results that so far have only been published in international conferences but will be published in journals with our eight year study and taking many sites across the National Electricity Market, we find that biofuel gas turbines only need to contribute about two per cent of the annual electricity generation. And so it doesn't matter that the cost per kilowatt-hour of gas turbine use, whether it is biofuelled or fuelled on natural gas, it doesn't matter if that cost per kilowatt-hour is high because there is hardly any kilowatt-hours per year. So the annual cost of putting in those gas turbines is very low and in fact we treat the gas turbines as essentially a form of cheap storage or cheap reliability insurance.

MR JACOBI: In terms of plant size, what sort of plant size are we looking at with respect to the concentrated solar thermal plants and the biofuel plants?

ASSOCIATE PROF DIESENDORF: Well, sort of standard size, 50 megawatts electrical for concentrated solar thermal. It depends – the plant size depends a lot on the policy measures that are used. For example, 50 megawatts electrical has become the standard in Spain because the governments only agreed to pay feed in tariffs for up to 50 megawatts. So the Spaniards rolled out 50-megawatt units and they do that very easily but some of the latest CST plants are bigger than that, the order of 100 megawatts.

MR JACOBI: Yes.

ASSOCIATE PROF DIESENDORF: Solar PV plants can be built on a whole range of different seizes, so the plant that has just been finished in Nyngan in Western New South Wales is 102 megawatts but solar PV can be – you know, it can be this small to run a light in a developing country, or it can be hundreds of megawatts depending on land use and various other factors.

MR JACOBI: Perhaps returning to the overriding theme in the opening part of the questions, in terms of achieving the high penetration outcome - - -

ASSOCIATE PROF DIESENDORF: yes.

MR JACOBI: - - - that you have described, is that something that will be arrived at in the system on its own, or does that require government policy to achieve that particular outcome?

ASSOCIATE PROF DIESENDORF: I am sorry, I am not quite sure what you mean by in the system - - -

MR JACOBI: Okay.

ASSOCIATE PROF DIESENDORF: - - - of its own? Do you mean according to - - -

MR JACOBI: Will the economics - - -

ASSOCIATE PROF DIESENDORF: - - - the current market?

MR JACOBI: Yes. Will the economics drive that particular outcome?

ASSOCIATE PROF DIESENDORF: Not at present. Not without some government policies to support the transition. I am talking now about large-scale transition. So – yes.

MR JACOBI: Right.

ASSOCIATE PROF DIESENDORF: I can expand on that if you want to me to?

MR JACOBI: I am interested in understanding; you have described it in terms of technologies that exist at present. I am just interested in understanding have you modelled how quickly such a transition could be made in terms of transition from the current state of generation technology that exists in the grid, to the sort of outcome that you have described?

ASSOCIATE PROF DIESENDORF: Well, to really model a transition rigorously, you need to do an entirely different kind of study and to my knowledge; nobody in Australia has really done that properly. We haven't attempted to do that. What we have done is look very simply at the kinds of technologies that are needed and the construction times. The construction times for solar PV power stations and wind farms are very short and some – in some cases one year, two years, at most three years, compared with large fossil fuel or nuclear stations where you are talking about much longer time scales. So construction time isn't a limit but there are issues about where are these plants going to be manufactured. Now ideally, many of the components would actually be manufactured in Australia, preferably South Australia, and in fact this is feasible for some of the larger components, say wind turbine blades. Towers already manufactured in Australia, wind turbine blades, most of the wind turbine components in the hub and the blades were actually manufactured in Australia for Vestas back in 2006. At the time, we had a renewable energy target and it looked like it was going to be extended and Vestas which is the world's large – was then the world's largest manufacturer of wind turbines, set up a blade manufacturing factory at Portland in Western Australia and another factory for manufacturing hub components in Wynyard in Tasmania and the opportunities and the job opportunities were absolutely fantastic. It is expensive to ship these large components between continents, unlike solar PV modules for example. So there was real opportunity there and there were a lot of jobs created but sadly the expected – well, the first thing was that people realised that the then renewable energy target for 2010 was effectively reached about 2006, and when Labour promised before the 2007 election to expand the renewable energy target sadly took them three years in office to actually do it, so the result was that those factories closed down and a lot of jobs were lost, so I'm just trying to come back now. What was the original question?

MR JACOBI: I was interested to understand how quickly the transition could be realised.

ASSOCIATE PROFESSOR DIESENDORF: Depending on industry support policies from federal, state governments personally I think 2030 is quite feasible for a hundred per cent renewable electricity for the whole of the national electricity market and probably in South Australia with the right policies earlier than that, but part of the government incentive would need to be to introduce policies to support those industries in the early stages, to encourage them to locate in appropriate places and so on and to ensure that there's appropriate training and so on required.

To cut a long story short the reason we didn't try to do a rigorous study of the details of the transition was that you have to make all these additional assumptions about additional government policies in addition to just transitioning the technology, but we have done one thing that I should say. Very recently we have presented a paper at an international conference on a transition in which we look at a steady transition from year to year out to 2030, going from the current renewable energy contribution in the NEM to a hundred per cent and what we've looked at is the cost. Based on the current projections how does the cost vary as the penetration of renewable energy increases and the preliminary results are that there is negligible increase in cost, up to 50 per cent renewable electricity across the whole national electricity market and then there is a small increase after 50 per cent to a hundred per cent, but it's significant. It's under 10 per cent from memory, so that study has been presented at an international conference and the paper's available, but it came out after our submission, so I can provide that if that would be of interest.

