RESUMED **[10.59 am]**

COMMISSIONER: Ladies and gentlemen, welcome back. We will start with the next session from Ms Anna Skarbek, Climate Change Works. Mr Jacobi.

MR JACOBI: Ms Skarbek is the chief executive officer and executive director of Climate Works Australia since its inception in 2009 and she's been leading the organisations working in analysing emissions reductions opportunities and partnering with business and government in unblocking barriers to their implementation. She's also a director of the Clean Energy Finance Corporation, a trustee of the Sustainable Melbourne Fund, a member of the Australian Government's Energy White Paper Reference Panel, and the Grattan Institute Energy Program Reference Panel.

She's an experienced investment banker, policy analyst and qualified lawyer, and before Climate Works she was working in London in London's carbon markets as a vice president of advisory with climate change capitalist specialist investment manager and adviser. She holds first class honours degrees in commerce and law. She's principally to give evidence today in relation to a report published by Climate Works Australia in September 2014 entitled Pathways to Decarbonisation in 2005, How Australia Can Prosper in a Low Carbon World.

COMMISSIONER: Anna, welcome and thank you very much for joining us.

MS SKARBEK: Thank you.

COMMISSIONER: Perhaps if we could start with an explanation of the purpose of the pathways project.

MS SKARBEK: Yes, this project was part of an international collaboration auspiced by a United Nations initiative called the Sustainable Development Solutions Network. It was tasked with the exercise of creating country level - bottom up - modelling to support the Paris negotiations for the two degrees climate goal discussions which are often supported by international modelling that's considered top down. The exercise was to allow countries to explore their own energy resources and endowments and challenges and opportunities to address the question, "If nations agree to stay within the two degrees goal as recommended by scientists, what does that look like in your country?" There was a particular focus on the energy system.

In Australia, Climate Works worked with Australian National University and the CSIRO using a complex set of interactive models that had been built for the Garnaut Review. I understand you've heard from Prof Garnaut this morning. We were fortunate that we could look not only at the energy system but also at the land system. The CSIRO had the technical capability to integrate those modelling tools and link them to the economy-wide model.

MR JACOBI: Was it possible in other countries to link them to the economy-wide model or - -

MS SKARBEK: Yes, but those countries didn't extend their analysis to the land sector. Most of them focused on electricity and energy only.

MR JACOBI: You've mentioned the ANU and the CSIRO, can you explain what their role was with respect to Climate Works.

MS SKARBEK: ANU and Climate Works jointly led the project. We each contributed the expertise of our respective teams and we commissioned the CSIRO to update the modelling exercise that they had undertaken for the Garnaut review.

MR JACOBI: With respect to Climate Works itself in terms of its funding source, how is it funded?

MS SKARBEK: Climate Works was created by the Myer Foundation in partnership with Monash University. Initially our sole funding came from the philanthropic institution of the Myer Foundation and support from the academic institution at Monash. Since then we have earned other revenue - undertaken commissioned work for multiple governments at state, federal and local level, and a number of corporate commissions as well.

For this particular project, being a large undertaking, we sought sponsorship from a variety of agencies and they are named in the report. They include the Australian Renewable Energy Agency (ARENA), the Global CCS Institute, and TransGrid and Atsenta, and a philanthropic trust called the Mullum Trust.

MR JACOBI: Perhaps moving into the model itself but starting at a very high level, I'm just interested to understand in terms of what was the core assumptions or the large assumptions that underpinned the model.

MS SKARBEK: The primary assumption, as I mentioned, was guided by the two degrees goal of the international climate negotiations. Our task was to assume that that goal was intended to be met in your country and to run the modelling exercises to understand what would happen to the energy system, how does it change and what does the energy mix look like, and how close to net zero emissions can your country become given its existing and future potential. We were not specifically tasked with modelling a policy set such as an emissions trading scheme, and we were not asked to assume that there would be an international emissions trading scheme. But instead we were asked to assume that governments would commit to keep global emissions within the two degrees goal.

So in Australia what we translated that to is that it could be a variety of policy mechanisms that gets you there. From a modelling perspective, whatever policy mechanism you choose, whether it's a set of emission standards or a pricing mechanism, they ultimately have an economic effect on the technology costs and their relativities and that's how it's modelled. So in the model, what we have modelled - and it's described in the report - is an abatement incentive, which some might say looks like a carbon price but it is ultimately the economic impact on each technology of a suite of policies that are not determined by this model. The abatement incentive is an economic tool that represents a stylised set of policies that could vary.

