Event:	**Public lecture: Launch of Update Paper 5 – The Science of Climate Change**	**Date & time:**	**10 March 2011, 6.00pm – 7.00pm**
Speaker:	Ross Garnaut	**Location:**	Stanley Bruce Theatre, UTas, Hobart
		Duration:	65 minutes

Transcript:

STEVEN RINTOUL, CSIRO: Ladies and gentlemen, welcome to this evening's presentation. Before we begin I would like to show my respect and acknowledge the traditional custodians and land of elders past and present on which this meeting takes place.

I'm Steve Rintoul from CSIRO and the Antarctic Climate and Ecosystems Cooperative Research Centre and it's wonderful to see so many people here tonight.

I need first to pass on my apologies from Bruce Mapstone, the chief of the CSIRO division of Marine and Atmospheric Research, who is unfortunately unwell and can't be here tonight and so asked me to stand in, in his place.

It is a real pleasure for me to introduce Professor Ross Garnaut this evening. Professor Garnaut is one of Australia's most eminent economists. He's Vice-Chancellor's Fellow and Distinguished Fellow of Economics at the University of Melbourne and Distinguished Professor of Economics at the Australian National University. And his many achievements span the worlds of academics, business, government and diplomacy.

In his many roles he's really played a major part in defining Australia's relationship to Asia and the Pacific. His academic achievements include authorship or editorship of 37 books. In business he's been chairman of the board of many large national and international companies and international institutions.

In government his roles have also been substantial and diverse, including being the - Australia's Ambassador to China from 1985 to 1988, Principal Economic Advisor to Premier - to Prime Minister Bob Hawke and has led many high-level government reviews and commissions. And it's in that role that he comes to be with us tonight.

In 2007 Professor Garnaut was commissioned to perform an independent study of the economic consequences of climate change and to recommend policies that might put Australia in a position to improve the prospects for sustainable prosperity.

This report really energised the climate change debate in Australia and provided, for the first time in the Australian context, an assessment of the economic consequences of climate change. In November this year

Professor Garnaut was commissioned by the Minister for Climate Change and Energy Efficiency to update that report.

And tonight he's here to launch one of eight update paper, with tonight's on the science of climate change. Climate change clearly poses significant challenges for Australia and the rest of the globe. The actions we take or don't take will have consequences and repercussions that will be with us for a long time, so it's important that we get it right.

To make sound choices we need the best information we have and part of that information comes from science and many of you in the audience are involved in climate science. And our role really is to provide the best possible information we can about the climate future that we face.

That's a tough job, given the complexity of the climate system, but it looks pretty straightforward compared to the task that Garnaut and his team have been given, which is to consider not just the state of climate science, but also the economic consequences and moreover to propose policies and to assess the costs and benefits of various approaches to responding to the challenge in climate change.

In other words, not just to tell us about the magnitude of the problem, but to propose a path towards a solution to that problem. The careful and comprehensive analysis being carried out by Professor Garnaut and his team is providing the information we need to make some of those sound decisions.

And my own hope is that when the report is released that it will also play a role in transforming the debate in Australia from its present largely polarised and not so helpful state, to one that's based to a sound and more careful discussion of a pathway to an effective response to climate change.

So please join me in welcoming Professor Garnaut to the stage, to launch his update paper on The Science of Climate Change.

PROFESSOR GARNAUT; Thank you, Steve; Amanda; the Lord Mayor, who I met on the way in. My hosts are here tonight, the CSIRO, the Centre for Australian Weather and Climate Research.

And thanks to Tom Keenan and his team for all of the help in our work on the paper that's being released tonight; the Australian Antarctic Division, Lyn Maddock; the Antarctic Climate and Ecosystem CRC; the Institute for Marine and Antarctic Studies at the University of Tasmania; the Bureau of Meteorology and the University of Tasmania. And I'd also like to mention Helen Cleugh, who can't be here tonight, but has been a very big help in our work.

Well, it's a long way into my career to say this but it's the first time I've given a lecture at the University of Tasmania. And if I can be excused a little bit of disciplinary parochialism, as an economist I can't be at the University of

Tasmania without acknowledging this place as really the beginning of the Australian economics profession, Giblin's platoon.

Professor Giblin and his students and staff members in the '20s really got the Australian economics profession going, a story that's written into a book called *Giblin's Platoon* by economic historian Selwyn Cornish. So lots of reasons to be very pleased to be here, but that's one of them.

I've been deeply immersed in many dimensions of the climate change question for almost four years, since I was commissioned to do my first review of climate change and Australian policy on climate change. Since then many people have asked me, what's an economist doing talking about climate science?

