

COMMISSIONER: Ladies and gentleman, good morning. Can I start by acknowledging that we meet on the traditional lands of the Kaurna people and that we respect their spiritual relationship with the land. Today, the Commission's public sessions commence and, before I call the first witness, I thought I might explain the purpose of these public sessions. The overriding objective is to permit the Commission to speak to those with expertise and information relevant to its inquiry. Doing so will allow it to understand the reasons why the potential activities that the Commission has been asked to consider might present either a risk or an opportunity.

The sessions are designed to draw from a wide range of expertise and experience. The witnesses that will be called, both from Australian and overseas, have practical experience in implementing, managing, regulating, or organising the issues that we are considering. The public sessions are simply part of the Commission's ongoing fact finding and evidence gathering process. It will be an overriding theme of these public sessions that witnesses are not only asked for their view, but most fundamentally, to explain or to justify it.

As we know, the area is abound in claims from both those that support it and those that are opposed to nuclear activities. The point is not the claim: it's the reasons and the views that are most important. The goal is to identify areas of consensus of opinion or view and, in the event of differences of opinion, to understand the reasons why. All of this activity is directed at forming a rational and coherent basis for our report to government. The public sessions are organised around many of the issues that will fall within the areas of exploration and extraction, further processing, energy generation and storage. Many issues of considerable significance will be addressed.

For the next couple of weeks, those topics will set the scene of what is to follow, matters such as climate change, energy policy, and the national electricity market demand for low carbon technologies. Subsequent sessions will explore a range of other issues, including the threat posed by radiation to humans and the environment, the storage and disposal of waste, and best practice in community engagement.

It should not be forgotten that these sessions are an addition to the evidence received in the written submissions. The public sessions are simply a different way of collecting further evidence. They are not an occasion for accounting what has already been said in written statements. Not all of the issues and the terms of reference will be addressed. No conclusion should be drawn from that. Some issues, particularly those that are highly technical, are not effectively addressed in this format.

What is said in public sessions is evidence. Witnesses, as is the custom for Royal Commissions, will be sworn. Those formalities will be attended to, as

far as possible, in advance of the session. The sessions are intended to run as informally as the process permits. The goal is to have a discussion in a format that is most conducive to the evidence we are considering. These public sessions will offer a clear insight into the materials and other research that the Commission is considering.

Having explained what the process is, it's important to say something about what the process is not. This is not an adversarial contest. The purpose of the public session is not a trial between competing cases, nor is any witness on trial. There is no score to be kept. This is just too important for that sort of approach. I also ask those who are interested not to jump to conclusions. As with any inquiry, new issues will arise and some will fall away. It will be important to consider the evidence as a whole. No conclusions can be reached from what one witness might say in answer to a question as to what that might mean to the eventual outcome.

A witness can express a view and explain the reasons, but as anyone that has contemplated the 250-odd submissions that we've received to date and the abundant material written on these issues almost on a daily basis, the evidence at the public sessions will only be a part of the puzzle. The person sitting to my right, Mr Chad Jacobi, Counsel Assisting the Commission, has the general role of guiding the discussion with witnesses, asking questions on issues of interest to the Commission. He will introduce the witness before they are called and, before the public sessions commence each day, a brief statement, which explains the context of the evidence given on that day as part of the Commission's overall inquiry. Mr Jacobi?

MR JACOBI: Today's and next Monday's public sessions are concerned with the topic of climate change and energy policy. The Commission's terms of reference require it to consider the possible future viability and risks of nuclear activities, each of which are tied to energy generation both in Australia and overseas. The so-called front-end nuclear activities, extraction and further processing, necessarily depend on there being a demand for energy generated from nuclear fuels.

The potential viability of storage and disposal activities are substantially related to waste generated from nuclear energy, but the potential future for nuclear energy and its associated activities are to be considered against arrangements for the generation, distribution, and consumption of energy that can be expected to rapidly change over the coming decades. There will be a number of drivers of that transformation. Each of those drivers, climate change and energy policy, the nature of the electricity market, generation, transmission and distribution infrastructure, and the development of low-carbon technologies will be considered in sequence by the Commission at its outset in the coming sessions.

For today, the key driver to be considered is climate change and its likely impact on the development of energy policy. Any prediction about the viability of nuclear activities in South Australia and the conditions necessary for their viability must take account of these developments. There are a number of steps in that analysis. The first is to contemplate what reasonably might be agreed over coming years and Australia's contribution, and then to contemplate the possible pathways driven by technology and cost.

Against a background of existing targets and policies, the international community will meet in Paris in December, seeking to reach agreement on further targets to limit the emissions of greenhouse gases. The principles underpinning those new targets, limiting mean surface temperatures to 2 degrees above pre-industrial levels, the associated concentrations of carbon dioxide and other gases, and the speed with which those reductions must occur and the sharing of responsibility between nations are critical to any view of international and domestic energy policy and that is so because the emissions from the generation of electricity in Australia account for about a third of Australia's carbon dioxide emissions. It is not only a focus because they are single point sources of most emissions and also because of their share, but because the potential pathway for reduction of emissions in other sectors lies in many cases through low emission electricity. The interactions in this respect are complex and make prediction challenging. The likely developments include not only increasing measures to improve efficiency with a result in decrease in demand, but fuel switching to electricity from carbon intensive fuels particularly in transport and industry. For Australia such predictions must also be made against a back drop of changes in materials, processing and manufacturing.