MR JACOBI: Yes, the Commission would be interested in a copy. I'm just interested to understand you expressed a projection of about a 10 per cent increase from 50 per cent upwards. Does that apply in what I might describe as the last quartile where one is squeezing out the last amount of what I might say is entrenched fossil fuel?

ASSOCIATE PROFESSOR DIESENDORF: Yes, to some extent although by that time most of the coal has gone across the whole national electricity market and that's Victoria, New South Wales, Queensland, which are the coal states. The last few per cent may not be very difficult, it depends on the relative costs of fuelling gas turbines with natural gas or - with fossil gas or with renewable gases or liquids and in our estimate it's going to be roughly about the same, but nobody can be absolutely certain of that and it's possible that the renewable gases and liquids will actually be cheaper than fossil gas by 2030 because, certainly what's happening in the eastern states, as I'm sure you're aware, the growth i export of natural gas and coal steam gas is dragging up the domestic price of gas and in Queensland it's dragged it up almost to export prices, which are now – they're nearly three times what they were five years ago and the same increase is starting to occur – has already occurred, but not to the same extent in New South Wales. We also don't know how much gas is left in the Cooper Basin for South Australia and it may well be that gas becomes a scarce recourse; not so scarce that it can't be used in a very limited way for fuelling gas turbines just to fill in the gaps in sunshine and wind that occur occasionally, particularly on winter evenings following overcast days, but it may well be that gas is quite expensive or fossil gas and in that case biofuel gas from agricultural residues, for example, may even be cheaper.

MR JACOBI: Can I move to dealing with transmission?

ASSOCIATE PROF DIESENDORF: Yes.

MR JACOBI: Your submission refers to transmission augmentation on pp.38 and 39 and I'm just interested in understanding whether transmission augmentation is a necessary condition of the transition that you describe.

ASSOCIATE PROF DIESENDORF: Yes. First there is already some modest transmission augmentation taking place with the upgrade of the Heywood link by about 200 megawatts, so we assume that that will be all completed very soon. Is upgrade of transmission beyond that necessary? We think the answer is no. We have done a preliminary simulation of South Australia in isolation from the rest of the national electricity market. AEMO thinks that a failure of the links to Victoria is extremely unlikely. For example the Heywood link is a double circuit link, so there's two sets of power lines basically, so it would need a deliberate terrorist strategy to bring them both down at that same time. AEMO says it's extremely unlikely, but we thought we'd have a look and so the first result we have got is that it would be possible and reliable to run South Australia in isolation on a hundred per cent renewables, which would be mostly wind and solar PV and concentrated solar with thermal storage, but the whole system will work much better with augmented transmission because there's still huge untapped potential for wind and solar in South Australia that could be used in the eastern states, so for this reason we do recommend that in the longer term, and it is in the longer term because you can't build a transmission line as fast as you can build windfarms and solar power stations, but in the longer term we think it would make sense to build a new transmission line joining Port Augusta to Broken Hill in New South Wales and then from Broken Hill to the main 500KV grid in eastern New South Wales and this would have multiple benefits both for South Australia and for New South Wales, so it would mean South Australia could sell more excess wind to New South Wales; it would mean New South Wales could feed solar power from large solar power stations in western New South Wales into its main grid and if hot rock geothermal power ever becomes commercially available, currently it's only been demonstrated in a very small scale around the world, then it would be possible to join the proposed geothermal in northern South Australia to Broken Hill and into that line.

MR JACOBI: Before new transmission can be constructed I understand that there's a requirement that there's a demonstrated net market benefit associated with that transmission being constructed.

ASSOCIATE PROF DIESENDORF: Yes.

MR JACOBI: I'm just wondering whether that's been modelled for the sort of proposal that you're speaking about.

ASSOCIATE PROF DIESENDORF: To my knowledge it has not been modelled. The National Transmission Network development plan didn't model that. It did model an alternative, which I think I should have given more weight in my submission, which is an additional 500KV link between Heywood in Victoria across to South Australia and that was modelled to have a net present value that was positive, I think about $90 million from the top of my head, but I've got the figure here somewhere, so almost certainly AEMO and others would put that at a higher priority than joining New South Wales. The joining of New South Wales we put emphasis on because strategically in the longer term it makes more sense. The problem with the kind of market analysis done for the national transmission development network development plan – I've jumbled that up – the problem with that is that they're just doing a cost benefit analysis at the margin, in the short term, so they're not really taking a long term strategic approach, which I think is really important to take if you're planning a future direction for electricity in Australia, so they're saying, you know, "At the margin the year after it's completed", there will either be net benefit or not however I guess my submission is proposing that if you take a more strategic view linking South Australia to New South Wales directly would be valuable but not essential. I mean most of our modelling has been done without including that link but the whole system works better.

The National Electricity Market is almost unique in the world; that is, it is a long skinny transmission system extending from Northern Queensland through New South Wales and Victoria to South Australia - many thousands of kilometres long. This is not an ideal system in terms of designing a reliable stable system. Although I'm not a transmission engineer, my transmission engineer colleagues inform me that linking South Australia to New South Wales would have a number of technical benefits in operating the whole National Electricity Market.