And what I'm mainly doing is trying to understand it, trying to interpret it for people who have to make decisions on the basis of it and to try to use the wisdom of the climate science as a basis for making sound judgements about what we should do about it.

At the commencement of the review I faced the question that confronts all who are not climate scientists and who are required, for one reason or another, to take a position on the climate science. How do we know if propositions put forward by some climate scientists are right?

I began with some general awareness of the issues that arrived in part from my association with the International Food Policy Research Institute in Washington, which undertook some of the important early research on the interaction of climate change with global food security.

But I began with no strong views and no more than a common knowledge of climate change science. I did not then know how strongly the main propositions of climate change science were held in the mainstream science community. I was aware of sceptical views and set out to understand them, even to the extent of chasing down the best qualified of all the sceptics, although he was based on the east coast of the United States.

By the time I concluded the review in September 2008, I had read a fair bit of climate science published by people, including some sceptics with genuine credentials and records of publication in professionally reputed scientific journals.

Few who contributed to this climate science doubted that the average temperatures on earth were rising and that this reflected the increase in concentrations of greenhouse gases in the atmosphere as a result of human activity.

I was exposed to more of the literature through the work of a conscientious team and the review secretariat, I'd like to mention Liz Edye who's here tonight, who helped me with the original review and has helped me with this update. And also I was helped greatly by the Australian science community

who were advising me in various ways.

As I noted in the review, there was no genuinely scientific descent from the main propositions of the physics of climate change, that increased concentrations of greenhouses gases raised the Earth's temperature by calculable amounts. A small number of scientists with relevant credentials held the view that increases in emission concentrations, as a result of human activity, caused warming. But thought that these effects were small compared with other sources of changes in temperature, including feedbacks from greenhouse gas warming that counteract rather than extend the effects.

There were other reputed views in the science, larger in number than the sceptics within the genuine scientific community, who thought that the effects of increased greenhouse gases on the world's climate would be much larger than suggested by the mainstream science and would be triggered by lower greenhouse gas concentrations and at lower temperatures.

Examination of the credentials and numbers of climate scientists who express both the mainstream and sceptical views led me to the premise upon which the 2008 review was built, that the central conclusions of the mainstream science were right on a balance of probabilities. Some in the community of Australian climate scientists told me that I had offered unwarranted respect and credence to dissenting views in putting it that way.

To say that there is overwhelming support within the mainstream scientific community for the central propositions about climate change is not to say that there is no debate about myriad and important detail. For example, while there is little dissent about the association of increased greenhouse gas concentration with warming, the scientific climate models reveal wide variations in expectation of the regional distribution of changes in rainfall and in some regions about the direction of change.

I ran into one example of this in the review - the differences in the myriad detail - when converting the information from the climate models into likely impact on Australia that would affect economic activity. I applied the insight from the excellent Australian climate projection work of the CSIRO which embodied expectations of greater drying in southern Australia than is suggested by some other legitimate approaches.

The review had modelled wet and dry as well as most likely futures for the Murray Darling under the warming associated with unmitigated, moderately mitigated and strongly mitigated climate change.

Recognition of this uncertainty was not enough for some participants in the scientific exchange. The Australian Academy of Sciences' 2009 report on priorities for climate change science research noted that some other models gave different results. I was grateful for the careful attention to the review's

work.

Another example of an issue that is strongly contested in detail amongst scientists with relevant expertise, who hold to the general mainstream propositions about climate change, is the extent of sea level rise that is likely to be associated with specified degrees of warming.

There's a slice of research relates to the massive land-based ice in Greenland and Antarctica. There are few deep specialists in this area. The mainstream view from the peer review literature, brought into the public domain mainly through the 2007 IPCC report, embodied sea level rise for thermal expansion of the oceans as temperature rose and some contribution from melting of alpine glaciers. But did not take into account the potential for accelerated losses from land-based ice in Greenland and Antarctica.

It was disconcerting to find the specialists in both hemispheres - and I spent time at the Potsdam Institute in Germany amongst people who were working on this - to whom I spoke personally, expressing private opinions that there would be a contribution from Greenland and west Antarctica to sea level rise this century, of uncertain but substantial and possibly greatly destructive dimension. All declined to put private views on the public record because the views were not yet reflected in the peer reviewed scientific literature.

My early exposure to sceptical and dissenting views identified a number of propositions that seemed to be worthy of exploration. It also identified some that discredited themselves with internal inconsistencies or contradiction of well-established facts.

The propositions that were discredited by contradiction of well-established facts including one that was common in 2008 as I was preparing the final report of the review. The proposition was pervasive amongst the many dissenters who were prominent in the Australian public discussion and about whom I said in 2008 that sceptic is a misnomer for their position because they hold strongly to the belief that the mainstream science is wrong.