In raising these issues it is important to identify what is beyond the scope of this Commission's role. The role of the Commission is not to express a view about what climate change policy ought or ought not be, rather its task is to make some reasonable estimation of it. Nor is it to identify what Australia's overall response should be to the implementation of those targets. Those issues are not within its remit, but its remit does require it to consider those conditions necessary for viability as it must understand the policies directed to tackling climate change because they will have a dramatic effect on energy generation, demand, transmission, distribution and consumer behaviour. The purpose of these sessions is to further the Commission's understanding from the perspective of those with experience and knowledge about their view as to the likely arrangements.

To that end the Commission's first witness is Professor Ross Garnaut, AO, who is a professorial research fellow in economics at the University of Melbourne since 2008 and prior to that at the Australian National University he

was the distinguished professor of economics 2007 to 2013 and prior to that a longstanding head of the division of economics in the research school of Pacific and Asian studies. He has a distinguished career in academia and public service. He is the author of numerous books, monographs and articles and scholarly journals on international economics, public finance and economic development. He is the author of a number of reports to government including Australia and Northeast Asia ascendency in 1989 and, most pertinent today, The Garnaut Climate Change Review 2008 and The Garnaut Review 2011: Australia in the Global Response to Climate Change. In addition to that he has chaired the boards of major Australian and international companies and the Commission calls Professor Ross Garnaut.

COMMISSIONER: Welcome, Professor. Thank you very much for joining us.

PROF GARNAUT: Good to be here, Commissioner.

MR JACOBI: Professor, I was hoping that we might start really at the starting point which is to get an understanding as at 2015 about what you consider to be the current international scientific consensus with respect to climate change predictions and its effects that will underpin the decision making related to Paris?

PROF GARNAUT: First my authority on this question, of course I'm not a climate scientist, but I've read deeply into the climate science literature from the time of my climate change review in 2007 and 2008 and had available to me then the major scientists of Australia who were working on climate issues. There's not much uncertainty about the broad parameters of climate change within the global scientific community. If you go to the peak scientific bodies, that national academies of science and their equivalents in every one of the countries in which you've got major scientific strength, all of the OECD countries plus the big developing countries, China, India, Brazil, the overwhelming view is that human activity, and especially the release of greater quantities of carbon dioxide and some other carbon compounds into the atmosphere, is already changing the world's climate and that if trends were uninhibited by policy intervention, if the relationship between economic activity and carbon emissions continued as it had once been then we would change the climate to an extent that was seriously damaging to economic activity and other dimensions of human life on Earth.

The science has always recognised that there are probability distributions, ranges of uncertainty around the core predictions. The mean, the weighted average, of the likely outcomes points to seriously damaging effects from unmitigated climate change seriously damaging to the extent of the catastrophic. It also recognises that the outcomes could be better or worse than

5 this mean and the way that we normally view uncertainty about possibly catastrophic outcomes is that the presence of uncertainty, probability distribution around an unhappy outcome usually adds to the case for urgent action because it adds to the case for insurance. In most other areas of life, from defence spending to insuring your house, when there's a range of outcomes, some of which are catastrophic ones, prepared to pay quite a lot for insurance, so the presence of uncertainty around the mean of expected outcomes, in the normal way of looking at such things, adds to the case for strong and early action.

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On the path that the world was on at the time of my first review, then I mitigated emissions, business as usual would have in the mean case, the average of the expected outcomes, generated temperature increases in the order of four degrees by the end of the century, but that would be just part of a process that would continue increasing from then on. Since I did that detailed work seven or eight years ago the area of uncertainty has diminished and it's tending to confirm the mean of the expectations that was apparent at that time, but the range of uncertainty is less than it was. Climate science is now identifying actual effects of climate change in current weather patterns whereas that was more difficult to do in 2007 and 2008.

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The effects on Australia were one of the main subjects of my original climate change review and it was clear that unmitigated climate change would have led to changes in the Australian economy and society that were seriously damaging. Some of the most important vehicles for damage were, it was expected, just the warming of a dry continent in itself; the effect on evaporation and the effect on wind patterns was expected by the science to lead to serious changes in agricultural conditions, especially in southern Australia. Sea level rise associated with the warming of the oceans and the melting of glaciated areas of the Earth would be seriously damaging to many coastal environments. There would be very large increase costs of maintaining infrastructure, building and maintaining infrastructure in a high temperature environment and for Australia, which alone amongst the developed countries lives mainly in an environment of developing countries, the greater vulnerability of developing countries to climate change was expected to be a particular source of damage. Many of the countries of Asia have a major part of their economic activity and populations near sea level, very vulnerable to rising sea level and more intense, extreme climatic events, and the disruption that this would cause would feedback onto Australia in a range of ways, some economic, some through other mechanisms. So I judged, in that first report, that Australia was the most vulnerable of all the developed countries to unmitigated climate change and, therefore, had the strongest interest of all of the developed countries in an effective global effort to combat climate change.

45 MR JACOBI: Do you consider that there is agreement on the means and

mechanisms for the avoidance of what might be described as “dangerous” climate change?