MR JACOBI: Perhaps if we start with the key finding and then perhaps we can work back through the model in more detail. What was the key finding for modelling?

MS SKARBEK: The key finding was that Australia can achieve a net zero emissions economy or carbon neutral country while maintaining economic growth at similar rates to what we've experienced in recent years.

MR JACOBI: Coming back to work our way through the methodology and the underlying logic, is there inherent in the - you've explained that there was an underlying assumption of an incentive or a price. Is there any assumption in terms of policy itself, or the policy settings that would be necessary to achieve the outcomes?

MS SKARBEK: No, the underlying assumption we built into the model was the emissions trajectory. For that we used the Climate Change Authority's report of February 2014 and it set a trajectory for reducing Australia's emissions from where they are today to a position of net zero emissions by 2050. That trajectory was set based on analysis of the global two degrees climate goal and what would Australia's share of that be. So we accepted that analysis and inputted, if you like, that emissions trajectory as the constraint on the model. So the model fed the costs of all the technologies in our energy system into the model of the electricity system in the land sector, the climate modelling and the economy, and allowed each of those to operate as they would ordinarily but with a proviso that emissions must reduce in line with that trajectory, which again was represented by an abatement incentive to be a proxy for what the policy set might be.

MR JACOBI: Expressed in another way, if government policy was to achieve net zero emissions by 2050 that would be consistent with what the model reflected.

MS SKARBEK: Yes. Of course depending on which policy mix you choose. Some policies can be more or less expensive than others or have different distributional effects, and we haven't modelled those. We have, as I say, used a single abatement incentive, which essentially is pricing the emissions, to represent what it would cost in each of those sectors to keep emissions at that reducing trajectory.

What that allows for is for a cost optimised approach. So we didn't impose any normative assumptions about which sector should do more or less or should go first in terms of reducing emissions. We allowed costs to determine that. But in allowing costs to determine that, we kept the emissions constraint on, which of course converts to the abatement incentive which then affects the relative costs of those technologies depending on what the level of emissions are at each decade in the model.

MR JACOBI: In terms of which sector emerged as going first in the model in terms of what emerged from the costs in the technologies, what sector is it that moves first?

MS SKARBEK: In fact the way we've described it is that there are four stages that move in parallel. They are ambitious energy efficiency, low carbon electricity or decarbonising the electricity supply, electrification and fuel switching, and sequestering non-energy emissions through industrial capture known as CCS and tree planting or carbon forestry, as it's described. The research assumes or reveals that in fact we must move forward on all of those together and it's not a linear pathway where some can wait until others however they are interrelated, so, for example, if the ambitious energy efficiency is not undertaken then we’ll have greater electricity demand and would need to build more sources of electricity for example, so we have assumed in the modelling that they happen in parallel, so that the energy efficiency is undertaken which reduces electricity demand, but at the same time the third pillar of electrification is undertaken which increases electricity demand particularly in the transport sector where cars move to electric batteries and in the industrial sector where wherever fossil fuel use such as gas that’s being used for electricity could be substituted for zero carbon electricity, so we actually ran all of those in parallel so that they operate in an integrated way and the result is emissions are reduced as much as possible essentially using the principle of is there a substitute for the emissions intensive source of energy and if so you use it, so, firstly, can you avoid the use of energy with energy efficiency; secondly, if you’re using electricity that’s not from a zero carbon source can that be switched over and, thirdly, if you’re using a different form of energy that’s a fossil fuel and has emissions can that be substituted either for the electricity which would be zero carbon or a lower emissions form of fuel, so, for example, diesel in trucks could be substituted with biodiesel or with gas as one example. In aviation we had a blend of biofuel and traditional fossil fuel jet fuel and, finally, the sequestration was calculated on the residual emissions which results from those other integrated activities occurring in parallel.

MR JACOBI: Was there a need in the model to specify that transition and electricity generation would need to move first before one could get benefits in things like fuel switching?