The proposition or belief that was common in 2008 was that the Earth was cooling. The question, is there a warming trend, can be answered by statistical analysis of time series data of a kind that is familiar to economists. I asked two leading econometricians, Trevor Breusch and Farshid Vahid, who are authorities on the analysis of time series, to examine the temperature record from the three authoritative global sources.

They concluded that "The temperatures recorded in most of the past decade lie above the confidence level that is produced by any model that does not allow for a warming trend." I asked them to repeat for the update - the paper that released this evening - the analysis for a period that included data since the review up to the present and they have confirmed the earlier conclusion.

The statistical evidence on the significant warming trend did not stop assertions in the public debate that the Earth was cooling. But it does seem to have discouraged at least the numerate and rational from repetition of errors into which they had carelessly fallen.

[Laughter]

As I absorbed more of the complexity of the science, both mainstream and sceptical, I began to recognise a number of recurring criticisms of the mainstream, for which there were rounded and effective responses in the science.

The end point of having observed the sceptical responses, examined them, looked at the responses to them in the mainstream science; the end point was an increase in personal confidence in the mainstream science. On a balance of probabilities would understate my current view of the likelihood that the mainstream science is correct. I would now say that it is highly probable that the central propositions of the mainstream science are correct.

Of the range of genuine scientific views around the mainstream, defining the centre of peer review literature as the mainstream, I would now be tempted to say that views that temperatures and damage from a specified level of emissions over time will be larger than is suggested by the mainstream science and much more likely to proven correct than those that embody the opposite expectations. But I won't say that.

Later sections of the paper that's released present evidence from the peer review literature as if it were all that we know. To allow all people of intellectual integrity to remain in touch with each other on this critical subject, it is important that our dialogue remains grounded in the mainstream scientific literature, whatever our personal views about whether the received wisdom understates or overstates the reality.

In the full paper I do however return to these issues in a few final reflections on publications' lags and scholarly reticence. I note that the tendency for what is actually happening consistently to come out on the bad side - in the middle or the bad side of the projections - is not what one would expect if error was randomly distributed. And so at the end of the paper I put out tonight, I just ask a few questions about whether that is evidence of scholarly reticence.

Well just a few points from the body of the paper. The update paper aims to provide a non-scientist perspective on how decision makers can consider and view scientific evidence. It's not meant to be a scientific paper in itself. The update paper provides a synthesis of the discussion of climate change science and impacts in the review as they've changed as the new information - the new science - has developed new knowledge over these last few years.

The paper focuses on areas of new knowledge of particular importance to

Australia and the policy debate. Observations and research outcomes have confirmed and strengthened the propositions of the mainstream science since 2008.

Just a few points - there's quite a lot of points covered in the paper - but I'll just make a few points really to illustrate the remarks I've just made; that generally the new knowledge has confirmed or strengthened what was then the mainstream knowledge of 2007-2008.

Just a few slides if [waits for slide] - this slide shows Australian average annual temperature anomalies above an average - above and below a specified mean. And the black lines represent decadal averages. And you can see pretty clearly from that that since the '40s, each decadal average temperature has significantly exceeded that of the decade before.

Now an economist used to looking at evidence from time series and asking for evidence of statistical significance is impressed more by the statistical analysis of time series than by the number of lines on a chart. That's where a paper by Breusch and Vahid, which is on the website, comes into play - that demonstrates the statistical significance of the warming trend for the world as a whole.

A second important confirmation of the propositions of the mainstream science relates to annual sea surface temperatures. I had very interesting discussions at CSIRO today where very important work is going on, on the ocean science - globally important work. Ninety per cent of the increased energy in our atmosphere finds its way into the ocean. So with a lag, the warming of the atmosphere is accompanied by warming of the oceans.

And there's the data for around Australia; a steady decadal increase in average temperatures and 2010 was the warmest year ever for the seas around Australia.

A third, important bit of data - one that people working on here in Hobart are world leaders, whose published work is followed very closely all over the world - relates to sea level rise. The turquoise lines represent the likely confidence limits of the IPCC projections and the darker single lines, the outer boundaries, reflect a wider range of possibilities. You see actual sea level rise tracking well above or in the high part of what the IPCC recognised as the range of possibilities. Sea level rise has accelerated and is tracking near the upper limit of the range suggested by the IPCC.