5 PROF GARNAUT: There is considerable agreement. Obviously, there are differences in emphasis and perspective, but there was a very important development at the Copenhagen meeting of the United Nations Framework Convention on Climate Change in December 2009, when the international community agreed on a goal of holding temperature increases to 2 degrees. Now that is a political decision, a consensus decision of the leaders of the world.

15 Every country on Earth that’s a member of the United Nations participated in that decision, although there was some unhappiness amongst South Pacific countries who thought that anything more than 1.5 per cent would threaten their viability because of sea level rise, and they may very well have been right in that. The international agreement on the two degrees objective doesn’t mean that anything up to 2 degrees is not damaging, but climate change was already happening. It wasn’t going to stop immediately if only because there’s a lot of momentum already in the growth in greenhouse gas emissions.

20 So the 2 degrees was thought to be a point up to which the effects of climate change might be manageable. They would be costly and severe, but they would be manageable. Beyond that, we would go into dangerous territory, with more serious outcomes. That has stuck as an international objective. It continues to be the focus of the G20 heads of government when they discuss climate change, of the G7, the seven big industrial countries. It’s the focus of the UN framework convention still. So one can say there is broad agreement around that, although some cautionary words about whether the damage at 2 degrees is larger than we should actually contemplate.

30 There’s general recognition that what has to be done is to hold carbon emissions to levels consistent with that 2 degree objective is to radically change the link between economic activity and carbon emissions. There are some views that it’s not possible to change that link enough and that we will have to have lower economic growth, but that is not my view. I think the means are there for maintaining global economic growth and for continuing to elevate the living standards of people in the developing countries towards those of the developed countries while reducing carbon emissions. My own view is that there is a path to continued economic development, quite strong economic growth, that’s consistent with reducing greenhouse gas emissions.

45 How much will we have to reduce them? Well, from the levels at present, achievement of the objective would require the world as a whole to reduce emissions by more than half by the middle of the century and, not so long after that, well before the end of the century, to eliminate carbon emissions all

together. This is broadly the perspective agreed by the G7 heads of government in Germany earlier this year.

5 Now, if the world as a whole is to reduce emissions by more than half by the middle of the century, the developed countries will have to reduce emissions by over 90 per cent and some emissions are harder to reduce than others, so that really means effective decarbonisation of the electricity sector of the developed countries by the middle of the century. That's the implication of international acceptance of the 2 degree objective.

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COMMISSIONER: Could I ask what you think the outcome in Paris will be in December this year?

15 PROF GARNAUT: Yes, I think that Paris should be seen as an important step on a journey rather than a decisive point in itself. Because the Paris meeting is hosted by a major European country with strong commitment to strong outcomes, chaired by the French president, Paris is an opportunity for the world to get its act together and that is recognised by the leaders of the world. That's why the G7, in its last meeting, placed a major focus on the outcome in Paris and it's why, this year, we've seen serious interventions in the discussion by the world's major political and moral leaders.

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25 The series of statements by President Obama this year, leading up to the Paris meeting, have left no doubt of the United States government's perspective that this issue is – well, President Obama has said that the greatest international issue facing us at a time of great international issues, amongst many major statements by the world's leaders of religious faiths.

30 Probably the most powerful example was Pope Francis' encyclical a couple of months ago, which drew very strongly on the accepted climate science. He consulted closely the best of European climate science in developing that and came up with a very strong statement on the urgency of climate change, pointing out that reducing emissions, changing radically the relationship between carbon emissions and economic activity, was not only a great policy issue, but it was a personal, moral imperative that he hoped would be seriously considered by people, not only of his faith but of all faiths.

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40 MR JACOBI: Do you perceive any risk, whether at Paris or later, that the 450 ppm target will not either be agreed, or that countries won't agree on domestic action which is consistent with a 450 ppm target.

45 PROF GARNAUT: Yes, there's a risk, and one would have to say that the world, as yet, is nowhere near on a path towards 450 parts per million or 2 degrees, and we won't be on that path after Paris. What Paris might do is – well, it's already doing it – led to an elevation of ambition, but as I said earlier,

it is one step in what will have to be many steps towards elevated ambition, recognising that we won't get there in one step.

5 The United States set its post-2020 target, simply for a five-year period to 2025, recognising there would need to be a ratcheting up of ambition after that – the United States, since President Obama took office, has changed fundamentally the US approach to these questions. The US, back in 2009, committed itself to reduce emissions by 17 per cent from 2005 levels by 2020. Now that, for the United States, was a huge change in trajectory. Prior to that, 10 the United States' position had been that of President Bush, which contemplated continued increases in emissions until 2025 and then reduction after that.

15 The United States not only introduced an ambitious target, it's actually making strong progress towards that. In its 2025 targets to reduce emissions by 26 to 28 per cent by 2025, it has embodied in that target an acceleration of effort. There's a faster rate of change in the next five years and what is contemplated is a series of five-year steps in which there will be further accelerations of 20 effort. You're getting something similar in most of the world's major countries. One could characterise the European effort as being at the global frontier, ahead of the United States, although the United States is catching up.

25 You've got similar perspectives in such other developed countries as Japan and Korea. Japan had been way in front of the global effort for a long time, having been host of the Kyoto meeting back in 1997. The Japanese effort to reduce emissions took a big hit with the Fukushima nuclear disaster because one of the means whereby Japan had been seeking to reduce emissions was continued expansion of the role of nuclear energy and Fukushima raised technical and, more fundamentally, political doubts about that that led, in Japan, to the 30 closure of nuclear plants for some time. Prime Minister Abe is just now supervising the re-entry of some of the safer plants into production.