MS SKARBEK: The model results in that outcome in the sense that when emissions are priced in an economic way and, for example, the cost of operating a petrol car is the cost of the petrol emissions or you could switch to an electric car for the cost of the more expensive car, but the lower cost to emissions if the car is drawing emissions from the grid that isn't zero carbon then that cost is factored in to the model and there became, if you like, a tipping point where the electricity system decarbonisation had reached a sufficient share of low carbon electricity that on the costs the balance of the costs, take the car example; the more expensive car, but the less expensive emissions, switched, so that it became then in the models eyes the cost effective choice was to buy the electric car instead of to buy the new petrol car, so we didn't determine when that point in time was, but rather, because of the emissions trajectory, the model reduces emissions wherever it's most cost effective to do so initially and that interaction – what we saw was that it happens in parallel, that as more renewables enters the electricity mix that allows other sources of fossil fuel to switch off, say petrol, and on to electricity and we saw that happening in the late 2020's, particularly in vehicles.

MR JACOBI: You referred to the energy efficiency inputs as being ambitious. I'm just wondering whether you could explain that and I think you even described if you were switching requirements as also being ambitious.

MS SKARBEK: Yes. Because we were guided by the emissions reduction trajectory and energy efficiency is cost effective it assumes that all the actors in the economy act rationally, driven by cost decisions and what that means is that whenever equipment is being upgraded the most efficient form is chosen. We didn't force obsolescence into the model, although in the electricity sector I'll discuss later there we see the emissions trajectory does force early retirement of some of the coal power stations, but on energy efficiency it's essentially equipment and appliances that we're dealing with, as well as buildings and vehicles and what we had was a set of inputs around how technology advances into the future and what the energy savings are from using that technology relative to the increase cost perhaps of purchasing the more efficient model and the assumption was a cost effective decision would be made by the purchaser, usually that meant that it was made at the time of replacement of that asset, and we were fortunate that the evidence is technology does improve rapidly in terms of its energy efficiency, so, for example, in the building sector the results showed that total energy use for buildings in 2050 could be the same as it is today, notwithstanding that we will have continued population growth of over a per cent per annum.

MR JACOBI: I think we may have a graph that might - - -

MS SKARBEK: We might come to that.

MR JACOBI: Yes. I'm happy to come to the graph now if that would assist.

MS SKARBEK: Sure. Just to highlight the point around when energy efficiency is done well we have a lot of opportunity that can be grasped. The chart I think you're referring to is figure 14 from our report.

MR JACOBI: Figure 14.

MS SKARBEK: Essentially to show that looking at the two pillars together, energy efficiency and fuel switch, what we see happening in buildings is that whenever it's cost effective to upgrade equipment that upgrade occurs. That's not to say that we wouldn't need an information campaign and other policies that would drive that activity, but when it's cost effective we showed that it would occur and there is in fact a typo on the slide I highlighted to you that hasn't been corrected in the published report, but the key story of that blue box of electricity that the typo is that the two numbers are the same in fact of 376, so in 2012 what's shown there is 459 units, it's actually 375 units of energy and in 2050 the units were the same of electricity and the fossil fuel units were almost eliminated. What that really means is that where gas has been used, for example, for cooking and heating in buildings in a zero carbon world you would switch that to zero carbon electricity instead of emissions gas and we know we can run buildings on electricity without the gas and when emissions are priced that becomes cost effective to do. The key story here is even when you switch away from fossil fuel use in buildings to electricity and you allow population growth to continue as it is, so that's more buildings, and in fact more buildings than population because we have an increase in the number of single person dwellings as well, we don't increase the volume of electricity we're using because buildings become that much more efficient, so on a per square metre basis the improvement was that buildings would use 50 per cent less energy per square metre than they use today, that's over the next 30 years, that's the improvement that's expected under technology advancements.

MR JACOBI: That is ambition is not imposed on the model, it in fact emerges out of costs that are expected?

MS SKARBEK: That's right costs and energy savings that are expected, so the natural progression of technology has been that it gets more and more efficient over time. In the technical report we state what our sources are for those improvements over time.

MR JACOBI: I think the report refers to fuel switching also being on an ambitious basis and I think there's a table also to describe that, which I think is figure 15 in the report.