The IPCC, the Intergovernmental Panel on Climate Change, just for those of you not closely in touch with the science. So the IPCC, Intergovernmental Panel on Climate Change, is a unique scientific body set up by the United Nations because this issue was such an important issue for the international community and it brings together scientists from all over the world. A couple of thousand in number who carefully go through the peer review literature and come up with an integrated assessment of the science as it stands at

the time of each review.

The climate system will respond in complex ways to an increased concentration of greenhouse gases. I've only addressed here a few of the ways that climate will respond to greenhouse gases in this speech and for information on other factors and developments in severe weather events, changes in rainfall, ice sheets, ecosystems and tipping points is contained in the paper I'm releasing tonight. And that's on the website of the Garnaut Review, www.garnautreview.org.au.

Alongside that confirmatory evidence of what was coming out of the mainstream science, it's an awful reality that no major developments in the science since 2008 hold out realistic hope that the judgements of the 2008 review erred in the direction of overestimation of the risks of climate change.

Scientific development since 2008 strengthen the view that a challenging target of holding emissions' concentrations at 450 parts per million is worthwhile. That that's a worthwhile goal for the world and for Australia.

The 2008 review went through a rigorous decision-making framework to demonstrate that it was in Australia's national interest to play a proportionate part in a global mitigation effort directed at holding emissions' concentrations to 450 parts per million.

The analysis of climate change impacts on Australia along the way demonstrated that Australia was more vulnerable to the costs of climate change than any other developed country. So we are fortunate, we are lucky as a country that the international community has settled on a global target for climate change mitigation that's consistent with the Australian national interest. And that's the two degrees limit roughly corresponding to 450 parts per million of concentrations. That was agreed at Copenhagen and Cancun.

There is increasing discussion in the legitimate scientific literature of the possibility that large damage will occur at smaller increases in global average temperatures than two degrees. While the science has strengthened it would seem that public confidence in the science has weakened in Australia and some other countries. That's paradoxical but it is part of the current reality - one of the things that makes climate change policy difficult.

The actual evidence from the science is stronger but there's certainly no stronger public belief in that. A little bit the other way in Australia and the United States and some European countries. Not everywhere around the world - not in all the developing world, for example.

In a speech to the Annual Conference of Australia's Supreme and Federal Court Judges in early last year, I compared the challenge facing a judge with that of a layperson assessing the science of climate change. And I was really asking the judges to understand my predicament. And I said then to

the Supreme Court and Federal Court judges - I quote from the speech:

"A judge in a civil court must make a decision on a balance of probabilities.

Rarely in a case that comes before one of Australia's superior courts is the defence so weak that it can find no so-called expert to blow a fog through the proceedings. The judge's job is to avoid wrong steps through the fog, to assess the chances that one so-called expert is more likely to be right than the established opinion."

In order to understand the mechanisms and implications of climate change, an interested non-scientist must draw on the publications of experts in the field. The review's acceptance in 2008 on the balance of probabilities of the overwhelming majority of opinion in the Australian and international science communities has not been challenged by developments in the genuine science over the past three years.

The most - and I've shown you a few of them but we could go through more. The most important and straightforward of the quantifiably - quantitatively testable propositions from the mainstream science have been confirmed, was shown to be understated by the passing of time.

In addition, some important parameters have been subject to better testing as measurement techniques have improved and numbers of observations increased. And they too have tended to confirm the propositions from the mainstream science.

Some of the propositions for the mainstream science that have been confirmed by improved evidence, better techniques, include the warming of the troposphere and the cooling of the stratosphere and the long-term shift towards wet extremes and hot extremes coexisting. And I've cited papers that throw light on these issues that at three years ago were there in the theoretical literature but which couldn't be confirmed there and now, peer reviewed publications that give confirmatory evidence.

The science's forecast of greater frequency of some extreme events and greater intensity of a wider range of extreme events is looking uncomfortably robust. There are a number of matters on which measurable changes are pointing to more rapid movement towards climate tipping points than suggested by the midpoints of the mainstream science. Amongst these are the rate of reduction in Arctic Sea ice and the emergence of accumulations of methane in the atmosphere at a rate in excess of expectations.

Scientific developments since 2008 have introduced some additional caution about whether overshooting emission scenarios will lead to temperature increases that are not quickly reversed. And I'll just explain here what I mean by that. We were already hovering on 450 parts per million of greenhouse gases in the atmosphere, of carbon dioxide equivalent at the time of my report.

If 450 parts per million was the objective you could only get to that with an

overshooting scenario, going above it for a while and then relying on a combination of the natural sequestration capacities of the earth and the oceans, plus human-related sequestration to bring down carbon dioxide in the atmosphere.

So some of the published science in the last couple of years raises some questions about whether we can rely very much on the overshooting scenarios. We have to rely on them to some extent but the extent to which you can rely on them without long-term warming is questioned a bit more strongly now than before.

