RESUMED **[10.00 am]**

COMMISSIONER: We reconvene at 1000 and I welcome Mr Andrew Stock. Mr Jacobi.

MR JACOBI: Andrew Stock has over 40 years experience in the energy and petrochemical industries in Australia and overseas, mostly in senior executive management and commercial operational business development roles. His responsibilities have included developing Origin Energy's gas power portfolio of 3000 megawatts and its removal developments, a New Zealand dollars $1.5 billion offshore onshore oil and gas project, CSG to LNG developments and major gas pipeline infrastructure. He is a director of energy companies including Horizon Oil, Alinta Holdings and the CESC, as well as a past director of Silex Systems, Geodynamics, SEA Gas, Australia Pacific LNG and Transform Solar, and he is a councillor with the Climate Council. He is a qualified chemical engineer with first class honours from Adelaide University. I call Andrew Stock.

COMMISSIONER: Andrew, thank you very much for joining us. I note in your submission you talk about renewables having the capacity to deliver more than 500 times Australia's energy requirements, and also you note there's been a stalling in terms of policy uncertainty. We get a sense that we're falling behind the global response to climate change. I just want to get a sense of the technologies that you think might be capable of delivering what we need if indeed our response to climate change needs to be ramped up in the shorter term.

MR STOCK: Commissioner, Australia is very well endowed with renewable energies, wind and solar, in particular. I mean, yes, we have wave and we have some geothermal, and we can come back to those perhaps, but wind and solar, and unlike many overseas countries where you have high population densities on relatively small land masses, we have a very large land mass in this country with the capacity to exploit resources often where there's low population density. So when we talk about how we supply energy to systems which - like electricity, I think we are very well placed and we're different to some of the other countries in the world like many of the Asian countries where you have very high population densities and in some cases, you know, like South Korea, for example, or Japan, relatively small land mass.

So I think we are well placed to exploit our renewable resources and we can talk later about why I think that the intermittency of those resources isn't necessarily a problem. Perhaps just to touch on a few issues related to that though, we see that our demand for electricity isn't growing particularly. You would have heard that from AEMO, I think, and the AER, and what that means is that there's already existing capacity for handling intermittency which we have today in the grid.

I mean, you have got the biggest unit size in South Australia is 250 megawatts up at Northern. The biggest unit size, I think, on the Eastern seaboard is about 660 megawatts in New South Wales. So already today the system has to handle trips of those units, possibly a whole station going out like happened when I think the river got into the Yallourn mine a few years ago. So the backup is already there in a relatively flat demand outlook, the backup is existing open cycle gas principally. A lot of that is relatively new build and also obviously the hydro systems and the interconnectivity between the states as well through transmission links.

COMMISSIONER: I think we all understand that. I guess the thrust of my question was the ability to ramp that up quickly in response to a climate change - - -

MR STOCK: To be able to ramp up - - -

COMMISSIONER: Renewable.

MR STOCK: - - - the deployment of renewables.

COMMISSIONER: Yes.

MR STOCK: We can come back to the detail of it, but it does need a relatively consistent regulatory structure to do it. In a market that's not growing, people aren't going to go out and invest in capacity unless there's an incentive to do it. The market from a point of view of supply of electrons doesn't need more capacity, however, there's a huge challenge that Australia faces in terms of decarbonising its electricity supply. You know, people perhaps don't really appreciate just how serious that challenge is because it's not something we see day to day.

My person belief is I think before the uncertainties that arose with the RET structure since the last federal election, before that the industry was deploying in its last year $1.8 billion at the large scale renewable level and in seven years over 4000 megawatts of solar PV went on rooftops. 4000 megawatts is I think about 30 per cent more generation in seven years than in my, I don't know,

20-something years putting in power plants for Origin we managed to deliver, so 30 per cent more capacity in less than half the time by individual households putting the technology on their roof that wasn't commercial a decade ago.

That's the speed of change and I think that we will come back and see this, but that speed of change is happening with storage now too. It's yet to emerge in a way that's visible, highly visible, like solar is today when you drive around Adelaide suburbs, but it's heading in the same direction. It's on the same cost reduction path, the same slope of the curve, about a 20 per cent reduction in costs be doubling. What we don't know today is how storage will be used in the system to balance intermittency. We don't know all of the answers to that, I think, but a lot of people with very smart minds are working on it.

What we've seen recently in California is 100 megawatt storage system, AES, a big American utility, won a tender ran in California, one of the public utilities there ran a tender for support for network services, and so they were bidding against things like open cycle gas turbines and load management and those sorts of things, demand management. It was very interesting, I thought, and this was only reported recently in the last month or two, that battery storage, 100 megawatt of battery storage won that tender, it was the best offer commercially.

So that says to me that not only are were talking about batteries from the likes of Tesla for households, but we're also talking about this technology having the capacity to support networks and potentially to support power stations tripping off or things like wind and solar, and I think you heard from AEMO that, you know, they have predicability around wind that's very good, up to two days in advance, and that's plenty of time to ramp up open cycle gas turbines. I mean, the biggest of those machines, like the Mortlake one, 275 megawatts, it's the biggest on the eastern seaboard that I was responsible for building two of those, those machines, I think, ramped from memory - and it is a recollection - in about an hour or so. Aeroderivative machines can ramp in, you know, 10 or 15 minutes, they're like aircraft engines, and we know how quickly aircraft engines ramp up when you taxi down the runway.

So I think there's a lot of flexibility in the system to back up that intermittency that some people talk about with renewables and I think the industry with the right regulatory structures and bipartisan support, and it's going to take a little bit of time, I think, in this country to re-establish that because we have seen the flight of capital, Australia's ranking in renewables has gone from number 11th in the world in 2013 to number 39th in the world in 2014. It's going to take a while when people overseas talk about sovereign risk in this country to assuage those concerns and re-establish capital flow.