MS SKARBEK: Yes, and again we use the word "ambitious" because the model assumes that when it becomes cost effective to do so it happens and of course to make it happen across an economy is more than business as usual when that's not happening right now, so either it's a price signal or some other set of standards or requirements or incentives.

MR JACOBI: Am I right in understanding there's no lag?

MS SKARBEK: Beg your pardon?

MR JACOBI: There's no lag in terms of time response to cost?

MS SKARBEK: Yes, that's right however for large industry we did take account of, for example, particular facilities that have a published life cycle, that we would note that the refurbishment would happen at the end of that life cycle rather than halfway through, so above a certain scale in the model we took account of particular facilities in particular sectors. At the smaller scale the assumption was the equipment was upgraded when it was cost effective to do so and as you see from that chart the fuel switching shows that when emissions are priced, if you are using an emitting source of fuel, particularly, as you can see, gas and oil don't grow over the next 30 years, instead the use of electricity grows in the industrial sector.

MR JACOBI: Perhaps moving away from those two particular pillars of the decarbonisation story and moving back to the issue of low carbon electricity. As I understand it a similar analysis to this report was undertaken internationally with respect to electricity in other countries and that's addressed in figure 10 at p.18 of the report.

MS SKARBEK: Yes.

MR JACOBI: I'm just wondering about whether you can offer any insights into why different options appear to emerge in different nations.

MS SKARBEK: These research results are the results of local research teams. In some cases they are in research laboratories, in other cases they were collaborations of organisations similar to our own and they had available to them the best available data in their country and that was the reason for doing it in this way. What we made sure was that we had a common Excel template in the way that we collected and analysed the data and we used common inputs, for example technology costs from IEA and other sources were pre agreed by the group. We had global GDP growth assumptions and other external factors that were pre agreed by the group so that we could be sure when we looked at them in aggregate it was an apples for apples comparison and I think what you see here is that each country has a different endowment of energy assets and fuel sources. Some of those are driven by social or political acceptance in those countries and each team was free to impose whatever constraints on their modelling between fuel sources they wished to provided they net the overall goal which was show how your country can meet the emission reduction targets that are consistent with the two degrees goal and for energy system that meant achieving a near zero emissions energy system by mid-century. Near zero was the term used to recognise that this was the first time this exercise was being conducted in this way and there wasn't a precise number imposed, instead each team was invited to go as far as their national endowment of data availability would allow them to go in terms of reducing emissions in the energy system and so what you see is that, if you look to the right-hand side of the chart, the dark grey meaning the remaining fossil fuel sources of electricity shows that most countries did achieve near zero emissions, that it's less than 10 per cent in most countries in the study. There were 15 countries in the study, you can see they're named there, Brazil, Canada, China, France, Germany, India, Indonesia, Japan, Korea, Mexico, Russia, South Africa, UK, USA and Australia, and what you see is there's quite a bit of variety. It's clear that renewables, particularly solar, is a large share in many countries, but not in all countries and nuclear is a large share in about a third of the countries. There are a few countries where one source is dominant. South Africa being an exception to that where it's predominantly solar and Brazil being predominantly hydro. You'll see most of the other countries there has been a mix of technologies deployed in a somewhat even share, perhaps not exactly even, ranging between a quarter and a third across the key technologies shown here being hydro, solar, nuclear, other renewables and fossil fuels and, as I mentioned, some countries impose their own constraints. For example you'll see Germany has a zero nuclear share, that's a reflection of the local teams understanding of where their political and social acceptance is heading in their country and similarly you'll see Japan has a very small share of nuclear and this is a 2050 outlook by these teams.

MR JACOBI: Was there a particular reason that those 15 countries in addition to Australia were chosen?

MS SKARBEK: They represent 70 per cent of global emissions. Since then two other countries have joined this project and an updated report will be released, this month I think, in September internationally. Other countries have been invited to join and to share the same methodology and present their own analysis in this way. These 15 were chosen based on their availability to contribute to the project and importantly their contribution to global emissions.

COMMISSIONER: The two additional countries?

MS SKARBEK: If I'm right Italy is one and I'll have to take the question on notice for the second.

COMMISSIONER: That's fine. Will that materially change the 70 per cent number?

MS SKARBEK: Not materially.

MR JACOBI: Can I come to the three pathways that I think are shown at the top of that figure 10 for Australian, but I think are otherwise shown in the report in figure 13?