Now the politicisation of the science, as many countries have moved towards stronger action to reduce greenhouse gas emissions, has placed institutions conducting the science under great scrutiny. Exhaustive reviews have revealed some weaknesses in execution of the scientific mandate but none that are material to the reliability of the main propositions of the mainstream science.

The consistency of the understatements since climate change became a large policy issue in the early 1990s is a cause for concern. It will be much more of a surprise if the next large assessment of the IPCC led to a downward, rather than upward revision of expectations of damage from unmitigated climate change.

As I mentioned earlier in the address this raises a question about whether something in the environment for scientific research on climate change introduces a systematic tendency to understatement. It may be tempting to correct for this by giving more weight to the more concerned end of published research. This I think would be a mistake. In a highly contested and complex scientific matter with immense implications for public policy, for the allocation of resources and the distribution of incomes it is important to base policy on the established propositions of the science.

My personal intellectual journey over these past four years has moved me from acceptance of the mainstream sciences' main propositions with the degree of certainty required by the civil law, a balance of probabilities, closer to the criminal law requirements of beyond reasonable doubt.

[Laughter]

A balance of probabilities was enough to draw the conclusions of the review in 2008 that it was in Australia's national interest to do its proportionate part in an effective international effort to hold emissions concentrations to 450 parts per million of carbon dioxide equivalent.

The new scientific knowledge and the realisation of slow progress on

mitigation in the developed countries that has come with the passing of time has made 450 parts per million a more difficult objective. It would be wise for Australians, through their domestic actions and international interactions, to work towards achieving that much. Along the way we can assess whether developments in knowledge have made the case that our national interest requires higher ambition.

Beyond reasonable doubt is not the absence of all doubt. If it were, there would be few criminal convictions. On climate change, a small number of scientists who hold climate science qualifications and who continue to publish incredible outlets maintain the view that human activity is small amongst the factors driving global warming.

Their views can be respected and are a reason to continue to interrogate the overwhelming majority of reputed and relevant scientific opinion. There is still a high degree of uncertainty about myriad important details of the impact of increased concentrations of greenhouse gases. The uncertainty in the science is generally associated with the rate and magnitude rather than the direction of the science's conclusions.

There is no question that the presence of uncertainty complicates policy responses. As the Royal Society said in a statement about uncertainty in climate science - and I quote from that Royal Society document - like many important decisions policy choices about climate change have to be made in the absence of perfect knowledge. Even if the remaining uncertainties were substantially resolved, the wide variety of interests, cultures and beliefs in society would make consensus about such choices difficult to achieve. However, the potential impacts of climate change are sufficiently serious that important decisions will need to be made. That's the end of the quote.

The new scientific evidence has tended towards confirmation of the central points of the old understanding about climate sensitivity, that a doubling of concentrations would raise temperatures by about three degrees. Here the uncertainty has become more narrow, but still covers a range that matters a great deal to human society. There is little doubt - and here I'm continuing on uncertainties - that a warmer climate will mean higher rainfall on average around the earth. However, changes in wind patterns and other aspects of the wider climate system will make some regions drier and there is uncertainty about the boundaries of these regions.

This is of immense practical significance for Australia. The bigger and better climate models being developed in the joint project between the Bureau of Meteorology and the CSIRO are important to our understanding of future Australian reality. And it's unfortunate in this driest of the permanently inhabited continents that most of the models are showing

southern Australia, where most of us live, getting drier.

The review said that to ignore the wisdom of the mainstream science and to instead hold on to the hopes held up by the small minority of genuine sceptics in the relevant scientific communities, let alone to give credence to the wild claims of climate change dissenters would be to hide from reality. It would be imprudent beyond the normal limits of human irrationality. This is no less true today when there is higher confidence in the main propositions of the mainstream science. Thank you.

TONY PRESS: Thank you very much. We have about 20 minutes set aside for questions from the audience. If you wish to ask a question could you put your hand up? There are people at the back of the room that will come to you with a microphone. This is being recorded. The people up the back if you wish to ask a question, if there's not that many of you I'll ask you to come down into the front to ask the question. Otherwise I'll hold to the last part of the question time and put questions up to you. My name's Tony Press, I'm the CEO of the Antarctic Climate and Ecosystems Cooperative Research Centre. My first question is over here.

QUESTION: Professor, thank you. How would you respond to the criticism about approaching climate change that we are attempting to, as nationally address a global problem and the national means of addressing the global problem is to put a price on carbon. And that will – and if we do that in advance of many countries in the rest of the globe, such as China in particular and the US, that we therefore risk pricing our products and diminishing our standard of living?