MR JACOBI: You've described the NEM in Australia as being a long skinny spine. The submission refers to a number of examples internationally of countries that have a high penetration outcomes and I'm just interested in, given some of the differences between those countries - in particular, Germany I think is one of the countries that's referred to - I'm just interested in understanding - this is at page 23 - about your view as to whether they're a useful comparator for South Australia, given that some of those jurisdictions have high population densities and high levels of interconnection.

ASSOCIATE PROF DIESENDORF: Germany actually has severe disadvantages compared with Australia in some ways because it has large wind potential in the north and some fairly limited solar potential in the south. The problem is it doesn't have sufficient transmission links between north and south partly because there's very strong community opposition to building new high voltage transmission lines. On that issue I understand the environment movement in Germany is split. Yet it would be very valuable for Germany, and indeed for the whole of Europe, to be able to join the solar south to the windy north. So the result is that all the large-scale developments of renewable energy in Germany has been wind and most of the small-scale development has been solar in the south.

Probably a better comparison would - I'm just thinking. See, South Australia in many ways is far ahead of many of these European countries in terms of renewable energy resource because you have here huge wind potential and huge solar potential, while if you look at the northern Europe countries, they have big wind potential - not as big as South Australia - Denmark, Germany, the Netherlands, those northern European countries, and they have very little solar potential until you get down to the Mediterranean, where Spain and Portugal and little bits of Germany, like around Freiburg, have reasonably good sun. But comparing South Germany, you're comparing it to the solar input in Tasmania. So actually in terms of the resource, South Australia can operate much better.

Now, nevertheless, despite these limitations in northern Europe, two German states are now operating at a hundred per cent net renewable electricity, and they are Schleswig-Holstein and Mecklenburg-Vorpommern. By "a hundred per cent net", I mean that there is trading in electricity by transmission line between those two states and other states neighbouring to them around. So if they have an excess of wind power - and most of their renewable energy is wind in North Germany - they can sell that. If they have a deficiency of wind, they can buy-in. That's another reason why it's important for South Australia to remain connected to the rest of the National Electricity Market. It makes it much easier to provide a smooth, reliable renewable energy supply system that doesn't have completely outrageous fluctuations.

So we can compare with some of these other states and other places but in some ways South Australia has quite a number of advantages that it seize if it makes that decision.

MR JACOBI: I understand that there might be advantages in terms of generation and the question I was getting at was trying to draw comparisons between systems. I'm just interested in whether in your view there is relevant comparator between the sort of system that South Australia has and the extent and the depth of its interconnection with Victoria and New South Wales, and any of the international cases to which you refer - stepping away from generation.

ASSOCIATE PROF DIESENDORF: One of the points you made before is certainly important, and that is the lower population density in South Australia. There are some excellent wind resources in South Australia in areas where there are very few people to actually use that resource. That is a factor affecting decisions about extending transmission lines and so on. That certainly is different from northern Europe where the population density is much higher. So that would be one factor. But as I said, I'm not a transmission engineer, although I come from a family of electric power transmission engineers.

But I guess the other factor is that despite some of the key limitations like the lack of a strong enough north-south transmission links in Europe, there is quite a bit of international interconnection which has some advantages. It also has disadvantages in terms of reaching agreements between the countries about who pays for what. For example, there is a proposal for a new offshore transmission line running off the coast of Europe across northern Europe and joining the British Isles, and the main issue there is not the technical one but how different countries are going to contribute to the cost of it because most countries will benefit - probably all the northern European countries will benefit from that. It will enable integration of huge amounts of offshore wind power into the onshore electricity load centres of northern Europe but there are difficulties there. Perhaps they're similar to the difficulties of getting the Australian states to agree on some things.

MR JACOBI: On page 9 of your submission, in answer to one of the questions posed in one of the Commission's issues papers you explain the unique circumstances of South Australia and you express a view concerning the unsuitability of nuclear energy in that context but it's expressed in terms of drawing a distinction with the rest of the NEM. I'm just interested in drawing out your view as to whether there are features in the rest of the NEM that differ from South Australia that would make your answer with respect to nuclear energy different in those jurisdictions.

ASSOCIATE PROF DIESENDORF: The rest of the NEM is much bigger and what we're looking at at present, if we're talking about commercially available nuclear technology, you're talking about nuclear power stations of 600 megawatts upwards. That's, to my knowledge, the smallest commercially available nuclear power station. Although a number of people have been touting smaller plants that don't actually exist yet commercially, like the PRISM. So there's a real problem in integrating a single unit of 600 megawatts into a state whose maximum demand is only 3300 megawatts or thereabouts.

The existing largest unit size, if I remember correctly, is only 270 megawatts. So there are actual problems of handling a large power station in what is in a relatively small grid. I'm not into the fine technical details but generally speaking one wouldn't attempt to integrate such a large station into such a relatively small grid. Now, in the larger National Electricity Market it is certainly possible to integrate 600 megawatts as a single unit. That's not an issue. In fact in New South Wales the nominal generating capacity of some of the units are 660 megawatts. So in terms of unit size, South Australia would have great difficulty in coping with a unit of that size, while New South Wales or Victoria probably could manage that unit size. That's part of the problem.

The other part of the problem for trying to integrate nuclear in to South Australia but also the NEM is that it is operating costs are higher than that of a wind farm or a solar farm. The current way the market works is that power stations are bid in to the grid and operate in a price for electricity which is based on their short run marginal costs, their operating cost, although sometimes they play games around that and they might bid below – they might bid to operate at a loss, if they don’t want to shut down. But generally speaking, the operating cost is the first approximation to what they are going to bid. What we have already seen in South Australia with the growth of wind power is that wind is displacing – well, has been displacing coal very effectively but it is also displacing – displaced half of Pelican Point which is gas because their operating costs are much higher because of their fuel costs.