MS SKARBEK: Correct, yes.

MR JACOBI: Figure 13 which is found on p.22 of the report. I just want to come first to the premise for each of the three scenarios that were modelled and I wish to understand why were they the three scenarios that were modelled?

MS SKARBEK: The overarching premise, as I said previously, was to keep Australia's emissions within the trajectory determined by the Climate Change Authority which delivers Australia to a net zero emissions position by mid-century. The difference between these three scenarios; this is the one occasion where we did impose constraints other than the cost constraint on the model and we did so in order to show these three scenarios as a deliberate comparison and the first scenario, 100 per cent renewables, the constraint we imposed is that by 2050 no other electricity source would be a provider of electricity in the grid. You'll see there is a very, very small share, so we retained a very residual volume of gas electricity that was not retired from the existing model. The reason for that was that's the way to achieve the lowest emissions outcome, that is to eliminate as much of the other fossil fuel sources. We then ran the other two scenarios as distinct scenarios primarily for point of comparison because there is such discussion about CCS and nuclear we essentially to allow the maximum of the alternative technology in recognition that given the cost reductions in renewables it becomes a majority share over time and the question then is what are the technologies that can meet the final base load share, so we wanted to allow these scenarios to act as a comparison point, so for the middle scenario, the CCS scenario, we started with the first scenario, being the renewables one, and we allowed CCS in, but not nuclear and in the third it was the reverse. We started with the renewable scenario and allowed nuclear in, but not CCS.

We did look in to running a fourth scenario which was to allow all three. Cost constraints on the time and the effort of running that scenario meant that we didn't complete that work in the time for publishing this however the understanding from the team was that nuclear and CCS would then compete for some of the share and it would be a combination of the results that you see here.

MR JACOBI: In terms of interpretation of the columns, and then coming back I think to some of the things that we've talked about, there are numbers that appear on top of the columns which indicate the height. Is that a measurement in terawatt hours?

MS SKARBEK: Yes, it is. There is a lot of information on this chart, so I'll try and explain what you see here. If you look at the vertical columns, there are three in each scenario, they represent electricity demand, the usage in Australia of electricity in 2012, our base year, in 2030 and in 2050. The first point is that that's a much steeper increase than you would see in other forecasts for Australia, particular, say, the AEMO report or the Warburton report that has been published this year. The reason for that is the four pillars approach we discussed, particularly bringing in the integration of – firstly, there's energy efficiency, which reduces electricity demand, but then there's electrification, which increases it. When we set the goal of a net zero emissions economy, the model looks to use zero carbon electricity wherever it can substitute fossil fuel use.

Between 2030 and 2050, we see a lot of uptake of electrification in transport, so that's particularly passenger cars, where we see – where we reach a point of most new cars that are purchased are electric cars and we see an almost complete phase out of petrol cars in the 2040s, the late 2040s. The other area of electrification is in industry and, wherever diesel or gas is being used and it could be substituted for either grid electricity or off-grid, it is substituted when it's cost effective to do so.

The means that, particularly in the mining sector in WA and Queensland, where there's fantastic solar resource, by the 2040s, when there is suitable storage to support solar, there is a lot of replacement of off-grid diesel to support mining growth. That explains why particularly the 2050 electricity demand is quite a bit higher than what you might see elsewhere in business-as-usual scenarios.

The other piece of information, horizontally across the top there are some numbers in the grey bubbles there. That's the emissions intensity of the grid to show have we achieved our goal of actually decarbonising the electricity system? So that shows the emissions intensity in tonnes of carbon dioxide equivalent per megawatt hour, and you see that, in the renewables, it's .02, in the CCS, .05, and in the nuclear, .04, primarily because some gas generation remains in the mix.

When we lessened the constraint of being 100 percent renewables, it became cost effective to not retire that gas, allow the nuclear in, and offset the gas emissions with carbon forestry. Whereas when you put the constraint on, you can eliminate that gas if you wish to with more expensive, slightly more expensive, renewables. The final piece of information is the colour coding of the technology mix, which is explained in the legend on the right. What that shows is the renewables share of technologies are the green and orange colours, including blue for wind and hydro and biogas.