35 Canada is often seen, like Australia, as a laggard in these things. Canada, Australia, and the United States are the three developed countries with the highest per capita emissions, Australia the highest of the three. But Canada has tended, in practice, to accept the leadership of the United States and some of the domestic regulatory policies of Canada have been changing relationships quite a lot in recent times. Their target for post 2020 is in the direction of the 40 United States, but not quite as strong.

45 The most important country of all for the world getting on top of the problem so far this century has been China. A very high proportion of the growth in the world's carbon emissions in the first 11 years, or first dozen years, of this century was in China. I said in my report in 2008 that, unless there was a fundamental change in China, then the world would fail. China was so big in

the world story that, unless it changed fundamentally, the world wasn't going to be able to solve this problem. Well, the good news is that China has changed fundamentally. Last year, for the first time, emissions actually fell and, in the first dozen years of this century, emissions had grown at double digit levels.

There is a huge effort embodied in policy in China to radically reduce the energy intensity of economic activity and, even more importantly, to shift the main source of energy away from coal towards all of the lower emissions sources of energy. So in China, we've had, in recent years, the world's biggest effort in expansion of all of the low emissions technologies, including solar, wind, hydro, and nuclear and biomass. Also, there's been quite strong growth in use of gas rather than coal.

So all of the major countries have been changing very substantially the relationship between economic activity and greenhouse gas emissions. So far, they have not been changing at a rate that will deliver the 2 degrees objective, but the tendency for acceleration of effort in most of those countries and, most importantly, the two biggest emitters, China and the United States, leads me to the view that the 2 degrees target is actually within reach. You asked if there's a risk that it won't be met? Yes, there is a risk and, therefore, there is a risk of serious damage to global economic activity and global political stability.

MR JACOBI: If one is to come back to Australia and think about where we'll be in the medium term, say, in 2020 or 2022, do you have a prediction about what Australia's likely pathway will be at that point?

PROF GARNAUT: Well, it's clear what Australia's pathway will need to be if we're to do our fair share in a global effort to achieve 2 degrees. We'll have to reduce our total emissions by about 95 per cent by about the middle of the century and, because our population is growing more rapidly than other developed countries per capita, that might only be – sorry, at 95 per cent reduction in total emissions, but 90 per cent reduction in – I've had the flu. I can sort out the arithmetic later.

Australia, of all the developed countries, is the furthest from a path that would deliver its fair share of emissions reduction. I, myself, don't think that that is a sustainable position. It's not sustainable internationally, or in Australian domestic politics. We saw, when Australia hosted the G20 meeting of heads of government last year, that for Australia to sit a long way outside the global consensus on climate changes carries international, political costs. Australian prime minister aren't comfortable in accepting the sort of opprobrium from the President of the United States that we had to accept in the president's public statements in Brisbane at the time of the G20 substance, so there's a question I think that the Australian government recognises that and there has been a

change in the tone, at least in the rhetoric, of the discussion of climate change objectives since the G20 meeting, but it's also not likely to be acceptable domestically because a high proportion of Australians recognise that this is a very important issue and if governments are not contributing their fair share to a global effort then enough Australians care deeply about that for that to put pressure on outcomes, so I expect a ratcheting up of the Australian effort. We won't catch up with the international effort overnight, but I don't think there's much doubt about the direction we'll be moving over the next decade or two.

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10 MR JACOBI: To be specific is that a 450 ppm two degree pathway when you speak of the fair share?

PROF GARNAUT: Yes. The question of fair share is a complicated one of course and I sought to make my interpretation of a fair share quite explicit in my two climate change reviews. The first one for all the state and territory governments and the Commonwealth, the second one for the Commonwealth multi party committee on climate change 2008 and 2011. My own view is that there's going to be no basis for international agreement on fair shares of the effort that does not have its roots in equal per capita entitlements to emit. Now that doesn't mean equal per capita emissions because if emissions entitlements are traded across countries then some countries can emit more, some less, but they will pay others for the differential and I work systematically through that, through the implications of that basis of calculating fair shares and that was the basis of the view that Australian emissions needed to fall by 90 per cent by the middle of the century. Again I make the point that electricity is our largest source of emissions, but it's easier and cheaper to decarbonise electricity than some other forms of economic activity and so to get down to 90 per cent we really have to do 100 per cent of electricity.

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30 MR JACOBI: I think that picks up where I was going to go next and was to ask about where you think the sectoral shifts will need to be and perhaps to turn to what's the sequencing of those likely sectoral changes in your view?