COMMISSIONER: Thank you for that, and I might now let you backfill on

some of that information. Mr Jacobi.

MR STOCK: That's okay. Yes.

MR JACOBI: Perhaps if we can come back, and I think to pick up from where you were going in terms of the tender in California, and that is I am just interested from a commercial perspective, and that is a person that's been a director of companies involved in making decisions. Are you of the view that particular technologies will prevail ultimately over other technologies in supplying electricity in the market, and how do you think that that particular process will play out?

MR STOCK: It's my view, my opinion, that there are technologies that will prevail, and I've had a fair bit of exposure I guess, over my working life, to a number of those. I think they'll prevail because they'll be lowest cost.

I mean, at the end of the day, what, I guess the world, and Australia faces is a challenge, and the challenge is how to decarbonise its electricity supply, fast. We've had our federal government recently commit to a target of, I think, a 26 to 28 per cent reduction in emissions by 2030. Later on, we can talk about how long it takes to build large power stations, but it's generally around a decade.

So when we talk about emissions reductions of that size by 2030, and then we think about what makes the most emissions in Australia today, and it's electricity generation, is the single biggest contributor, what we're talking about is fundamental change in our electricity supply system, to, I think, get anywhere near those sorts of reductions.

You would've heard from David Karoly, that at least on a per capita basis, if we don't do something within seven years, we've used up our per capita carbon budget. So whether you subscribe to that or a broader view about a global carbon budget, there are lots of forecasts that say we need to decarbonise our electricity supply, almost totally, by 2050. That's only 35 years away, and in the context of electricity supply systems, that's not actually that long a time.

So you know, some of the statistics: we are, today, in the top 10 emitters of CO2 from electricity supply, in the world. In total, that's tonnage, our electricity carbon intensity is 60 per cent higher per megawatt hour than the United States; it's 80 per cent higher than the OECD average, that's per megawatt hour of electricity we produce.

I've said that our electricity supply is the biggest single contributor to our emissions, and I think the disturbing thing is, that our electricity supply emissions are now going up. They were going down, they're now trending up again; they are up 4 per cent I think, in the last year, to June.

MR JACOBI: Perhaps we'll come to that in a second.

MR STOCK: Yes.

MR JACOBI: Just coming back to this question about what might prevail; am I right in thinking that you have a view that really speed of deployment is something that's going to be essential, as well as cost?

MR STOCK: Absolutely. Yes, well cost and speed, absolutely. I mean, if it takes a decade and it's been my experience, on Mortlake for example, in Victoria, and you know, we might talk a bit more about that. But Mortlake took about 10 years from the day that we had the idea that we might want to build a power station somewhere in Victoria and where would it be?

We chose Western Victoria for a range of reasons: directly under a 500 kV transmission line - - -

MR JACOBI: It was an open cycle gas fed - - -

MR STOCK: Open cycle gas turbine. I mean, there were two or three years where power prices in the market didn't sort of, justify continuing the spend rate, so there was a bit of a hiatus, if you like. But in essence, from woe to go, it was about a decade. Now, an open cycle gas turbine plant, it did need a big switch yard as well, but that's about the simplest sort of fossil fuel plant you can build.

So that took about a decade. It was a big plant; I mentioned earlier the 275 megawatt units, there were two of them. So they're big gas turbines, but it took quite a while.

Now, I guess to put the other side of the picture, you can build those plants very quickly. So the fastest plant I ever built, or was responsible for building was up at Roma. Queensland was facing brownouts, almost, at the time; it was, I think back in the mid to late 90s or thereabouts, or maybe early 2000s. Anyway, the long and short of it was, we negotiated. From the day we started negotiating, to the day the plant ran was 17 weeks.

So that's probably two ends of the spectrum there. You can do things very quickly, it was used plant coming out of what was no longer East Germany. So - - -

COMMISSIONER: I guess our - - -

MR STOCK: - - - things can happen very quickly, but they also can take a

long time.

COMMISSIONER: Looking at the technologies, moving forward, clearly we'd be looking for something that was emission free - - -

MR STOCK: Correct.

COMMISSIONER: - - - or capable of emission free.

MR STOCK: Yes.

COMMISSIONER: So what sort of technologies do you think - - -

MR STOCK: What do I think?

COMMISSIONER: Yes.

MR STOCK: I think, my personal view for this country is that wind and solar have a very, very much bigger role to play. I think that because they are zero emission. I think that when you look at the track record overseas with capturing carbon out of power stations, perhaps as opposed to gas processing plants like Gorgon, but when you look at power stations the track record doesn't really match the hyperbole that you hear from the coal industry, in my opinion.

MR JACOBI: Well, perhaps if we can come back to capture and storage? We'll deal with that.

MR STOCK: Yes.

MR JACOBI: But I think, picking out, you talked about the trends overseas, and I think we've got a slide up that indicates the position of transition as it stood in 2014, in terms of new installed capacity.

MR STOCK: That's right.

MR JACOBI: I'm just wondering whether you can address what you consider are the key upshots?

MR STOCK: So if we look at the slide, I think one of the most dramatic, and this is summarising the additions to renewable capacity in 2014, I think you can see that on the slide, 134,000 megawatts. So that's probably somewhere between two and three times the size of generation capacity in Australia was deployed in renewables.

I think it's interesting that the biggest two contributors to last year wasn't hydro, it was actually wind, followed by solar, PV. So wind, about 50,000 megawatts was deployed last year, and 39,000 megawatts of solar PV.

MR JACOBI: Are these capacity, as completed?

MR STOCK: Yes.

MR JACOBI: Yes.

MR STOCK: Well, as I understand it. I mean, the data there is sourced from international bodies' reporting, so I think that's what it is, yes. Look, at the end of the day, particularly for solar, it's a little more problematic to get the actual number because a lot of it's happening in China, for example, same with wind. So the numbers move around a bit, but they're broadly in those sorts of ranges.