Nuclear is purple, CCS is the stripes, the black and white diagonal stripes, and fossil fuel is the colours that are grey through to brown and black. We've since published some updated slides that show the exact share of renewables in each of those years, in each of those scenarios, but what you can see visually is that, even by 2030, renewables is the majority in all scenarios. In the CCS, the nuclear scenarios, it's close to 50 per cent, almost an exact 52 per cent majority. In the 100 per cent renewable scenario, where you are retiring faster in order to bring a 100 per cent renewable scenario in, it's above 50 per cent share by 2030.

The interesting part of what we learn by comparing these three scenarios is that the overall systems costs were quite similar, and there's further information in the technical report about when we say "total systems costs", that includes, for example, additional transmission costs to bring some of the new renewables online. It includes the storage costs for batteries, or other solar thermal storage and/or it includes the CCS system costs, or the nuclear costs as well.

We were struck, firstly, that the total cost was quite similar in all three, and we were struck that, when we allowed CCS or nuclear into the mix, it didn't become the majority, even in 2050. Essentially, what that is telling us is that, based on today's estimates of what the costs of those technologies are – and again, working with CSIRO, we used peer-reviewed literature as the basis for those costs. Sometimes the market does move faster than those, but we used what was able to be published and shared in our bibliography, which is published in the report.

Based on today's estimates, the real question is: what are the technologies that you need in the 2040s, after we've had the 2030s, where renewables have become the majority share? What we find is that there's still a little bit of coal in the system that you see. It's begun to retire by 2030, but it's not all gone. So then the question is: what replaces that baseload? What we find is that renewables can do more than half of the system, based on, if you like, current technologies and management. So demand management, weather forecasting, allows the intermittent sources of electricity to be managed quite successfully for over half, up to around two-thirds, of the electricity grid.

It's the remaining third where you need what's called "more reliable" baseload power, where even the intermittency management techniques need to be supported. When you're in the 100 per cent renewables scenario, that means we must look to technologies such as geothermal or wave and tidal, in particular, or a greater use of solar thermal. With the other two technologies, that's where you see that the share of CCS and nuclear comes into play. What that shows us is that, on a cost basis, when you release the 100 per cent renewables requirements and allow CCS or nuclear to come in, they do come in for about a fifth to a third of the electricity system.

In the renewable scenario, where you don't allow that, you see a similar share, say, of the nuclear, the purple, box is represented by a similar share by geothermal and wave. What that's saying is those technologies, on today's costs, are still considered more expensive than nuclear or CCS, but, in an overall sense, because they don't become the majority share of the technology mix, it means that the three scenarios have a broadly similar economic cost.

MR JACOBI: Is it an implication, I think, of what you've just explained that, in the end, it will be the competition between those three technologies and the projections of their future costs, that is, geothermal wave, nuclear, and CCS that will drive filling that remaining portion of the electricity supply?

MS SKARBEK: Yes, that's a good summary. There's one element of the nuclear modelling that is not represented on this chart. The nuclear technologies there are the large scale nuclear technologies. There is, however, development into modular nuclear technologies, smaller scale, for example, 200 megawatt, and we were keen to explore that, but weren't able to present an additional scenario in full. What we looked at was, for example, thinking of the mining sector growth in WA particularly, where we've assumed solar thermal might replace diesel in the off-grid power, it's possible that modular nuclear could be the on-site power source instead of, say, solar to replace diesel.

We ran a scenario to investigate and what we found is that, when we only look at the large scale, the nuclear share there is 14 per cent of the total market share, but if we assumed that, for example, the off-grid – the use in WA was allowed to adopt nuclear power, we found then that nuclear would be the cost effective share up to about 27 per cent. So what was 14 would almost double to 27, moving - - -

COMMISSIONER: Presumably, that wouldn't be restricted to Western Australia, in terms of mining activity?

MS SKARBEK: No, it wouldn't need to be, geographically, but we were trying to look at where the scale of energy use would be and so the evidence on the current estimates would be that, if you're looking at, say – modular, whilst being smaller, is still quite substantial scale, being, you know, at around the 200 megawatt mark. So we looked at – that's where we would see that sort of growth, where there might be a cost effective use for it. There would, of course, be opportunity with greater resources to study that in more depth, and you may well be hearing from other experts on that, but there is some reference on page 44 of our technical report to our analysis, where we shared that scenario. So in essence, what you would see is, in the nuclear scenario, on the chart we've been discussing, where we present – at the moment, the assumption is solar thermal would undertake that extra demand. If nuclear met it, that purple bar would be twice as large as it is, but still be under one-third of the total mix.