PROF GARNAUT: Yes. I supervised a very elaborate modelling exercise in this for the first of climate change reviews and traced the possible changes sector by sector, but electricity is really the central one. When I initially did my report the electricity share of Australian emissions was around about 40 per cent. It's fallen a bit since then both because we've had some decarbonisation with growth or renewables and there's been some reduction in growth in demand whereas in some other sectors there's been big increases in demand, but electricity is central, but it's even more important than those statistics suggest because electricity would play a major role in efficient decarbonisation of other sectors, so some industrial processes currently use other forms of energy, but could use electricity and may very well – I think it's likely in many cases to be easier and cheaper to decarbonise the electricity than the alternative

sources and the decarbonisation of transport, and transport is a very big source of emissions in itself, is going to be cheapest and most effective through mechanisms that draw on large amounts of electricity. There's still a big competition going on about which electricity based source of fuel for cars will win in the local carbon economy. Some countries, the United States, probably Germany, some major car producing countries are focusing mainly on the battery direct use of electricity; Japanese car producers are putting a huge effort in to hydrogen, one of them will do better in the technology and force the others to follow. There are variations on the hydrogen theme for example ammonia is a fuel that's easier to transport than hydrogen, so could have some role in the decarbonisation process and similarly decarbonisation of transport will involve greater use of public transport both for metropolitan and inter metropolitan use. In Europe, China, Korea and Japan a much higher proportion of inter city traffic is taken by fast trains, electric trains and so within our public transport systems, railway systems there will be electrification, so electrification of transport and of industry is likely to be important in the decarbonisation of those other sectors, so electricity is important beyond electricity itself.

20 MR JACOBI: Do you think that in addition to the sectoral changes that there will be changes to the energy and emissions intensity of exports from Australia?

PROF GARNAUT: Yes, there will. We're already seeing radical changes. Australia has been a super power of the fossil energy world. We're the world's largest exporter of coal. We were once the largest exporter of both metallurgical and thermal coal; metallurgical used in steel making and thermal coal used for power generation. Indonesia has passed us on thermal coal during the recent resources boom partly because it's so favourably located in relation to China and India, but put metallurgical and thermal together and Australia is the biggest exporter. We're likely soon to become the world's biggest exporter of natural gas and the fossil energy sources have been a major source of Australian economic activity and prosperity in the past. They've been the sources of relatively low cost energy for households, electricity and heating, and have also been the source of competitive advantage for some export oriented industries. Australia has been or was for a considerable while, and probably still is, the world's biggest exporter of aluminium metal which is highly energy intensive and the most powerful increase in incomes from the fossil fuel industries has been relatively recent during, what I call, the China resources boom from 2003 to 2011 when coal prices rose to extraordinarily high levels, LNG prices rose to very high levels and that encouraged huge expansion of our LNG industries and so there was extraordinary growth of incomes in Australia on the basis of investment and exports in coal and LNG. That boom was entirely a product of the – no, not entirely, mainly a product – exceptional growth in Chinese demand from the beginning of the century until

2011. China, the world's most populous country, experienced faster economic growth than any country ever has and it was exceptionally energy intensive and metals intensive growth. That was the structure of their growth, partly a function of their planning and political system, and that led to shortages of coal and gas, extremely high prices, and that gave us our resources boom.

Since 2011, Australian incomes have sagged, or the incomes of ordinary Australians in real terms are lower now than in 2011, and the ratio of employment to population is significantly lower now than at the peak in 2011. That's the resources boom going into reverse and the resources boom was mainly two energy commodities: coal and LNG, plus iron ore. That's all gone into reverse.

One of the reasons, especially on the energy side, in which it went into reverse is that China changed its model of economic growth and one of the powerful motives for China's change in the model of economic growth was realisation by the Chinese leadership, under some pressure from the Chinese community, that the environmental impact of the old model of growth was seriously damaging. The Chinese authorities were mindful both of the domestic environmental impact, the effect of coal particles, or particles from combustion of carbon fuels, on health and longevity, with serious scientific studies showing that the concentration of small carbon particles in the atmosphere in north China was seriously reducing the life expectancy of citizens.

The other dimension was the international one that I've already mentioned, that the Chinese leadership came to accept that China was a major part of the international problem on climate change and had to play its part in a global solution. Since 2011, you had fundamental change in the Chinese model of economic growth away from heavy reliance on growth and demand for fossil fuels. I follow China very closely and have done for 35 years, and I think it's true to say I spotted the changes when they started to happen, but I underestimated the extent of them. They are far reaching, with huge implications.

Now, one of the implications is that the change in China's model of economic growth changes Australian opportunities. We could not grow our incomes and employment from expanding our fossil fuel industries today as we did between 2000 and 2011. Even if we wanted to, it was Chinese environmental policy that huge impact on Australia, in fact, a much bigger impact than any change in Australian policy would have. But that doesn't mean that Australia need do badly in a low-carbon world. In fact, in a public lecture at the University of Adelaide Engineering School in June, the Luxton lecture, I set out the reasons why I think that Australia's advantages relative to other developed countries are even greater in a low-carbon world than in a fossil energy world because, compared with other developed countries, our endowments of most of the

low-emission sources of energy are greater than they are in the fossil fuel area.

5 In Southern Australia, the combination of solar energy opportunities and wind energy opportunities are exceptional. One day, wave and tidal energy will be more important and Southern Australia is exceptional for the quality of wave resources. Australia is much richer in high-grade uranium oxide, the basis of nuclear energy, relative to other developed countries, than it is in gas or coal. Australia also has exceptional opportunities in biomass of various forms. So the low carbon economy of the future, the low carbon world economy,  
10 Australia can win back the advantage that it once held as a low energy cost country.

I should add one other point. A very important development during the China resources boom is that we saw the internalisation of a number of Australian  
15 energy markets that had once been domestic markets. Our relative abundance of natural gas in eastern Australia had once led us to have about the lowest gas prices in the developed world. There was no export market and the gas just had to be sold at the best price it could, and that ended up with cheap gas. That was the basis of a lot of highly competitive manufacturing activity, gas-based  
20 manufacturing activity, especially in the cities of Melbourne, Geelong, and Adelaide.