I think the other thing, just to draw out, and perhaps if we go to the bottom of the slide, is the growth rates. So these growth rates were taken, again, from the industry data, industry reports. We've seen over the period from 2009 to 2014, growth rates, year on year, of 50 per cent a year for solar. That means the industry doubles in size globally, every two to three years.

Wind, obviously, it's more mature in terms of its deployment than solar. It's growing at 18 per cent per year. Concentrated solar thermal's growing very rapidly, but it's starting from a very, very small base, and in different sorts of projects. They tend to be more like large power station projects than they are highly distributed projects.

You'll probably get it from other areas, but I've also summarised the additions of nuclear there. Coal and CCS, 110 megawatts last year, became commercial operations. It was the Boundary Dam project in Canada. 110 megawatts, net. So I think there's a big difference in the deployment of coal and carbon capture, and we can perhaps touch on that a bit more.

MR JACOBI: I think - - -

MR STOCK: Just a couple of other points, if I may. This deployment of renewables isn't just a flash in the pan for 2014. Bloomberg reports on the deployment of new renewable capacity globally, versus net fossil fuel additions. Deployment of renewables has exceeded fossil fuel additions for the last five years, and it was, I think, around 270 billion US dollars in renewables investment last year. It's been growth credits, over a decade long.

MR JACOBI: I was just going to come to, perhaps, a comparison of the

position in Australia, as it stood in 2014. I don't think I've got a slide for this, but in terms of the sorts of trends that we've experienced, that were shown on the first slide, what was the position in Australia?

MR STOCK: We talked about the resources here; I said earlier that if we went back before the 2013 election, the investment going on in large scale renewables in Australia was somewhere between $800 million to $1.8 billion a year, in the latter years leading up to 2013.

South Australia has benefitted substantially from this deployment of capital, in this industry. In 2014, renewables supplied about 40 per cent of South Australia's electricity, which puts us on par with leading countries globally, as a state. Obviously, nationally, the level is much less than that. On some days, renewables supply all of South Australia's power, but what we saw after the 2013 election was a stalling of investment in renewables.

I mentioned earlier that in 2014 only $230 million was investigated in large-scale renewable projects. It was down around 90% on the year earlier, and most of that investment was reliant on co-funding from ARENA or debt funding from CEFC at least in part, Clean Energy Finance Corporation, which were both agencies under the Garnaut bid, I guess, at least in 2013 and 14. So I mentioned earlier that our country's ranking in terms of global renewable investment fell from eleventh in 2013 to thirty-ninth in 2014. So that's large scale. On a small scale we have seen continued growth in solar PV and I think others have talked to you more about that. That continues on notwithstanding that feed-in tariffs have largely washed out of the system at least for new installations.

MR JACOBI: You mentioned feed-in tariffs. To what extent do you think that the LRET, the amount of capacity that's required by that, is going to be essentially met, meaning that there's not going to be further investment driven by that?

MR STOCK: So I think there will be, but I think it's still a little challenging for the industry. We're starting - when I say "we", I think through some of the things I'm involved in, the industry is starting to become interested again. There are some projects that are being discussed and approaches for financing. Large-scale solar, for example, through the CEFC and ARENA we have just made public a program to try and accelerate the roll out of large-scale PV projects, typically ten to 50 megawatt type size projects, because Australia is not leading in that area globally. It's actually well behind some other countries like the US in terms of the roll out of large-scale PV, partly because it's more expensive today.

COMMISSIONER: Did you see the results of the Alinta study into - - -

MR STOCK: As a director, no. It wasn't shared in detail. It may have been done earlier before I came on board, but, no.

COMMISSIONER: There's a conclusion in terms of large-scale solar PV that in Port Augusta it wasn't cost effective.

MR STOCK: PV or thermal?

MR JACOBI: CST.

MR STOCK: I think it's thermal, and generally my opinion is that thermal projects have got a way to go in terms of being cost competitive, and I guess it would've been thermal because they might've hoped to use the turbine block, you know, to generate power. So I think that's consistent with my view, Commissioner, that PV is still an area that has got a lot of growth potential.

COMMISSIONER: Okay.

MR JACOBI: You were involved in Geodynamics.

MR STOCK: Yes.

MR JACOBI: And geothermal was much discussed, particularly in South Australia, in the latter part of the last decade.

MR STOCK: Yes.

MR JACOBI: And I'm just interested to understand your view about the prospects of geothermal again in South Australia into the future as a low emission source.

MR STOCK: Again, it's my opinion, and it's formed based on having been a director of Geodynamics for 11 years and followed that industry very closely, at least with respect to one company. I think it's fair to say that company was probably the most successful of any of the geothermal players in Australia during that period where the industry did get quite a lot of attention and there was a lot positive things said about it.

Geodynamics did manage to achieve a technically successful project up at Innamincka. They managed to drill wells. They managed to conduct large-scale hydraulic fracturing of the rock, and we're talking about projects here that are not around volcanic geothermal, but it's engineered geothermal systems, which means cracking the rock underground to be able to get water through it and extract the heat from the rock. So they were successful in doing

all of those things and they generated power at about a level of a megawatt, I think within the high 90s availability in terms of the machine running for the three months or so they ran the test.

The hard, cold reality is it's very expensive to drill wells to 5,000 metres or so to access these hot rocks, at least with oil and gas drilling technology, which is what you need particularly up there with the high pressures. So my personal opinion is that I don't think in the time frames that we are looking at domestically and globally to see the deep reductions in emissions that we need to achieve, my personal view is I think geothermal in this country has very, very small role to play, if any role at all. Some people may not appreciate that, but I think that's the view that the management and board of Geodynamics came to, which is why that company is now looking to diversify into other areas.

MR JACOBI: And you mention the costs associated with drilling itself. Is there thought to be a barrier given the location at which the drilling was occurring in terms of connection to the construction of new transmission?