ROSS GARNAUT: Yeah. Well, it is true - and all of my original review and the update are premised on the truth - that the only effective mitigation is going to be global mitigation. The right positioning for Australia is for it to make sure that it does its proportionate part in an effective global effort. That proportionate part has to be properly calibrated.

The international community and we, as a part of the international community, have accepted that developed countries with very high-per-capita emissions - us with the highest of all the developed countries - have to do more earlier than poor developing countries. That's accepted. But within that framework, which I elaborated on in detail in the original review, we have to do our proportionate part.

Now a lot of the discussion in Australia is conducted as if, if we do something now, like putting a price on carbon now, we're doing something

ahead of the rest of the world. Well, we're not. It takes profound ignorance to take that position.

[Applause]

And in the second of my update papers, which is on the website review, garnautreview.org.au, I set out in some detail what's happening in the rest of the world. It's well-known that in the European Union of course, which now is bigger than the European Union used to be, they've had an emissions' trading scheme since 2005, five-hundred million people.

Jill Duggan, one of the senior executives administering that program for the European Union is in Australia at the moment. She was in the press this morning. I spoke to her on Monday in my office at the University of Melbourne. She is just amazed at the Australian discussion. She reads these reports of some Australians thinking we would be getting ahead of the rest of the world. She just scratches her head and saying, how is it possible in 2011 that some component of humanity can completely shut-off simple information from the rest of the world?

[Laughter and applause]

I'm going to continue for a moment, because this is a very important question. Now it is common to identify the United States and China, which are - not in that order. China and the United States, the right order, are the world's two biggest emitters of climate change, so what's the point of us doing something if they're not doing anything?

Well the head of the secretariat for my review, Steven Kennedy, he and I spent a week each in Beijing and Washington early this year just - and we've reported the results of that in that update paper. The United States has a target of reducing emissions by seventeen per cent on 2005 levels.

Americans always do something different; they drive on the left-hand side of the road, they decided to make their base 2005 simply because when they were developing the policy it was 2006 and they had the data for 2005. If they had based their target on 2000 instead of 2005 their emissions reduction would have been sixteen per cent.

I spoke to senior members of the Obama Administration, including the energy secretary, Steven Chu, who happens to be a Nobel laureate in physics so thinks quite a lot about these questions. I spoke to Todd Stern, the leader of the climate change group in the State Department, the chief negotiator in the United States. The Obama administration is strongly committed to reaching that target.

They've been denied by the Congress, as you're all aware, the House of Representatives changed into Republican hands at the elections in November, so they can't get legislation for an emissions' trading scheme through the congress. So they're going to do it by regulation and very strong commitment, partly through the Environmental Protection Agency,

also through a lot of other mechanisms.

A lot of regulation extending over the types of cars you can drive, types of appliances you can have, the types of electricity generators you can maintain or build.

One consequence of that is that there's no prospect - and you can get this from the top of the largest mining companies in Australia - of a new coal-based power generator being built in the United States.

In China they're also making very - quite dramatic progress actually in reducing the emissions' intensity of production. Mainly through regulatory action; closing down highly emitting generators. There's a coal-based plant generator being closed every one or two weeks in China. You hear a lot about a new coal-based plant being opened every month, well that's true, but there's one being closed every one or two weeks.

The new ones are super hypercritical plants burning coals very efficiently; they happen to be big, but a lot lower emissions per megawatt hour than what they are replacing.

And then China has the world's biggest nuclear program, the world's biggest solar program, the world's biggest wind energy program, the world's biggest hydroelectric program, the world's biggest biomass program. They're not very big yet on wave energy, but they're putting a big investment into it to see if they can get there.

Now China and the United States, unlike Europe, are not doing - making this progress by putting a price on carbon; they're doing it through regulation. Well we could do that, but as an economist I've spent too much of my life studying regulatory versus market approaches to these things to have any confidence that regulatory approaches will be as cheap as market-based approaches.

So those countries have committed to major changes in trajectory on greenhouse gases. They've chosen to do it through a relatively expensive mechanism. We've got to make a proportionate effort getting similar outcomes. I think we would be smart to do it through a low-cost way and the low-cost way of doing it is through making the centrepiece - it's not the whole of policy, but making the centrepiece putting a price on carbon.

[Applause]

TONY PRESS: That was indeed a comprehensive answer.

[Laughter]

A question down here in the front row.

QUESTION: Professor, as I understood your speech, you're expressing some concern about the poor credibility amongst the general public of some of the pronouncements. And I'd like to offer a comment about one particular facet that I see the public are continually badgered over; that Australia has the highest rate of emissions per head of population, be it in energy consumption or in greenhouse gases.