The development of major new export markets took away that domestic price advantage. We're still in the process – we're not there yet, but it's in the  
25 process – of raising gas prices to international prices and the effects of this were even more far reaching, because the United States went in an opposite directions during this period and it restricted exports, leading to very low gas prices. So the effect of that is that, apart from all of the other factors I've mentioned that were changing the Australian energy story during and after the  
30 resources boom, the movement of our gas prices to export parity prices has taken away what had once been a source of competitive advantage for quite a lot of manufacturing activity.

35 In the low-carbon economy of the future, Australia's advantages are likely to be more sustainable and permanent because, for the foreseeable future, the low cost of renewables in Australia relative to the rest of the developed world will be manifest in low prices to domestic users. First, an illustration of the extent of the Australian advantage. I was assisted in my work on climate change seven or eight years ago by a visit from the leader of the Director General of  
40 the German solar energy program. At the time, that was the biggest solar program in the world. It's since been overtaken by China. He was lamenting that, while he was supervising the world's biggest solar program, the best place in Germany for solar power was not as good as the worst place in Australia. He identified the west coast of Tasmania as the worst place, and that was better  
45 than the best place in Germany.

Whereas we lost our price advantage from natural gas through the development of an export industry – and I’m not a critic of that. There’s a case can be made for that policy, although it’s a case to be argued rather than simply asserted.

5 It’s a complication question, but the consequence of internationalisation of the gas in coal markets was that we’d lost our advantage as a low cost energy source.

10 We won't lose the advantage we've got as renewable energy become much more important in all of the world's developed countries because renewable energy is not exportable in the same way. One day we may have a high voltage transmission line to Java and Singapore but that won't be for quite a long time and so one can see the advantages from Australia's low cost in producing low emissions energy as being sustainable in the way that the cost  
15 advantage from fossil energy was not.

MR JACOBI: By that, am I to understand that you concede that low emissions energy is simply embedded in products in Australia which are then exported?

20 PROF GARNAUT: You see, the relatively low energy costs that I think will emerge, if we play our cards right - of course we can mess it up - but if we play our cards right and commit ourselves unambiguously to effective use of low emissions energy, then the Australian Standard of living, Australian prosperity, will be helped in two ways by relatively low costs of energy. One is  
25 households will have access to lower cost energy and their equivalents in other developed countries. That's a source of advantage for the Australian standard of living. But it will also make Australia again, as it once was, a logical location for energy-intensive processing industries.

30 I've already mentioned that we became the world's biggest source of exports of aluminium metal. Aluminum metal is based on reasonably proximity to aluminium raw materials but even more importantly to low cost energy. So when fossil energy costs were much lower in Australia than elsewhere, then this became the logical place to set up processing plants for export. It's been  
35 some time since anyone considered a new aluminium plant in Australia and we won't get one based on fossil fuels.

40 But looking forward to the day when many countries, including Australia, have made a transition to lower emissions energy then we will again be, if we play our cards right with sound policy, a country in which the world seeks to undertake energy-intensive processes. The prime candidates will not necessarily be the same industries as in the past. If you've already committed aluminium capital expenditure in other countries, then they don't shift  
45 overnight.

But the transition to a low carbon world economy is going to rapidly increase demand for a lot of products that draw on raw materials that use energy intensively in their processing. I would include in these uranium enrichment, nuclear power as a low emission source of power and whatever the eventual  
5 outcome of the response to Fukushima in Japan and Germany and elsewhere in the developed world; that there is nevertheless certain to be very strong growth in nuclear energy production in China and India, the two big developing countries.

10 But the list is actually quite a long one of energy-intensive processing that will come into greater demand in the low carbon economy. Photovoltaic panels are built on systems based on pure silicon. To produce pure silicon you need silicon oxide, which is sand or quartz in high quality - and we've got a bit of that - and huge amounts of electricity. At the moment, that huge expansion of  
15 photovoltaic panel production in China is mostly being supplied from pure silicon being processed in China but it's being processed using expensive electricity. In the low carbon world of the future, Australia becomes a logical location for that.

20 Many of the rare earths used in modern battery - and the technology here is still sorting itself out - but many of the raw materials require energy-intensive processing - graphite, an input into some of the newer low emissions technologies. Graphite and carbon fibre require highly energy-intensive  
25 processing. In the low carbon world of the future, I see Australia emerging as a highly competitive supplier of many of the inputs into the rapidly expanding low emissions industries of the world.

COMMISSIONER: You talk about the importance of not mucking it up. What are the things that you would consider - as we develop a future energy  
30 policy, what are the critical issues from a national perspective?

PROF GARNAUT: First, Commissioner, let me apologise for my voice. I've had the flu and it's a bit weak. Policy continuity and certainty is tremendously important. Uncertainty raises the supply price of investment and increases the  
35 cost of all of the new things. So one has to say that we've seen an extreme of uncertainty in Australian policy over the last decade and there's no getting away from it, that's been costly. That's raised the supply price of investment.