MR STOCK: Look, I think, yes, that was a barrier because it was, I think, 500 kilometres or so away from Olympic Dam. There was a nearer connection at the Moomba facilities. I think that was around 70 kilometres away. The difficulty there is that Moomba didn't need a lot of power and if it was ever going to be commercial it needed to be scaled substantially to start to get some economies, but the problem with doing that is it needs a very, very large amount of money, and it's equity capital because it's still got technology risk and other risks associated with it, and it was just very expensive to do that. So I actually don't think it would've made a lot of difference, frankly, if it was down in the southeast, for example, sitting right underneath the interconnector.

MR JACOBI: I think we'll sort of come back to coal with CCS, and I'm just interested in understanding your view about what the recent prospects are of that before we come to deal with what we think the future might be.

MR STOCK: Yes. So a lot has been said earlier - in fact the Minerals Council is currently running an advertisement saying how good coal is, including claiming that emissions can be reduced up to 40%. I think the overlay that needs to be put on all this discussion about coal is commerciality. I do believe that Australia has got a challenge because I think something like 65% of its power stations will be over 40 years old by 2030. So a lot of the eastern seaboard big units are aging. They already use technology which the IEA should no longer be built. That's subcritical technology. 90% of our power stations use subcritical technology.

So coming back to carbon capture and sequestration, the track record isn't very

good overseas, and when I say that, there are only three projects that I'm aware of in western countries that are being developed currently. When I say developed, being built. There's others that are talked about in relation to power generation: that's Boundary Dam in Canada, it's 110 megawatts; Kemper County in the US, it's about 580 megawatts net; and there's another project in Texas, the WA Parish Project, about 240 megawatts. So the first and the third are post-combustion capture. So what they are are retrofits on an existing power station where you take the flue gases, you process them with chemicals to remove the CO2, and you do things with the CO2, sequester it, and we can come back and perhaps touch on the costs of those.

But, you know, the intriguing thing with CCS overseas is that the carbon dioxide that's captured is actually being used. It has a value. It's value is being able to inject it into enhanced oil recovery schemes in partially depleted oilfields to enhance the recovery of oil, which is a bit problematic because what happens to the oil, it gets refined into products that then get burnt. So I'm not sure how much emissions they actually are reducing when you draw an envelope around the broad, but just to put the envelope around the power station, I think it's around 6 million tonnes a year, and I don't have, off the top of my head, how much CO2 the global coal industry for power generation produces, but it's an awful lot.

So in this country I think there will be challenges with deploying it. A lot of the power generation sits in New South Wales and Queensland and there are not - as I understand it, others can better to talk to this I think later in the week - the sort of aquifers and depleted oil and gas fields that you might put CO2 in for Queensland and New South Wales are more distant. Victoria is better suited because you've got the Gippsland Basin which is a lot closer, but you still need to deal with CO2, so you still need to purify it. You need to dehydrate it, remove the sulfur, remove the heavy metals so that the material - the pipes that it goes through, the compressors and so forth that have to deal with it don't suffer metallurgical failures.

COMMISSIONER: If you don't have the commercial use for the CO2, you sequester it, I presume that makes it much more difficult.

MR STOCK: I think so. I mean, you're trying to spend billions of dollars extracting a product that has no value, so until we have a carbon price, at the very least I think in this country - or alternatively a regulatory regime that mandates it in some fashion, or mandates power stations that are high intensity power stations, achieving targets for less carbon intensity, unless there's something like that in this country, then it's very hard to see it happening because why would you spend a lot of money doing something for something that has no value.

COMMISSIONER: I also assume that once you do sequester it then it has to stay there for a considerable period of time, who owns the responsibility of any leakage of the system?

MR STOCK: That's a good question and there are probably others that are better placed to answer that than me, but I guess one of the things that it also comes back to, Commissioner, is social licence to operate and one of the things that I think a lot of these energy industries - and I think, you know, the renewable is in that space too, you know, when you look at some of the debate that's happened around wind, but certainly I think large plants and large industries have to deal with what is a very rapidly emerging or developing way in which society and groups in society deal with large projects, and around their social licence to operate, and it's certainly challenging. So I think that is another area that the CCS industry in Australia really hasn't come to grips with yet.

MR JACOBI: I think if we can skip over the present state of nuclear developments in the world - - -

MR STOCK: Sure.

MR JACOBI: We addressed it in the other sessions and we're familiar with that information, and can come - to pick up this issue of costs, which I think is picked up in our next slide - the slide as I understand it shows the estimates of LCOEs for various technologies across time and I'm just wondering whether you've got some key observations that you'd like to draw from that particular information?

MR STOCK: I do and there's a lot of data on this slide, so if anyone's looking at it online they won't be able to read it, so we maybe just touch on some highlights from the slide. I don't intend today to drill into the numbers, but just to make some overall points. There are a lot of studies out there where people look at the costs of - well, the levelised cost of energy, it's call - LCOE - for different technologies and I don't know whether it's worth just a couple of sentences on how LCOE is determined, or not, but - - -

MR JACOBI: We're familiar with that.

MR STOCK: You're very familiar with that? So we won't deal with that, but what I think we're seeing is that - in my personal view, and I've held this for many years - is that there's a technology race going on in the world and that race in the electricity sector is how you get carbon out of electricity fast. Who's going to win that race? So we went back a decade ago, we would have seen solar much more expensive, wind more expensive and statements about the cost for carbon and CCS on coal, for example - and probably nuclear too.

In the decade that's followed, we've seen very high growth in two industries, wind and solar. Literally no growth at all in CCS and, you know, variable growth with nuclear. The growth's really important, particularly for industries that are early in their life cycle and there are others better to talk to the detail of that, but what growth enables manufacturing organisations to do is to take out cost, and you see it with every product just about we use in the Western world today. Less so with automobiles, perhaps, because they're very mature products. Much more so with things that - like, mobile phones, televisions and so forth.