So with gas, you are looking at about four cents a kilowatt-hour, I think, if it hasn't changed much and with coal at least one cent a kilowatt-hour these are just operating costs. They don't include the capital cost component and wind can be operated much more cheaply than that. So what wind is doing, as its penetration increases, it is displacing what were formerly base load stations and turning them in to intermediate load stations which means that they are not operating continuously. Their income is reduced and the other thing that wind is doing is reducing the wholesale price of electricity in South Australia and that has been clearly demonstrated by work of Hugh Saddler in Pitt and Sherry. So wholesale price is declining as the result of wind and that is again, the way the national electricity market works. The final price of electricity at any time step which might be a five minute time step, so the cheapest gets the first priority and then it goes up to the other bids until the demand is supplied and then the highest price that is bid determines the price of electricity for that time step. With the growth of wind, that highest price has declined. So the wholesale price of electricity in South Australia has declined as a result of wind but as far as I can see that benefit hasn't been passed on to retail customers.

But that is a real problem for nuclear and fossil fuels in the current way the national electricity market is organised and the only way nuclear could operate in this system would be if they got a further subsidy in addition to all the other subsidies they get which is to allow them to operate continuously even though it is cheaper to operate wind, and solar for that matter. So this is a real issue and it hasn't really been given much public discussion, pretty well any public discussion although it is discussed in the more specialist websites like Renew Economy. In Germany it is an issue too. In Germany the wholesale price of electricity is declining and displacing other formerly base load plants and in Denmark the same thing has occurred.

MR JACOBI: By subsidy did you have in mind the notion of a capacity payment?

ASSOCIATE PROF DIESENDORF: No, no, I was just referring to all the other subsidies that go to nuclear energy which I enumerated – listed in my report – in my submission.

MR JACOBI: I just wondered, we touched briefly before upon the modelling of reliability of the system - - -

ASSOCIATE PROF DIESENDORF: Yes.

MR JACOBI: - - - and you referred to some computer simulations which I think you address in your submission at page 26 and this is after a discussion about the practical experience.

ASSOCIATE PROF DIESENDORF: Yes.

MR JACOBI: And I am just interested to understand – you explained that that modelling had been done; I think you said, now over eight years – over an eight year set of data, on an hourly basis.

ASSOCIATE PROF DIESENDORF: That is correct. So the papers we have published in international journals so far, were based on a single use modelling which was 2010 but since then we have presented several papers at international conferences and we have submitted them to journals based on eight years of simulations. The results basically don't change. So one, it actually gives quite a good picture, and I should say that current research that I am just writing up for a paper, we have a synthetic data set of 30 years. Well, it is synthetic in the sense that it is based on satellite data provided by NASA and even with 30 years it is – well, it is looking like there is no major problems to supply 100 per cent renewables, provided we have got some means of filling a few small gaps that usually occur on winter evenings such as with gas turbines or further down the track, possibly with batteries.

MR JACOBI: Is there a reason for a choice of doing it on an hourly basis, or would it be preferable to do it on a deeper basis that is more granular than an hour?

ASSOCIATE PROF DIESENDORF: Well, our colleagues, and we have collaboration with University of Melbourne Energy Institute, they have been looking at much shorter time scales. Much shorter time scales are particularly valuable for studying solar energy because a cloud can pass over, overcast can develop fairly quickly, so they have started to publish on shorter time scales, much shorter time scales. But in terms of wind which is probably going to be the principle contributor, wind doesn't very suddenly across a large area, even a single wind farm might spread out 10 or 20 kilometres and so if you have got wind travelling at 20 kilometres an hour and it suddenly drops, it is going to take time across the wind farm before the whole wind farm drops. Then if you have got wind farms separated by hundreds of kilometres you can really track the changes in wind very easily and you are not going to get sudden disappearance of wind. And if you take the whole national electricity market, we have done some preliminary studies including – well, we have done more than preliminary studies now, including more sites in New South Wales and Queensland. So in our early work, we simply took the existing wind farms and we scaled them up and they are almost all in South Australia or Victoria and they are almost all in the same wind regime so you have a situation where you get deeper fluctuations in wind than you would get if you spread them out.

Certainly our work suggests that if you spread out, you put some more wind farms in New South Wales where the wind regime is quite different in some regions, like in western New South Wales or parts of Queensland, it smooths out the variations to a considerable degree. Smooths out the variations in wind. Similarly with solar power stations, although already in our simulations we had initial simulations were based on rooftop solar in every capital city within the national electricity market, so there was geographic variation there.

MR JACOBI: The reason I asked the question with respect - - -

ASSOCIATE PROF DIESENDORF: Yes.

MR JACOBI: - - - to the hourly times is, perhaps we can come to wind especially - - -

ASSOCIATE PROF DIESENDORF: Yes.

MR JACOBI: - - - and is that sufficient to pick up what might be described as a low probability extreme event to model on an hourly basis?