In the case of the changes of the renewable energy target, for example, that was  
40 a change in a policy that was legislated. It had the support of both sides of parliament when it was legislated. Before the last election both sides of politics went into the election committing themselves to no change in the policy and yet it was changed. Sovereign risk is often much discussed. Sovereign risk is a term that's thrown around too lightly but that was a case of  
45 sovereign risk and that raises the - people had invested on the basis of the old

legislation and it will be a while before investors have full confidence in the stability of Australian policy again.

5 I'm afraid, Commissioner, we've already mucked it up a fair bit but stability of policy is the first requirement. It also can only realistically be stability of policy if it's policy based on realistic objectives, and in my view that realistic objective is Australia doing its fair share in the global carbonisation effort. We're most likely to get the investment in the new low emissions industries that can give Australia many advantages in the low carbon world economy of the future if we set policies towards long-term goals and allow business to respond and make the best of those policies without constant recalibration.

10 MR JACOBI: Stepping away from long-term policy, reading the 2011 report and also your Luxton lecture, you spoke of there being other barriers to the low-cost, low-emissions energy to which you referred and particularly talk about the electricity market, costs of transmission, distribution. I was wondering whether you could expand on that?

20 PROF GARNAUT: Yes, this is a particular Australian problem of the last decade. The cost of electricity to a final user, whether it's a household or a business, involves the cost of generating the electricity itself and then the cost of transmitting it to where it's going to be used. We put in place, in a series of steps that matured in 2006, a regulatory regime for networks that, while well intentioned, had the effect of increasing the costs of our network more than we had ever seen over a comparable period in Australia before, increases in real terms of inflation and also increase in Australian network prices that were higher than any other developed countries had experienced over that period. In fact, there was no other country anything like Australia in increases in network costs over that period.

30 So even if you're generating electricity at a very low cost, if you've got very expensive networks, you've killed your advantage both to the household and the business wanting to use that electricity. Reform of the system is a rather complicated one. I've given quite a lot of thought to that and talked about it in some other places, a little bit in the Luxton lecture. I think we can work our way through that, but getting that right is one more condition for Australia using its advantages in the low carbon world economy of the future.

40 MR JACOBI: Can I move to deal with what you consider to be, going back to the electricity sector, the transition pathway that you consider that electricity generation will go through, that is, in terms of the fuels that will be used, or the technologies that will be used as a we move towards the decarbonisation of that sector?

45 PROF GARNAUT: Well, back in 2007-2008, published in my 2008 review, I

5 supervised the most elaborate exercise that's ever been done in Australia and one of the most elaborate anywhere of possible transition processes, and I lay a lot of that out in that 2008 report. Now, that sort of modelling exercise has to be premised in the nature of things on very specific assumptions about rates of change in technology, rates of improvement of different technology, and so on.

10 One can be sure of one thing: that when you're predicting rates of change of technology, you're going to be wrong. At least all the assumptions were made explicit. In that exercise back in 2008, I saw a steady growth in the role of renewables, an early considerable growth in the use of gas as a transitional fuel, and then that being, at some time, with rising carbon prices, it would become economic to capture and store emissions from coal combustion and, if you were able to capture and store emissions from gas combustion and coal combustion, you would turn them into much lower emissions sources of energy. On those assumptions back in 2008, not for some time, but later in this half century, if economics were the only factor driving things, you would see the emergence of some nuclear energy in Australia.

20 Now, since then, at least we've learned what's happened to relative rates of technology change since then. We still don't know the future, and we've also learned something about economic developments. Amongst the most important developments since 2008, affecting the perspective that I described there, first, the internationalisation of the gas industry in eastern Australia. Western Australia is a different story, but in eastern Australia and southern Australia, sorry, the national electricity market – the four mainland states, excluding WA, plus Tasmania, the national electricity market, including South Australia – the internationalisation of gas prices is in the process of raising gas prices to an extent that prices gas out of most electricity generation.

30 In some recent times, gas has supplied about 20 per cent of the electricity generation in the national electricity market. Well, that's shrinking rapidly and the role of gas will continue to shrink with the rise in domestic prices, until gas comes just an extreme peaking fuel. It will have some role of bringing on gas turbines, because gas turbines can come into production at very short notice. So if you get a peak in demand on a hot summer afternoon, the electricity price tends to go very high and the owner of a gas generator can justify using expensive gas. Whereas that modelling of seven or eight years ago had suggested a fairly large role for gas as a transitional fuel, we won't get that now because of the internationalisation of the gas industry.

40 Another thing that's happened is that the rate of technological change in all of the low emissions electricity generating technologies has been much faster than my modelling anticipated. This is most spectacularly so in the case of photovoltaic solar. The last time I looked, the capital costs of photovoltaic panels had fallen 80 per cent from the levels I was working on in 2007-2008,

but there's also been large reductions in the costs of wind turbines and very considerable improvement in design, making them more suitable for a wider range of wind conditions. That's been reducing the cost of wind turbines.

5 There's been an optimisation of an old technology in hydroelectric power generation that's brought down costs, improvements, and cost reduction. There's also been a reduction in the costs of nuclear power. In all of these cases, the cost reductions are the result more of improvements in manufacturing technology than in clever breakthroughs in scientific  
10 knowledge.

Now, there will be breakthroughs in scientific knowledge from time to time that, over time, will transform the costs of some technologies. But the very big changes we've seen in the last seven years are mainly the result of larger scale  
15 production and shifting of the production on a large scale into China, where the normal processes of learning by doing in a new manufacturing process lead firms to find better ways of doing things year by years; lots of small improvements rather than big scientific breakthroughs. That's accumulated into a very big change.