So the theory goes that as growth accelerates, what that means is that costs go down and you can actually chart this for any number of manufactured products, and there are charts for solar PV and wind in particular. So what we've seen are growth rates - and I talked to these earlier - field scale PV is growing globally at around - I think I mentioned 50 per cent a year overall and interestingly, Bloomberg's numbers on the right-hand side of that chart show that over the period from 2009 to 2014 the cost of PV in field applications - that's megawatt-sized projects - has come down 50 per cent, and that's really because of the power of the experience curve and rapidly accelerating global deployment.

That data in the table indicates that winds come up about 15 per cent and these are Bloomberg, but IEA has similar stats. They issued a report recently - I think June 2015 - and showed similar sorts of reductions between 29 and 2014 or 15 in terms of LCOEs for those technologies. So there are a lot of forecasts out there for what the future might be - 2020, 2030, people like McKinseys, Citi Group, International Energy Agency and while they vary, they're generally consistent around significant cost reductions by the time you get to 2020 for PV and continuing through for a further decade.

So I think if we move perhaps to the bar chart - it may not be in there Commissioner - I mean, perhaps that's probably a little more useful than table of numbers because it shows some relativities, and what it shows is that just how expensive the CCS projects are and there's only really, if you go to the left-hand side of the slide - there's the IGCC - well, there's only one of those projects that's been built in the world and same with supercritical coal and capture.

There are no actual projects that have been built around gas-combined cycle plants capturing carbon and that's quite difficult to do that with gas turbines, which we don't need to go in today and then I've got on the right-hand side of the slide a couple of renewable technologies, and I think the interesting thing is that actual outcomes, while they're quite variable - and this is again industry literature, industry report - while they're quite variable for PV because they

depend on location, they depend on a whole range of things and I'd have to say what I've seen in relation to Australian projects at the moment, without support would be something towards the higher end of that arrow bar for PB fuel, which is why people like ARENA are getting involved, because we need to bring that down and currently projects rely on grant funding to help make them commercial to people like AGL, who have invested in two of them.

Wind in Australia right in the range of the bar that's shown there. It's a little more expensive than some places overseas. These are US dollars, by the way, so I guess in you converted it with the current currency, you're probably right in the middle of the bar. Most wind projects in Australia get away under $100 a megawatt in the contract, so not all of them perhaps, but most of them will be under a hundred and it's hard generally to get those numbers, because they are typically contracted between a group like an AGL or an origin, and a project. So there's not a lot of visibility, but they're in that range.

MR JACOBI: Yes, I'm just interested to understand - the green arrow shows data. I'm just interested in what's the data source that you've used in order to superimpose those particular actual figures.

MR STOCK: Yeah, so they come from different areas. I mean, again they're typically - the global data sources are from international reports and they're shown on the bottom of that graph. It's a bit harder to comment about specific projects domestically, but it's fair to say that I've seen quite a few of them through my different roles but, you know, they're commercially confidential so I'm not able to disclose those. But I think people in the industry would confirm what I've said about wind in Australia being sub a hundred.

MR JACOBI: Perhaps if we can go to future costs very briefly and then we might work our way towards some actuals against the LCOEs. I think on our next slide you've expressed a view already about expectations for costs declining - - -

MR STOCK: Yes.

MR JACOBI: - - - and solar PV likely to being a prevailing technology. I'm just wondering if you could explain the import of that chart, to your view?

MR STOCK: Well, what this chart is showing that experience curve for PV, over something like 40 years. It's not my chart, it's sourced from Bloomberg, but there are any number of representations of that around.

What it's showing is, the top curve is crystalline silicon, which can be multi-crystalline or single crystalline silicon, and that typically is, I think, from memory, around 80 to 85 per cent of the global PV being rolled out. It's still

crystalline silicon, and it's been that way for almost 40 years, notwithstanding there have been other silicon technologies that have emerged, most of them haven't been able to gain market share.

The lower curve which is shown is a thin film, it's a cadmium telluride thin film solar technology, developed by First Solar out of the United States. That technology shows, on that curve, to have lower cost. And yes, it does, but its efficiency is typically less than crystalline silicon. But it is being deployed quite rapidly around the world, in these large scale projects. I think from memory, some of the ones in Australia that are being built, currently use First Solar technology.

MR JACOBI: Now, as I understand it, your view is that can be seen to have fed into LCOEs, and I think that might be picked up on our next slide.

MR STOCK: That's right. So what you've seen as a declining cost in the experience curve, and obviously there's more to solar projects than just panels, you need to have a whole range of other stuff as well, including inverters and connecting them up and so forth.

What this chart, which is drawn from a report that was done, I think, for the United Nations, by Bloomberg and Frankfurt School out of Germany, charts cost of PV in particular. You can see, just in the period from 2009 to 2015 how they've come down, in the green lines.

It doesn't really matter so much whether it's thin film or crystalline silicon. Crystalline silicon is probably getting driven more by Chinese experience. If you went back a decade ago, the Chinese were virtually not visible in the PV industry, today they're the biggest manufacturers.

MR JACOBI: Do you have a view as to what, if anything, is shown by the relevant flatness of the onshore wind?

MR STOCK: Yes, I must admit that when I looked at this and then looked at some of the other statements about wind, it does raise a question, and I don't have the answer to that. What this would say is, that wind isn't getting much cheaper, and certainly what it also says is that offshore wind is expensive.

I think that's partly as it relates to, perhaps in some jurisdictions overseas, the availability of good wind resources, perhaps being used. So the opportunity to deploy machines that might be bigger and have lower costs associated with them per megawatt hour may be limited, because of availability and space. I don't know.

But I think in Australia, my view would be that there's still ample locations to,

you know, install new wind, and to do it very cost competitively. Nevertheless, the number for wind is still at or about a hundred, so it's still very competitive, even against solar PV.

MR JACOBI: We've been looking at LCOEs so far, you've superimposed actuals onto those analyses.

MR STOCK: Yes.