MR JACOBI: I think we – and I hope we might descend, just for a brief moment, into parts of the technical report dealing with the issues of costs. I think you've already mentioned that the decline, or projected decline, in costs of renewables is inherent or built into the model. I was just wondering if you could explain how that was done?

MS SKARBEK: Yes. We have published a table in our technical report, and I'll find the page for it in a moment, where we have explained, decade by decade, what the assumed technology costs are for all the technologies that were fed into the electricity system model. It's table 2.5. No, sorry, that's the on-site generation. It is table 2.3 on page 33, which is not a chart, but a table of figures. The rest of that chapter explains the sources of those figures, which again, working with CSIRO, are all from published reports. What you see there is that, decade by decade, it is an estimate of the capital costs for centralised generation technologies and then, a few pages later, it is the capital costs for the decentralised generation technologies.

MR JACOBI: Now, were they the internationally agreed costs for technologies that we were referred to before?

MS SKARBEK: Yes, that's right, however, we were allowed to use local reports, for example, where there was more up-to-date data. So the IEA costs was, if you like, the central starting point. But we have looked, you'll see, in the report to BREE, the Bureau of Resources and Energy Economics, and a number of other published sources in Australia to use, particularly for solar and other renewable energies, where the costs are related to the quality of the renewable resource, the distance from demand centres and so on. It's important to use localised data there as well.

MR JACOBI: I think we've got, with respect to predictions, a table that appears from the technical report, which I think was figure 2.5, which appears on page 31 of the report.

MS SKARBEK: Yes.

MR JACOBI: With respect – I'm sorry, do you have that?

MS SKARBEK: Yes, I do.

MR JACOBI: That chart - - -

MS SKARBEK: Figure 2.5, yes.

MR JACOBI: Sorry, that chart shows expected costs for a range of technologies. I'm just wondering about whether you could offer some brief interpretation of that figure?

MS SKARBEK: Yes, so again, a lot of information presented on one side here. So horizontally, you're seeing the major technologies that were studies and the four bars of costs represented for each of the technologies show, if you like, an evolution in time. So the far left blue bar was the original Garnaut review modelling and the consultants who did the work there in 2008. Those same consultants were commissioned by the government three years later to update that work for the Clean Energy Future policy analysis, which introduced the carbon pricing scheme into Australia. That second one is the dark blue bar.

The green one is a study two years later in 2013 for the Climate Changes Authority's review, which I referred to. Then the fourth one, the final one, is the one that we used in this study. You'll see there's quite a bit of discussion in the technical report about why did CSIRO choose certain data points and costs levels and the sources that are used for that. So I won't go into that now, of why that fourth blue bar is the level that it is, but what's interesting here is to compare over time how, particularly, the renewables costs have fallen and, particularly, solar PV large, the first one in the first set of columns there.

These costs are the 2030 estimates, so not today's estimates, but they're the estimates at the time of writing for what the cost would be in 2030. What you see is that, at time of writing in – so the first blue bar compared to the last blue bar for solar PV – at time of writing in 2008, the cost in 2030 for large scale solar was estimated to be above $5000 a kilowatt and, in the report that we've published in 2014, that was below 2000.

Interestingly, what we find is the dashed black line is the realised cost in 2012. So that's not looking out to 2030, but it's saying, in 2012, what was the published cost according to the government's agency brief? We show that as a point of comparison to say it's four years after the Garnaut review used the best available data to estimate what would solar PV cost 15 years from now. In just four years, the real world cost was already ahead of what they thought the 2030 cost would have been. That helps explain why the blue bar that we have used, which is between $1000 and $2000 a kilowatt, is so much lower than what was used previously. It's because the real world costs have already exceeded what those future costs had been estimated to be at the time of writing.

MR JACOBI: I think that we've also got a subsequent chart also of the technical report at figure 2.6, which was page 32, which I think, in fact, shows those real world - - -

MS SKARBEK: Yes, that demonstrates that cost reduction, indeed. This is from an international set of data. The previous charts were Australian specific studies.