ASSOCIATE PROF DIESENDORF: The hourly data gives very good results for the reasons I just indicated, that wind takes a long time to fluctuate across a region. So yes, hourly data is pretty good. Others have done half hourly, it makes no difference. It is the kind of thing we are interested in, really with very short term, say measurements on seconds or minutes is – relates more to the stability of the grid rather than the reliability. So earlier this morning, AEMO referred briefly to questions of stability of frequency maintaining a fixed frequency of 50 cycles per second in the alternating current provided by the grid. That needs to be investigated on very short term, very short time scales as well as longer term time scales. That is perhaps really a separate problem but it is of interest and we have done some – there are certain things you can learn on an hourly time scale even about frequency response that – say, for example, some of our simulations we have constrained the mix of renewable energy to ensure that there's always some rotating machinery on the grid in terms of concentrated solar thermal or gas turbines or hydro with water turbines, so that increases the cost a bit, slightly, so we can specify, for example, that the component of wind and solar PV is limited to 70 per cent annual average or even hour by hour or 80 per cent and we find that we can still provide a stable system, at least on that time scale, but if you want to discuss more details of the frequency component we can hive that off separately if you like.

MR JACOBI: I was hoping to pick up on some comments you made about the relative costs of nuclear and wind.

ASSOCIATE PROF DIESENDORF: Yes.

MR JACOBI: At page 33 of your submission you address comparisons of levelised cost.

ASSOCIATE PROF DIESENDORF: Yes, that's right.

MR JACOBI: I'm just interested in understanding and taking that as read in a sense and then picking up from that and thinking about do you consider that LCOE is on its own a sufficient metric to compare generation technologies or - - -

ASSOCIATE PROF DIESENDORF: No, I don't. It's a very useful metric, that's the levelised cost of energy, but there are other factors that I mention in my submission. For example the operating cost is also important, even though it's part of LCOE it needs to be looked at separately in terms of the merit order effect that I mentioned before where power stations with higher operating costs are going to get displaced by those with almost zero operating costs like wind and solar PV, so that's an issue there. It's an issue in terms of whether there will ever be another substitute for Pelican Point for example which is – can think of either as a base load or intermediate load gas fired turbine with an operating cost of at least four cents a kilowatt hour. In fact it would be more than four cents because that's only the fuel cost, so that's another factor. The actual capital cost in dollars per kilowatt is also relevant in terms of how you're going to finance the power station, so that needs to be looked at separately even though it is also included, smoothed out within the LCOE. I've just got to check my submission where I actually listed – my notes actually where I listed some of this.

MR JACOBI: If you give me a sec I'll help you find what I think you're referring to.

ASSOCIATE PROF DIESENDORF: Just one second.

MR JACOBI: I think you're referring to page 32, some dot points there. Is that right? No, sorry.

ASSOCIATE PROF DIESENDORF: No. It is in the submission, but I just have to go back to that part, so it's in the main part of the submission because I know I'm overlooking some things. Here we are.

MR JACOBI: 28?

ASSOCIATE PROF DIESENDORF: Yes, I've got it, so it's on pages 3 and 4 of the submission where I've put in this table. Then there's the question of integrating into the grid, which is relevant for both renewables and nuclear and I guess that's another factor. I'm just trying to find the – somewhere it's been written down.

MR JACOBI: That's all right. Perhaps if we step away from the submission for just a minute and what I'm interested in understanding is how one moves away from the LCOE I guess in a sense. Am I right in thinking that it's a relevant starting point, but the question is then how one moves away from it?

ASSOCIATE PROF DIESENDORF: It is.

MR JACOBI: I'm just interested in understanding its limits having read some debate in a recent IEA publication about whether it captures the full value. Perhaps if I put it this way: do you agree that LCOE in essence assumes that energy from different sources has the same economic value?

ASSOCIATE PROF DIESENDORF: Yes. Yes, it does, so it doesn't deal with issues like the greenhouse benefits of the technology, the benefits of the technology in reducing air pollution and associated respiratory diseases. There's a whole range of benefits that are not necessarily directly economic although they have economic implications that can't be encompassed in LCOE. To some extent it could if you internalised the external costs, but that isn't usually done in using LCOE.

MR JACOBI: What about the imposed system costs, that is in essence that a certain plant will need different backup capacity?

ASSOCIATE PROF DIESENDORF: That's not really included, but in our work we've looked at the costs to the whole system, so if we compare a hundred per cent renewable, say, with an all gas scenario those costs are included except to the extent that in our simulations we haven't done detailed transmission studies, so we've treated the transmission at a high level, a top down level, and to actually deal with the fine details of the transmission system would make the whole study very involved, so we haven't gone to that extent yet. Again I think that's something that Melbourne University is beginning to look at and possibly AEMO, so we have done some costings of including one or two additional major transmission spines in the system, so we did look at what it does to put in a major transmission link between South Australia and New South Wales and one between South Australia and Queensland and that basically added 10 per cent to the capital cost, so it's significant, but it's not going to change the whole ball game because an error or uncertainty of 10 per cent, I mean, sort of disappears in the uncertainties of the policy process of facilitating technology, so the point is that if you look at the whole hundred per cent renewable energy system it really includes the backup. In a sense the gas turbines that are in there are the backup for periods, the rare periods, when there's simultaneously insufficient wind and sunshine. It needs to be probably addressed in more sophistication still in the simulations, but basically we’re at a stage where we can whole scenarios and that’s what we’ve done, so we’ve compared a hundred per cent renewable electricity with an all gas scenario; we’ve compared it with the most efficient fossil fuel scenario based on commercially available coal and gas technologies and we’ve done a comparison with one including hypothetical carbon capture and storage with coal and with gas, so looking at the whole system - and all our hundred per cent renewable electricity scenarios have to meet the reliability criterion of the national electricity market, so in a sense, apart from the details of the transmission system, it’s already in there. All our simulations are constrained, so we throw out every simulation that doesn’t meet the constraint for the national electricity market that the energy shortfall must not exceed .002 per cent of the annual electricity generation, that’s the NEM’s reliability criterion for the whole system, so to some degree it doesn’t matter a great deal how reliable the individual power stations is. It’s the sum total of them operating as a system and that’s the emphasis we’ve placed; that our system has to meet the reliability criterion and we’ve done tens of thousands of simulations now which meet that criterion with different mixes of renewable energy, with different operating strategies for the renewable systems and for the storage.