MR JACOBI: And I think the next slide might show some actual numbers that you've used.

MR STOCK: Yes.

MR JACOBI: I'm just wondering whether - - -

MR STOCK: As to cost?

MR JACOBI: - - - you have a view as to whether anything can be drawn from the distinction between the actuals that are shown there, and what are the estimated costs?

MR STOCK: Yes. A lot of LCOE estimates use, sort of, build overnight-type estimates. That's the first thing, and so that might be relatively okay for a project like a PV field installation, where you can effectively erect it, probably in six months, from whoa to go.

It's sort of okay for wind, because generally again, once you're permitted and you've done the tower foundations and so forth, wind can go up pretty quickly, because effectively you're bringing in pre-fabricated units, be they towers, the cells or the turbine blades. They all come in, you bring in a crew from overseas typically, that knows how to do this well and fast with a very big crane, and you can put up a turbine a day. So if you had a 30 turbine installation, which would be 100 megawatts, you could erect it in a month.

So that's important when we come to these sort of LCOE estimates, because for large, complex projects, they don't happen in a month or two months, they happen over years, so the financing costs in particular start to become a very significant part of the total capital cost of the project.

I guess in Australia, unlike some jurisdictions overseas, and I was listening a bit this morning, we don't have regulated utilities in Australia, so if there's a cost associated with financing and the project runs late, if the party that's contracted for that project can't lay that cost off onto their customers. We don't have a regulatory structure that allows them to do that in this country,

unlike, typically, the US utilities do.

Why that's important is, that large, complex projects typically run longer than often people would like them to, or think that they do. The consequence of running longer, because they are complex and they have very complex supply chains into them, they are complex things to build, you've got bigger exposure to things like industrial relations.

If you have a project that runs over five years, for example, through to construction phase, you might have an EBA that runs for three years. That's not ideal, because you've got to renegotiate the Enterprise Agreement, part way through construction, which is not where you want to be.

Whereas, if you can do the project relatively quickly, and it doesn't use highly sophisticated trades, you've got a lot more competition for supply of labour and so forth.

What the outturn of that means is, that costs have turned out to be, on coal and CCS, much more expensive than most of the consultant desktop studies would suggest. You know, Kemper County which is the IGCC project in the US, which is effectively a chemical plant with a power station tacked onto it, ended up, or looks like it's going to cost around $10.5 million per megawatt, whereas the numbers in the chart from the consultant studies would suggest numbers around 30 to 40 per cent less than that, maybe more.

Similar outturn costs for the Boundary Dam project, and the difficulty I think with this is, that because there are so few projects, the capacity for learning when you roll more out is very limited, and it's going to take too long. These projects have durations that take a decade from permitting to commissioning, and that creates all sorts of risks that typically LCOS estimates, via consultants. I would guess, in my experience, you'd need to exercise some caution in how you use those numbers.

I think the main benefit of LCOEs, you know, is to look at the relative costs, rather than the absolute. But the caution about the relative is, that particularly with projects that are low carbon, and whether it's renewables, nuclear or CCS, particularly CCS on captive coal mines, I guess, is that a lot of the total cost of energy over the lifetime of the project is tied up in the capital cost. If the capital cost runs over significantly, that project is going to be, effectively, an uneconomic investment for its whole life.

I guess, typically what happens with large companies is that they will be required to impair the assets, in other words, take a write down, because the economic value of the asset is much less than what they paid for it. Unlike in the North America market, Australian retailers can't pass those cost overruns

through a regulator onto their customers, they have to absorb them. And, I think that will make them very wary about whether they are prepared to sign up for those sorts of deals. We can come back to that later.

MR JACOBI: I just need to understand, do you think that given the sorts of costs that have been experienced with respect to either of those CCS projects, that that's likely to have any implications as to whether CCS would be implemented in Australia on existing coal fired power stations?

MR STOCK: I think they do, and I think they will. Sorry, I'm just trying to find my comments there. Australian – I think they will for a whole range of reasons. Firstly, the current – not all but a large proportion of the existing large coal-fired stations, as I've said earlier, are getting older. So if you were an owner of one of those stations, you know you are facing a question, do you continue to operate it and then there's many billions of dollars to reduce its carbon footprint, or do you actually at – keep running it for as long as you possibly can, possibly buy some emission reduction certificates somewhere to offset some of the emissions that it's making, that is probably a better economic choice than investing multi-billion dollars to extend the operating life potentially for another 20 or 30 years. I guess, I sit on – I don't sit inside those companies any more, so I don't know how the likes of AGL and Origin and Energy Australia, who own a lot of these stations think about that. But I am sure, knowing how they think about making investment decisions, that they would think was a very sort of risky thing to do. That is, invest CCS on to one of their existing power stations at large scale.

It is also very expensive. If you take the sort of Boundary Dam numbers and you take 30 per cent off them, for learnings say, bring them back to Aussie dollars, I think I worked out a 500 megawatt unit, which is typically a Loy Yang unit, I think is a 500 megawatt unit, 660 (indistinct) those units – to do one of those units and Loy Yang's 2000 megawatt, so I guess it's four of them, to do one of those units would cost in the order of five billion dollars. I think Origin's market caps of the likes of seven or eight billion today and AGL's are sitting at around 11. So you are looking at something that just for one unit is a very, very significant part of the market cap of these companies. I don't know whether they would have the capacity, even if they had the desire, to go ahead and spend that sort of money in a very concentrated investment, that had the potential to run on and potentially cost a lot more than that.

MR JACOBI: I think picking up the last of these actuals, you plotted those actuals on a column chart - - -

MR STOCK: Yes.

MR JACOBI: - - - as against the LCOEs.

MR STOCK: Mm'hm.

MR JACOBI: This is our next slide.

MR STOCK: I think they are capex, yes.

MR JACOBI: Sorry. These are the projected estimates aren't they - - -

MR STOCK: Yes.