I suggest that Australia's got a very large aluminium smelting industry and you could easily improve that statistic by closing down half a dozen smelters, but really I don't think that's the solution that should be being adopted. But I think a more honest presentation of where Australians' emissions are, particularly if those smelters - or most of the smelters, except perhaps the Tasmanian one, are world leaders in low emission technology. I'd invite a comment.

ROSS GARNAUT: Yes, well the Tasmanian smelter does use low emissions' electricity. The Victorian smelter, a very large one at Portland is - if it's not the highest emissions per tonne of aluminium in the world, it wouldn't be that far from it, because it uses lignite, one of the most emissions' intensive forms of energy. Maybe the most emissions' intensive form of large-scale energy.

If you closed down the Portland plant and that plant went to somewhere else, I think you'd be battling to find a way it could increase global emissions. The big aluminium companies of the world recognise that it does not make sense any longer to use coal - and especially brown coal - as a source of energy for very energy-intensive activities like aluminium.

Now we have this large established aluminium industry and it doesn't make economic sense for that to close down overnight. But let's be clear, if the whole world had a reasonable carbon price that reflects the external costs of carbon dioxide, you wouldn't get any new investment in aluminium, based on Australian coal.

The new aluminium BHP smelter in Mozambique based on hydropower, the Rio Tinto investment in Sarawak is based on hydropower. Several of the major multinationals are putting in plants in Iceland based on geothermal or hydropower. The exploration of sites in Papua New Guinea, the Congo, Brazil, based on hydropower, that's the future of the next stage of investment.

Now, that's not inconsistent with current plants in Australia continuing as it is for the time being. But let's not think that it actually makes sense now that we recognise the external costs of carbon dioxide to do any more of this.

Now, the modelling that I did in the original review, looking at long-term energy costs, show that even when - well, the future of coal is going to depend on effective sequestration of carbon dioxide, either through geological means - geosequestrational - biological means of some form. So

quite a lot of work's going on in that. The success of that work will determine whether coal has a long-term future in a world that's dealing with climate change. I'm not actually pessimistic about that but a lot of work's got to be done before they're there.

But whether or not that is the case, there will come a time in Australia when we will again be a globally efficient site for energy-intensive processing, because we - not only are we world champions in endowments of coal per capita but we're also world champions for endowments of the sources of most of the alternative low-emissions forms of energy.

So our day will come again in energy-intensive processing when the world is putting a price on carbon, properly recognises its external cost. But there may be - there's likely to be a period in which the new investment - not necessarily closing down old plants, but the new investment takes place near the stranded aluminium and geothermal while we are developing the strengths in the new low emissions' energy technologies.

QUESTION: Thank you.

TONY PRESS: We have time for two more questions and I've recognised two people. First question down here; second question up the back.

JIM SALINGER; Yes, Jim Salinger from the University of Auckland, New Zealand. It's very noticeable, probably in New Zealand too, US - the public acceptance of the facts of climate change. And you've noted paradoxically-wider science is becoming more robust, the public acceptance of the science is becoming less and less. Quickly, why do you think that's occurring? But probably more importantly, what should the Australian science community do to improve the acceptance of well-established science?

ROSS GARNAUT: Yeah, why is it the case? Well, I think the most important reason is that we're getting to the pointy end of a lot of policy to do something about the problem and once something becomes politically contested then the fog goes up. There are a lot of vested interests with a very strong interest in nothing happening and that changes the environment with - in which knowledge fights with ignorance.

But as you say, the more important question is what we can do about it. Well, I hope to do a little bit about it in the next little while. I think that our scientific community could probably put a little bit more effort into talking clearly to the community. I've found in my work that you sometimes have to dig for quite a long time before you can find out exactly what the message is.

But I think that all of us need to be part of an act of public discussion. In the end, we'll only get good policy in Australia if what I call the independent centre of the Australian polity - people who don't have interest in anything other than the truth being recognised and the public interest being advanced - playing a role; taking an interest; letting their voices be heard.

Otherwise those with an interest in the question will dominate the discussion, as they've tended to dominate recently.

TONY PRESS: Thank you, and I won't allow any scientist to respond.

[Laughter]

There's a question - a very last question - up the back. Thank you.

QUESTION: Yeah, thank you.

Professor, Greg Combet on *Lateline* last night, I believe, said that the Government expects that the carbon price around the level that they're considering will lead to a transition out of coal investment and production into gas. And I'm just wondering if you can comment on that, because, you know, that seems to me a bit of a worry when we really need to be going further into investment in renewables.