MR JACOBI: In the costings with respect to those systems, I think we've already dealt with transmission augmentation to an extent today. I just am interested, has there been modelling yet done of distribution augmentation as well, given that, at least as I understand it, some of the plants that we're talking about take into account places of high solar insulation and also the likely location of some of the wind farms will be at fringe of grid? Does it take into account the upgrades to what would be the distribution network at those locations?

ASSOCIATE PROF DIESENDORF: No, it doesn't. This is something that even the electricity industry is just starting to look at in relation to renewable energy. But one of the interesting things that is happening is in Queensland, that Ergon Energy, which is one of the two distributors responsible for South East Queensland is buying two megawatts of batteries because they think it may be cheaper to install batteries in the distribution system than to augment the distribution system. So they're doing it as I guess a practical experiment but they wouldn't be doing it if they didn't think that there's a serious possibility that even now, even at this stage, when batteries are still produced on a rather limited scale, they may actually be economic.

As you know, we're in a situation where over the next five plus years battery prices could half - lithium-ion battery - with the construction of these Gigafactories by Tesla and other corporations now. This is something that probably can't be looked at on the kind of scale of the National Electricity Market or even easily on a single state, but it's more specific to local distribution in specific areas - where will upgrades be required?

Then there's the other side to the whole story, that installing solar in some locations actually reduces costs. So particularly in rural areas some solar is now being installed in order to reduce the costs of maintenance of the single wire earth return lines that are so unreliable that go out into rural areas. There's lots of value in installing solar in key areas as well as some disadvantages in other key areas. At this stage it's very difficult to draw any kind of conclusion about the overall effect. All we can say is that there are some costs and there are some real benefits in economic terms by installing solar and other renewables scattered around the grid that can benefit the distribution system as well as causing some costs for it in other places.

MR JACOBI: I guess what I'm interested in understanding is that if one was to undertake a like-for-like comparison, for example, of the relative benefits of installing one generating technology or system on one hand and talking about the scenario that you're talking about on the other, which is this high penetration scenario, that in order to fully account for the costs would one not need to model fully those costs in due course? Is that a step that needs to be taken in the analyses in due course?

ASSOCIATE PROF DIESENDORF: Some things can be modelled and other things are so complex that probably the best modelling is to try it out on a limited scale rather than doing a modelling exercise with a hundred assumptions. There's a number of value issues that can't ever be quantified in economic terms, or in some cases can only be quantified with difficulty. I guess to a limited degree you can quantify the reduction in respiratory diseases by installing renewable energy instead of fossil fuels but we don't have sufficient data to quantify the risk of, for example, nuclear war produced by proliferation of nuclear weapons facilitated by a civil nuclear energy program in a country.

There's no way we can calculate the value of not using nuclear because of the potential for rare but catastrophic accidents like Fukushima. All we can do is say estimates of partial damage at Fukushima are now being measured by Japanese government and other economic agencies at hundreds of billions of US dollars equivalent while Fukushima Daicchi was insured for $US1.5 billion equivalent. We could probably use that as an argument to say that currently insurance for nuclear power stations is totally inadequate. I mean we've actually tried, we've actually done a study on what would be a fair insurance premium to try to cover major nuclear accidents at a nuclear facility and there are some studies done but they all make various assumptions because there isn't enough data on major accidents.

There are hundreds of minor accidents that occur in nuclear stations but there's really only three major accidents that have occurred: Fukushima Daiichi, Chernobyl and Kyshtym in the former Soviet Union. All we know is that they were devastating and had the potential of producing tens of thousands of cancers. Although in the case of Fukushima they were very lucky because the wind was blowing offshore. They weren't very lucky but Tokyo was very lucky because the wind wasn't blowing towards Tokyo, it was blowing over the Pacific.

What I'm trying to say is that not everything is quantifiable in terms of the value of particular technologies or the anti-value, but that doesn't mean that it's not important. For me, it's very important to know that in fact nuclear energy has assisted countries to develop nuclear weapons and therefore has increased the risk of nuclear war, even though we hope that that will never happen or that it will be a rare event. But we can't ignore it. It needs to be stated in there. So if we do a quantitative analysis, we also need to include a qualitative analysis to say that, "This quantitative analysis ignores the following hazards or values that need to be taken into account." Some things we can estimate, like health benefits in some cases. Other things we just don't have the data for, and we may never have the data.

MR JACOBI: I wanted to address one of the externalities you address in your submission and that's at page 7. This is the externality of carbon dioxide emissions.

ASSOCIATE PROF DIESENDORF: Yes.