MR JACOBI: - - - of the cost?

MR STOCK: Yes, but they're capital costs, they're not energy costs, so they are just reflecting what I have just said about the costs of the projects in North America, on the left hand side. Combined cycle gas, I mean, one of the projects I had was a very large combined cycle project on the eastern seaboard, in fact the largest at Darling Downs was air cooled, so it didn't use a lot of water but that ended up about $1,400, I think from memory per megawatt of capacity, $1,440 and that's taken from Origin's announcements about the cost of that project. Again, the capital costs of PV and wind are taken – they're international costs but in the case of wind, in particular, they're fairly typical. That range is fairly typical of Australian projects. The nuclear projects, you will have others that will talk more to that but they reflect projects under construction or being contemplated in the west, Gen III projects, not projects in China or Russia or areas like that.

MR JACOBI: I think the underpinning project was at Flamanville for the one on the right.

MR STOCK: Yes. And obviously people have talked about Hinkley and how much Hinkley is contracted for, you know, 35 years with CPI escalation. I think that would be a very difficult pill to swallow in Australia, in our energy market.

MR JACOBI: Just want to move on and perhaps if we can pick up from some of the issues that you've discussed in terms of investing in CCS but generalise the discussion in terms of thinking about the challenges for large projects in the energy sector in Australia.

MR STOCK: Yes.

MR JACOBI: And the sorts of issues that would affect the minds of those considering those sorts of investments? We touched on it right at the start, issues of the flatness of demand - - -

MR STOCK: Yes.

MR JACOBI: Just wonder whether there are other issues that we need to unpick?

MR STOCK: So large projects like nuclear projects and CCS projects provide base load power and base load power is typically the lowest price power in the market. It has been since the market started in the NEM and it's in over supply. So there are some commercial issues around that clearly. One of the other issues around base load is that the customers that tend to use it are the industrial customers, so if you're a retailer like an Origin or a AGL, you're not using that power, you're selling it on to others, so if you're contracting to buy it, you're looking at your customers and the base load customers typically industrial customers. At least existing industrial customers tend to contract short in my experience and I've had experience over the years of running electricity contracts. So when I say short, three to five years.

MR JACOBI: Okay.

MR STOCK: So they won't take long-term deals which is surprising but that's been a consistent track record in my experience even going back a decade ago when we were trying to get up a very large cogen at a paper mill in Victoria. They didn't want to take a long-term contract at the end of the day and that's one of the reasons that project fell over.

MR JACOBI: Is there a particular market characteristic that's driving that - - -

MR STOCK: Well - - -

MR JACOBI: Sorry.

MR STOCK: - - - energy supply costs, even though they're large numbers, typically for those businesses aren't a big part of their overall operation costs. I mean they are for aluminium smelters, so they're probably the one distinction here, is that they do tend to contract long, at least when they get built, perhaps less so once they're built. But others typically contract relatively short. I mean they're longer than, you know a household contract which can be a year, but they're certainly not the sort of timeframes that you need to build large projects. The problem for that is then that the gentailers, the people that sit there generating and retailing between the, if you like the generators and the ultimate customers have got to decide where they want to put their balance sheet, behind a very long-term contract. And that's a problem because you would want to be very sure if you were entering in to a long-term contract in the absence of some regulatory structure that requires you to do it, like an

LRET that that was competitive. And even if you had an LRET scheme in place, or something equivalent, you would want to make sure that the deal you had was a better deal than your – or at least as good as your competitors in the retail market because you've got to pass it on under the regulatory arrangements.

I think the other comment about large industrial customers, at least today is that they have been one of the least willing groups of customers wanting to take carbon price risk, in other words, or paying a premium to take carbon out of their electricity supply. Quite a lot of vocal opposition against the renewable scheme has come from large industrial customers. Not all by a stretch but certainly they've been quite vocal in their opposition to bearing more of those costs. And so some of the deals around reducing or ameliorating the impact of the LRET scheme has been on those large industrial customers. I think the other challenge though here is that the projects that take 10 years or more to deliver, and if it's not been done by an integrated party, like a gentailer, like the likes of the Origins and so forth, how do you write a contract that doesn't start physical supply for 10 years? And even if you get to the point where you've done all your permitting and you're about to get in to serious contracting for building the plant, so you've got your permits, you're about to start that contracting process, you've got to then progress your contracting for supply off take at the same time so you can get your financing in place. And the challenge, I think is it would have to be a very good deal commercially for someone to take a contract when supply under that contract may not start for five years and perhaps upwards of a decade.

The industrial customers that you've got there today mightn't be there in 10 years time. So I think this is a real challenge and when I reflected back on my experience at Origin, most of the projects were done, didn't have off take contracts associated with them. They were able to be done because the company had a retail customer base, it was prepared to take investment decisions around adding generation capacity to meet the more sticky part of that retail customer base that they were more confident would be there in the long run, and effectively internally finance and contract that capacity. I think that's a very different situation to what you're looking at where you have third party being the constructor or the developer, and needing a contract with a large retailer. The risks are very different, and I think make the whole development process much more difficult and problematic.

MR JACOBI: Do you think the position has changed? Perhaps just taking the example of the gas part of. Gas industry matter, the form of generation. Has the position changed from the position that prevailed at the time that you were installing gas turbines?

MR STOCK: I think it has to a degree, at least in respect of plant that doesn't

have a regulatory arrangement in place that requires it to be installed. We've already talked about the market being oversupplied. Certainly oversupplied with base load. We know that the market - we know that carbon needs to be reduced from our energy supply, electricity supply, so regulatory arrangements are very important here because I don't believe even with a carbon price that would probably be politically acceptable in Australia in the near term, that you'll get the sort of investment that's needed to de-carbonise electricity supply in the time frame required.