20 In the case of the nuclear costs, costs have been reduced because in China, unlike anywhere where nuclear has been used before, you're now getting new plants built on a scale that you can have continuous production processes. In the old days in France, or Japan, or the United States, or Britain, if you were  
25 building a new nuclear plant, you would pull together a team of engineers and they would design the plant and then there would be a lot of batch engineering for each component and, when the plants was built, everyone would go home. The spill base would be weakened and then you would do it all again for a new plant.

30 Well, China is building new nuclear plants on such a basis that you get continuous production, a variation on the theme of assembly-line production of some components, and that's reducing costs. So the effects of all of the technological changes has been mostly importantly to reduce the cost of solar, especially, but also low emissions technologies more rapidly than was  
35 embodied in the assumptions of my initial modelling seven or eight years ago. Will that continue? It can't continue forever without new technological developments and, in all of the industries I've mentioned, there's a lot of work going on at the scientific level, which could lead to a big further step down  
40 in costs.

As a result of all of these developments, the costs of moving the world, in general, and Australia, in particular, to low emissions electricity now looks much lower. The cost looks much lower than it looked eight years ago, and it  
45 will go lower still. In Australia, the reduction in costs of renewables is

especially large and so I would anticipate a much larger role of renewables at an earlier stage.

5 If economics were driving outcomes – and by economics and the market driving outcomes, I mean economics and the market with an economically efficient carbon price. All of the champions of the market economy, even those who are seen as being extreme in their support of free markets, like John Stuart Mill and Frederick Hayek and Milton Friedman, acknowledged explicitly that if some economic activity imposes external environmental costs  
10 on other people, then the market will only generate good outcomes if you tax the externality, if you tax the costs. If you do that, then you can rely on the market to give you good outcomes, or else you can regulate the activity that's imposing costs on other people.

15 This is a fundamental premise of free market economics, not to – if you've got external environmental damage from some economic activity and you don't regulated it, or don't tax the external cost, then you won't get good outcomes from the market exchange. So not to have regulation or a carbon price is to subsidise the activity that is generating the damage to other people. I was  
20 looking at what would happen to the mix of technologies to the transformation in Australian energy if you'd had an economically efficient carbon price in place and if the market was driving outcomes. I described earlier the likely result.

25 If you had a similar re-run of that today – it's a big modelling exercise and I would hate to attempt to do it again – but I think the changes in technology and in the economics of gas would lead to a much smaller role for gas from an early stage and a much larger role for renewables. In the case of nuclear, whether you would get nuclear power generation in that scenario would depend  
30 on rates of change of technology, rates of cost reduction in nuclear compared with renewables. Just at the moment, the renewables costs have been going down faster than nuclear.

35 That may change but, from that perspective, one would expect that, compared with the results of my 2008 review, you would see a smaller role for nuclear power generation in Australia. But for the reasons that I described earlier, you may actually see a larger role for Australia in other parts of the nuclear cycle, particularly uranium enrichment.

40 MR JACOBI: I think, finally, do you have a view about what should be the sound basis for making decisions about climate change and energy policy in Australia and how that might be achieved?

45 PROF GARNAUT: It has to begin with serious study by serious people of the issues, and these are complex issues. I'm afraid that making policy by political

slogan, which has been a bit of a tendency in recent times in Australia, is inimical to good outcomes. I think it's crucial to first take seriously the science. These aren't matters of opinion. We wouldn't get very far if we all had our own opinions on Newton's third law of motion. If we all acted on  
5 different opinions on that, we wouldn't get our car down the street very far. So let's stop thinking of climate science as being a matter of opinion. There's real science that can guide us and let's root our policy in acceptance of that. Australia happens to have more than its share of first-rate climate scientists.

10 Secondly, once one accepts that there is external damage done by the old patterns of economic activity, then it should be a simple matter of accepting that one needs to find ways of reconciling private profit making decisions with the interests of society as a whole and economics is very straightforward about that. You can do it by regulation, you can do that by taxes and prices, but an  
15 economy-wide carbon price allows freer rein to the market and allows businesses to react more or less automatically to new information about improvements in costs and technologies across the board. So that's likely to be a smooth outcome.

20 Carbon pricing is not the only way to do it. You could do it through regulation. It's more complicated. It requires more information to government. It requires more government intervention, but if there's an ideological objection to the use of market, you can get there through regulation. Whatever we choose to do, let's recognise that this is a fundamental transition in Australia's energy sector  
25 that has to play out over decades, and it will be much more costly if we chop and change policies.

It's very important to have steady policies over long periods. It will also be much more costly if we leave it too late. We're not going to reduce the  
30 demands on us for reducing our emissions by delay, but by delay we can increase the costs of making the adjustment by forcing the adjustment into a much shorter time period than we would have if we reacted in a timely way.

COMMISSIONER: Professor, thank you very much for joining us today and  
35 I'm sorry to put you on the spot with the heavy coal, but you've added to our store of knowledge, which was the goal. So thank you very much for coming across to help us. We'll adjourn now and recommence at 11 o'clock with Ms Anna Skarbek, the Climate Works Australia CEO.

40 **ADJOURNED**

**[10.31 am]**