And my second question is just about the targets. I'm wondering if you can explain, you know, why you've settled on a 450 degree - 450 parts per million or a two degree-type of target, when I'm aware that there's a lot of - you know, there's a movement around the globe calling for us to reduce our carbon levels down to three - or go no further than 350 parts per million. And some countries like Tuvalu and others in the Pacific are calling for a 1.5 degree target. Thanks.

ROSS GARNAUT: Well, I didn't hear Greg Combet on *Lateline* last night because I was finishing off the science update paper.

[Laughter]

But if he said that the price will be a price that leads to a shift in power generation from coal to gas, I think that's an important and significant statement. I think that globally, natural gas does have a role to play as a transition technology. We have to be mindful of the cost of the transition.

Amongst other things, if the cost of the transition is too great, we won't do as much of it. And typically, gas will be forty per cent, or sometimes a bit less, greenhouse gases and the same amount of power generated from brown coal and less than half the greenhouse gas emissions from black coal. So it's a shift that makes a difference.

It's easier to capture the carbon dioxide emissions from an exhaust stream

from gas combustion than coal combustion and so it's more likely and more cheaply amenable to sequestration in some form or another. But I see gas, especially in Australia, as a transitional technology.

Australia's got wonderful opportunities for a wide range of near-zero emissions' technologies, and that will be the long-term future. Maybe gas, with geo or biosequestration can be part of that long-term future and meanwhile we should be putting a lot of investment into innovation that reduces the cost of a range of low-emissions and zero-emissions technology.

Another point to mention on the role of gas: Australia's on the way to being the world's biggest exporter of liquefied natural gas and it is the main source of high-grade uranium oxide for nuclear energy in the world. A lot of the exports of these two things go to the same places - Japan; China; Taiwan; Korea.

And economically it makes more sense to burn gas here and to use nuclear in Northeast Asia, because you lose so much of the energy in the liquefaction and transport process for gas. So gas will have a logical role for longer and there won't be a logical role in nuclear for longer in Australia than in the countries that are our markets for gas and uranium.

So for all of these reasons, I think that as a transitional technology, gas has an important role in Australia. The second one's another big question, but I discussed in the paper - and I won't go right over that ground - why I think we should be making sure we achieve the 450 parts per million. But to summarise the discussion, we're already over 450 parts per million of carbon dioxide equivalent.

We've - since I began my work on the first review we've exceeded the 450. We're now above 465 parts per million. We're headed towards much higher. The international energy agency says that even with the rather substantial commitments that were put on the table at Copenhagen and Cancun - and they're not trivial commitments, substantial commitments by many countries - that heads us towards something like 650 parts per million.

We're heading obviously much higher than 465. The path to 350 or to 400 depends on us first finding a credible path to 450, and I think we put in place the policies that get us to 450, then that is the same path that, if we choose to do so, can lead to higher levels of ambition.

TONY PRESS: It's my great pleasure now to ask Lyn Maddock, the director of the Australian Antarctic Division, to give the vote of thanks.

LYN MADDOCK; Thanks, Tony.

It's been a privilege for us here today to have Ross Garnaut and his team launch their report, particularly the update report that they have available outside.

It's fitting recognition indeed of the important role that the Tasmanian scientific community plays in undertaking the research that informs the discussion on climate change through organisations such as UTAS, particularly the CRC, through CSIRO, through the AAD. And in many ways the Tasmanian research is an important contribution, particularly where we're looking at the Southern Ocean and the Antarctic, which are our natural areas of specialisation.

And it's also of importance that the public discussion carefully and calmly examines the science and what the science is telling us. As Ross says in his paper, it's important that our dialogue remains grounded in the mainstream scientific literature, whatever our personal views about whether the received wisdom understates or overstates the reality. And Ross's paper and the work that his group are doing are an exemplar of that approach.

It's truly significant that with the careful and rigorous approach that they bring to the issues that they've moved from the position of the 2008 report of the mainstream science's approach main propositions were right on the balance of probabilities, to an acceptance that they're highly probable and much closer to being beyond reasonable doubt. A truly significant comment on the value of doing the science carefully and well and applying it to the policy debate.

The contribution that Ross Garnaut makes to the discussion in Australia of climate change and the possible policy approaches is of enormous value. It's an often heated debate, as we all know and he and his team bring that careful rigour that is so needed. It's of enormous value that we have the marriage of the science and the economics led by a man who is such a titan of the Australian public policy scene in this enormously important area.

So I want to, on behalf of us all, thank Ross and to thank his team for the work they're doing. I want to thank them for coming tonight. And on behalf of us all, I think we've been very privileged to have them here.

Thank you.

- ENDS -

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