MR JACOBI: You deal there with the full life cycle analysis of carbon dioxide from nuclear energy generation and there's a comparison drawn there in circumstances where ore grades at mines to fall. I'm just interested to understand the reason for the selection of the .01 per cent ore grade and whether you think that's a relevant scenario to today.

ASSOCIATE PROF DIESENDORF: Today uranium ore grades are still generally higher than that but the likely trend is to follow what has happened with all mining; that is, the best ore grades get mined first. Obviously it's the cheapest. The cheapest oil is drilled first but now they're drilling under the ocean bottom in places and so on. It's the same with uranium. In the early days most of the really high grade uranium actually came from Canada and the ore grades were extraordinarily high. Most of that is now gone. I guess I would say it is inevitable that the uranium ore grade will decline and some of the studies that have been done suggest that it will be over a period of decades, even just based on the existing nuclear power stations.

So nobody can say for certain exactly when only ore grade less than .01 per cent will actually be reached, but it is a useful guideline because it gives a very large carbon dioxide emission a life cycle emission, particularly from the mining and milling of uranium, assuming that mining and milling continues to be done mostly with diesel. Now it is true that in some places it may be possible to use renewable or nuclear electricity to power mining and milling, well certainly the milling is easier but the mining is done with gigantic trucks, they are not going to be electric vehicles charged with renewable energy and what happens when the ore grade gets this low, .01 per cent, is that mining becomes – mining and milling become really dominant if fossil fuels are used. Now there are various provisos. If in the future fast breeder reactors become commercial and they have been trying for decades to make them commercial then they breed more fuel than they actually use and then their lifecycle emissions would be very low but there aren't any commercially available fast breeder reactors in the world at present. So I am not sure if this answers your question because – but certainly the convention has been to take .01 per cent yellowcake as a low-grade ore. It is a convention that has been used by a number of authors, so that is – I guess that is really all I can say.

MR JACOBI: You referred in your answer to there being "some studies", I am aware of at least one other that is more recent that suggests that – and this is, I think by your co-author in 2010, that addresses those issues. Again, are you familiar with that analysis that has been undertaken more recently?

ASSOCIATE PROF DIESENDORF: Well, I am not sure which one you are referring to. My co-author Gavin Mudd, I assume?

MR JACOBI: Yes.

ASSOCIATE PROF DIESENDORF: Well, Gavin Mudd is a world expert on mining and particularly uranium, so he has published several papers. Apart from the paper that we published jointly, I don't know of any papers where he has made projections of ore grade but he has studied changes in uranium ore grade and I mean he knows all the uranium mines in the world. I am not sure if he is appearing before you but – so I can't – without knowing what paper it is, I - - -

MR JACOBI: No, that's all right.

ASSOCIATE PROF DIESENDORF: - - - am at a bit of a loss there.

MR JACOBI: Not a worry. Can I ask you, there was a final topic I want to address and this is the content at page 34?

ASSOCIATE PROF DIESENDORF: Yes.

MR JACOBI: This is a discussion with respect to opportunities and I think this picks up something that you were discussing earlier in your answers and I am just interested to understand, you refer to – at the bottom of the page, transition to 100 per cent renewables, you express a view there that it could lead to new jobs in manufacturing turbine components which I think you have explained but just hoping you might be able to expand on the reason for your view that it could lead to work with respect to CST power stations and electric vehicles?

ASSOCIATE PROF DIESENDORF: Well, CST power stations, some of them have very large components and size is important because it means that the cost of importing them can be quite high, the transport costs. We do have a glass industry and that could make the mirrors for CST and there is a number of other components that if we had a policy to facilitate the growth of renewable energy and CST in particular, say a target for CST, then an industry could grow quite readily. So I do feel that in the manufacturing, there are opportunities and I think the earlier situation that I mentioned with manufacturing wind turbine components illustrates this opportunity with components that are quite large to be shipped. We would have, for example, enormous difficulty competing with China in manufacturing solar modules, although Tindo Solar has got a little niche in there. They are making a particular kind and so they have a niche market which is fantastic, in South Australia. But in general, I can't see us competing with China. For those – for solar modules, solar PV modules – so for manufacturing larger components definitely. But the jobs aren't all in manufacturing. With solar PV they are mostly in installing them on rooftops, sales, retail sales, auditing the sites.

I mean this has been the most job creating part of renewable energy so far in Australia. Back in 2011, and I have got the figures, I think somewhere in my submission, you are looking at somewhere 12, 13,000 direct jobs in solar PV already. Now a few thousand have been lost since then because of government policies but even then in 2011, 2012 when the industry was quite tiny in Australia, you already had more direct jobs than are employed in that part of the coal industry in Australia that is concerned with coal use within Australia. Coal industry employs about 50,000 direct jobs entirely in Australia but most of that coal is exported. So 80 per cent is exported, so if you just roughly say well, there is one fifth of the jobs are employed for coal fired generation and other coal uses in Australia that is 10,000 jobs. Well, already back in 2011/12 there were 12 or 13,000 direct jobs in solar PV alone in Australia. So the job opportunities are terrific, particularly with solar and also energy efficiency because the components are small, these are mass produced things, so they – see unlike say a large 660 megawatt turbo generator for a coal fired power station in New South Wales, there is no way we could make that because there would be so few to be made for Australia. But if you have any industry in solar and wind we can manufacture parts, we have installation, all it needs is appropriate policies to provide training in technical and further education, with the technologies and some TAFEs already provide courses, the sad thing is that the state – well, I won't – I am not talking about South Australia but more generally, state and federal government policies are not terribly encouraging for the growth of renewable energy. Even in some states, they are not encouraging for energy efficiency.