MR JACOBI: In terms of the upshot that emerges from the entire discussion, is cost seen to be a deriver of outcomes?

MS SKARBEK: Yes, absolutely. As I say, the only constraint we imposed on the model was that emissions must fall in line with the trajectory determined by the Climate Change Authority but, after that, we assumed, as most models do, that economics is the driver for all decisions and that, therefore, cost effective decisions are taken. Now, that does mean, of course, that, because of that emissions constraint, we are assuming that emissions have a cost themselves and, therefore, avoiding emissions has a cost benefit. That helps the cost effectiveness of low carbon technologies against the fossil fuel technologies.

The other thing that helps is that it's a 30-year study. It's looking out to 2050, which is the time period for the emissions trajectory, and, given the rapid pace of reduction in solar costs, in particular, and the evidence that that reduction is set to continue, it places renewables in a competitive position in the decades ahead, even for the technologies that have historically been more expensive.

MR JACOBI: I think with all of those matters in mind – we started with the finding of your report – is there a finding to be made with respect to them, as an overall conclusion, as to what the first sector to undergo transformation will be in order to achieve the sorts of outcomes that are going to be necessary under this sort of - - -

MS SKARBEK: The electricity sector is an absolutely essential sector for enabling the transition. Whether it's first, again, I would prefer to use the words "in parallel" because, for example, energy efficiency needs to be occurring in parallel, or we will need a lot more renewable electricity, or nuclear, or CCS. But without decarbonising the electricity sector, then we will struggle to decarbonise the transport sector and the industrial sector. So it is an enabler and an essential precondition for decarbonising much of the rest of the economy.

MR JACOBI: Does a view of achievability emerge from the model? There's the ability to achieve a net zero emissions outcome?

MS SKARBEK: Yes. Australia is really fortunate to be blessed with multiple choices in decarbonising its electricity system in particular, and because the electricity system, as I said, enables the decarbonisation of the rest of the economy alongside the land, particularly our land mass potential for bioenergy and carbon forestry, it was striking to us in doing this work how blessed Australia is for options in terms of transitioning to a low carbon economy.

We've modelled these three scenarios because we could be a 100 per cent renewable powered economy if we wanted to be. We have the technological ability to do that, and the research we did with CSIRO showed that proven technologies can already perform to the necessary level, but similarly we could also nuclear in the mix for 14 to 27 per cent based on current costs, or we could use CCS because we have the opportunity for stable geological storage and abundant - particularly coal powered resources.

Many other countries don't have those options and so Australia was really fortunate and I think the conclusion of the comparison being that all three were at a similar cost today is that essentially it will be, you know, subject to a policy that drives emissions down; that the jury is out as to which technology would fill that final share of Australia's electricity mix in a decarbonised electricity system because on current cost estimates they come out as a similar total system cost, noting that renewables is the majority in all three.

But I see from how rapidly renewable energy technology costs have fallen that they often outperform what the estimate of future costs on paper today says. So it's possible that renewable costs could fall further than what we have published in this report because past evidence has suggested that's certainly been the case historically. In that case, renewables would become more competitive than the nuclear and the CCS options that we've looked at, unless those technologies also fell further.

COMMISSIONER: Can I just explore the policy setting. I mean the assumption of this modelling is that activities are driven by cost and that influences the market. If we looked at our policy-setting, it wouldn't necessarily show that direct relationship. The policy-setting, is that something that you've looked at or because of the need to create assumptions for them all to run, that is the basic assumption that you've had to take?

MS SKARBEK: Yes, I think, if I'm understanding your question correctly. We didn't model alternative policy settings. There's been a lot of modelling, for example, of an emissions trading scheme for Australia and multiple versions of different schemes that were presented to parliament over the last decade. We certainly didn't replicate that kind of modelling. But you're right about the cost assumption, that we have assumed there is a policy or set of policies that results in a cost signal to energy system owners.

COMMISSIONER: Thank you, Anna. I don't think we've got any further questions. It was very clear and we look forward to reading the final technical report.

MS SKARBEK: Thank you.

COMMISSIONER: We will adjourn now until 1 o'clock, when Prof John Quiggin from the University of Queensland will join us.

ADJOURNED **[11.54 am]**