So I think regulatory arrangements are critical, and I think the challenge here is that we've had a regulatory arrangement in place, or we had two of them, LRET and a carbon price, and we no longer have a carbon price in the country, and I think we're still going through a process of re-establishing confidence around the large scale renewable scheme. Provided, I think, there is bipartisan support and continuing bipartisan support for the LRET scheme, I think that confidence will come back and people will re-establish investment, but it might take another year or two before it starts to hit its straps again.

If we got another change in policy or something that would make it much more difficult. But I also think it makes it more difficult for any new policy that might be advocated for because ultimately if you think about the nuclear industry, the amounts of money involved are very, very large, and - I mean, others can better talk to it, but I'd be surprised if people were willing to sort of put that money into the ground without having a very, very confident view about the future regulatory arrangements.

MR JACOBI: Can I just come to the question of project management. I think they might be assisted by an extra slide that we don't have available to us in terms of - which shows the sorts of time frames that are involved. I'm just interested to understand your view about whether - again, not with particular regard to the technology, the sorts of project management skills that are necessary to implement the projects of these sorts.

MR STOCK: Yes. This graph which will become available shows just a couple of international projects that are large and complex in the carbon capture area, and Australian projects, one of which I had responsibility for at Mortlake which we talked about, and the other one which is Kogan Creek, which is based on the time frame that's come out of literature information. Kogan Creek was the biggest single shaft coal fire plant built in Australia. 750 megawatts off one shaft.

That took about 10 years from start to finish in terms of building it. The interesting thing is that these projects were finished probably somewhere between three and five years ago, maybe a bit more in Kogan Creek's case. There really hasn't been any large projects like this other than LNG type

projects, or power stations associated with LNG being built in Australia since, because the market doesn't need them. The types of projects that are being built are wind projects and some solar.

They're quite different projects to execute. In fact power projects are quite different to oil and gas projects to execute as well. When we were doing Mortlake, which I think was one of the last big projects built on the eastern seaboard, and Darling Downs, in the Case of Mortlake, the project managers were close to retirement, and in fact I think we used up, if you like, two or three project managers on that project because they were close to retirement, and it's a very stressful sort of thing to do, building a large plant.

In the case of Darling Downs, the large contractor that had principle responsibility, CH2M Hill, brought their contract management team out of the States because there were no people in Australia. So if we look 10 or so years down the track before we maybe need to build another large complex project, where are the people going to come from that have got the experience to build it? Some of them will come out of probably the LNG projects that are being build currently, but there is a difference between building a project like that and a power plant.

There's a lot of electrical gear in a power plant than there is typically in a chemical processing plant. So I suspect we'll end up bringing the skill project management teams in from overseas. I think that's a contrast with the renewables because, as I said earlier, you can build renewable projects very quickly. They're very modular, they're not complex, technically. Some of the kit is complex. I mean, making solar cells is sort of complex, but when you're buying panels and you put them on, you know, galvanised frames out in a paddock, it's not that complicated relative to building an integrated power project.

They're better suited, I think, to the skills match that we're likely to have in Australia going forward, and you can get teams that can move from project to project rather than all be concentrated on one large project. You've got supply coming from international manufacturers that supply globally, and benefit from economies of scale. I think also you've got less of your eggs in one basket. So coming back to the retail risk that you were talking about before, the contracting risk, you've got more of your - you've got more supply diversity.

Even though there's intermittency associated with it, that intermittency can be managed, and the fact that you've got more diversity means that there's less risk that at any one time you will have a lot of capacity of. I think - we did touch on it earlier. I think batteries are - I guess watch this space. My view would be - I guess I bring some perspective of this because I was responsible in origin for a technology in photovoltaics called slither. A decade ago we were looking

at what would happen to the costs of PV once the cost of supply of solar electricity intersected with the cost of buying power off the grid.

Effectively what that meant was that this supply-cost interplay would effectively create a market that was certainly grown globally very rapidly, and potentially becomes infinite when you look at it relative to plants that were making 20 megawatts of PV panels. So a decade ago - that's what happened. The challenge with that technology was how do you get on the - you're already on the starting blocks, and the others you're racing against are out in front of you. How do you catch up?

I think this is a challenge - that's why I think it is a technology race here. But the starter's gun has already gone off, and you've got some technologies that are already well out in front, and I think one of the very interesting aspects of PV is that it's so modular that you can put it on a rooftop, but you can also put 500 megawatts as in the Topaz project in the US out in the desert. But the essential units that you're using are the same, or similar units.

What that does is it just drives the market to grow and continue to get that virtuous feedback. More growth, lower costs, generates more growth, and I think that's what's so powerful with PV more so than wind, and I think that's what's going to happen with batteries. I think we might show one final slide that picks up where we think that's going to go. So this curve - obviously batteries are early in their lifecycle, particularly lithium-ion batteries.

Whether they're going to be the battery of choice for grid installations and so forth, you know, you'd best talk to others than me about that. But the reason I like this slide is it's starting to show the pricing history or the cost history for PV against lithium-ion. The interesting thing, and it's a log-log curve, but that's how you look at these things, the slope of the lithium-ion learning curve is not much different at all to the PV curve.

So you'd be a bold person today to make projections about where lithium-ion battery costs might be, you know, as global growth accelerates, but I think it's fair to say this would give you some degree of confidence that batteries are going to get a lot cheaper than they are today, and I think there are some people in the world spending very large mounts of money about making that happen, particularly Tesla with the project that they're building out Reno, Nevada which is represented by them as being able to make gigawatt per year of batteries for cars and home storage.

But they're also marketing those, coupling them up for networks and so forth. So I think it's a very interesting space. I don't think we necessarily know all the answers today by a long shot, but I do believe in the power of these learning curves and what they can do over relatively short time frames once growth

really accelerates. I think we've seen that in PV, and I think we'll see it in batteries.

COMMISSIONER: I think that's it. Andrew, Thank you very much for the work that you put into this presentation, for your presentation, and for your evidence. We'll adjourn until midday.

ADJOURNED **[11.11 am]**