So with a change in policy, more positive policies, we could see a lot more. In South Australia, part of the growth in wind has to be credited to states and territories outside of South Australia where recognising that South Australia has the best wind potential, they have been putting – been responsible for wind farms in South Australia. So it really is a national electricity market thing. But anyway. Yes. Well, what more can I say about the job situation? I have tried to list the types of jobs, as reported by the Australian Bureau of Statistics that exists so far and also suggesting some of the kinds of jobs that could be readily created with – once industry in the renewable energy area knows that there will be policies driving the industry further forward.

COMMISSIONER: I have one further thanks Professor. In your modelling did you come to a conclusion about the various generators within 100 per cent renewable energy? I see - - -

MR DIESENDORF: Mm.

COMMISSIONER: - - - you have got 75 per cent renewables and 25 per cent gas by 2030. Within the renewables does your modelling dictate how much wind, solar, solar PV?

ASSOCIATE PROF DIESENDORF: Well, we can - - -

COMMISSIONER: Just broadly.

ASSOCIATE PROF DIESENDORF: We choose. I mean we run many different combinations and - - -

COMMISSIONER: Is there an optimal combination?

ASSOCIATE PROF DIESENDORF: Well, we have done an optimal mix for using the Bureau of Resources and Energy Economics projections for costs to 2030 and in the published journal papers, the optimal mix was that wind was about 46 per cent, solar PV was about 20 per cent, concentrated solar thermal was about 20 per cent. This is 20 per cent of annual electricity generation. In 2010 hydro was 6 per cent. We're just taking existing hydro. Then gas turbines in that model were about 6 per cent. But since then we've spread out the wind farms more, which has reduced the need for gas turbines and increased the contribution from wind. So we can get wind well beyond 50 per cent and still have a reliable system provided we have a balanced mix of sources.

Perhaps I could just make another comment in relation to it, AEMO has done independent studies that didn't seem to be the subject of their submission. In their initial study they had some renewable energy technologies that aren't commercially available right now - namely, hot rock geothermal and wave power - making a significant but small contribution. We have repeated their calculations and agree with them but we also find that when we take out the non-commercial technologies - the wave and hot rock geothermal - we still get a reliable system. What we're saying is AEMO included those technologies but we don't think they were necessary. They would be a bonus. So if geothermal becomes commercially available, if wave power becomes commercially available, both which are relevant to South Australia, that would be a bonus but we can do a hundred per cent renewables without it.

There's another potential bonus, if I could just mention, that is briefly touched on in the report, which is hydro, sea water pumped hydro, for this state. So although you don't have freshwater facilities or enough freshwater to produce hydro from that source, there are some quite high hills inland from the coast, near Port Pirie and Port Augusta and other places, hills that are above 500 metres in altitude and they're only back from the coast about 15 to 25 kilometres. So it would be possible to use excess wind and solar power to pump water up into small dams in those hills and then use that as peak load to fill any gaps and to increase reliability at certain times. We recommended that an engineering study be done with an economic analysis - it wouldn't be expensive - just to assess that potential as an additional contribution that South Australia might have in the hydro area, quite unexpected.

So the mix can vary and we've done many mixes and we've found with many variations of mixes the costs don't vary a great deal. Although we have an optimal mix, the neighbouring mixes to the optimal mix are still costing much the same just a little bit more. Then if you're taking into account the costs that aren't easily quantified then you have a wide range of choices.

I'm wondering if I could add something about the economics of a nuclear fuel cycle in general that I've reflected on since I made my submission. I mean it would be fairly brief. I've reflected on it because the treatment of nuclear waste is another thing that is not properly costed in the nuclear fuel cycle. In the United States the utilities only pay a very nominal amount. They pay .1 cent a kilowatt hour to the government and then the government takes full responsibility for the waste. There has been a submission to your inquiry that South Australia store the world's nuclear wastes and I've looked at this from an economic point of view and there's really two ways this could be done. One way would be to attempt to do long-term storage of the wastes but the problem there is that there is no facility operating in the world to manage nuclear wastes long-term for 100,000 years. The United States has temporarily given up on its facility and there are two facilities under construction in Sweden and Finland. So it wouldn't be a very good idea for Australia to make an attempt in that area.

The proposal by Senator Sean Edwards is a different one. I'm sure he recognises that problem. So he has proposed temporary storage of the world's nuclear waste in dry casks in South Australia, and from an economic point of view this is really puzzling because dry casks are already being used at nuclear power stations overseas - at a number of them. So the question would be asked why would they take on the additional expense of shipping their dry casks to Australia? It doesn't make economic sense but it does make sense if those countries want to avoid the problem of dealing with the dry casks when they start to decay after 50 years, 100 years, 150, depending on how well they're designed and what's inside them.

It seems to me that the only motivation for sending the dry casks to South Australia is basically trying to find a sucker country to take on this long-term major problem for future generations. Those casks will not last very long under the situation they're containing materials that are hot, both in radioactive terms and in temperature. So they will decay and they will have to be handled. From my point of view, that would be a huge economic imposition to undertake that.

COMMISSIONER: Thanks, Professor.

ASSOCIATE PROF DIESENDORF: Thank you.

COMMISSIONER: We will adjourn till 1330. Thank you.

ADJOURNED **[12.27 pm]**