Energy Futures - What is the future of Australian energy exports in a carbon constrained world? – 5 March 2015

For the last decade Australia's balance of trade has been heavily reliant on coal exports, and we have great expectations to become the world's biggest exporter of liquefied natural gas. But things are changing: future global demand for coal looks soft, there is recent uncertainty about gas prices and Australia's competitiveness, and demand for renewable energy is rising. This forum considered the likely impact on Australia's future energy exports. Potential low emission technology options such as carbon capture and storage and concentrating solar thermal will also be considered, as will novel technologies including high-voltage direct-current electricity exports and energy intensive exports produced by renewable energy.

Moderator: Maxine Mckew, University of Melbourne

Speakers: Tony Wood, Grattan Institute
Tania Constable, CO2CRC
Fiona Wild, BHP Billiton
Keith Lovegrove, IT Power Group

INTRO: It is a pleasure to welcome you here to the seminar. I'll soon introduce our moderator Maxine McKew, but before doing so I'd like to acknowledge the Wiradjuri people who are the traditional owners of the land on which this university is built and pay respect to past and present Elders of the Kulin nations.

So I don't think Maxine McKew needs much introduction to our audience, but currently she is Vice Chancellor's Fellow at the University of Melbourne within the Melbourne Graduate School of Education. In her recently published book *Class Act: Ending the Education Wars* she draws on the expertise and substantial research of the school and conversations with some of the most prominent thinkers in education to inform stories of success and challenges in Australian education. This book makes an important contribution to the education debate.

Maxine's background of course is in journalism and politics and I think she's very familiar to all of you as a face on ABC TV, anchor of programmes such as Lateline and the 7:30 Report, but it's in entering politics that she wrote herself into Australian history through contesting the Sydney seat of Bennelong and defeating the then Prime Minister John Howard. While in government Maxine was Parliamentary Secretary for Early Childhood and later for Infrastructure and Local Government. She's a director of three not-for-profit boards, Per Capita, the John Kane Foundation and Playgroup Australia.

It's my pleasure to introduce her as the moderator for this evening, thank you Maxine.

MAXINE McKEW: Thank you very much for that introduction, you'll notice there that there's nothing on my CV about energy but, look, I'll do my best this evening I assure you. Welcome everyone to this forum which has been organised this evening by the Grattan Institute in conjunction with the Melbourne Institute of Energy. Our subject tonight, as you all know, what is the future of Australian energy exports in a carbon constrained world? We've brought together three speakers, Fiona Wild from BHP, Tania Constable from CO2CRC, and Keith Lovegrove, a consultant in solar thermal with IT Power. Now, we're going to hear from each of our speakers in turn, have a discussion up here on

stage and then of course, most importantly, is to throw open to all of you in the audience for your questions.

First of all I would like to introduce to you the Grattan Institute's Tony Wood. Tony Wood is the Program Director at Grattan with a background in energy himself at Origin Energy and he's going to give us a bit of a scene-setter to kick us off this evening. So Tony, I'll invite you up here. Thank you so much.

TONY WOOD: Thank you Maxine, it's certainly a pleasure to be in this very new facility and I guess the teething programs of new facilities is what we've also seen a little bit tonight. But I do want to just spend a couple of minutes trying to set the scene for what this discussion is going to be about. There are some significant challenges ahead for countries like Australia that's been variously called an energy super power, but what does that mean and what does the world look like into which this energy super power is going to have to compete in the years ahead?

The first thing to recognise is that the world committed to climate change litigation in Copenhagen in 2009 and countries including Australia have committed to this objective of seeking to constrain global increases of temperature average across the world above pre-industrial levels by no more than two degrees Celsius.

Secondly, countries and country groups are already moving. But what it means when you look at this top left-hand chart, for the energy sector the top line is what was the International Energy Association's description is called "new policies" and "new policies" in their jargon means the policies that countries have already announced, but may not yet have implemented and this is where emissions would go. In terms of meeting the two degrees limit that the world has committed to we have to basically achieve greenhouse gas concentrations in the atmosphere in 450 parts per million, that's what the IEA calls the 450 scenario, and the line there shows what global emissions will have to be to meet that and what the emissions from the energy sector would have to be, and you can see there is a small divergence between those two lines.

In terms of meeting that divergence, countries are starting to put forward commitments. So the EU only last week confirmed that they will be proceeding to commit to a target to reduce emissions by 40% by 2030, and that's domestic emissions, that doesn't include anything they might do in terms of international trading. The United States last year, in a combined announcement with the Chinese President, announced that they would seek to reduce their emissions by between 26% and 28% below 2005 levels by 2025, and I don't know what the next phrase means at all. And then China at the same time, as I said, also made an announcement and for the first time the Chinese government are talking about moving away from simply an emissions intensity target, and that is such that greenhouse gas emissions per dollar of GDP would go down, which could then mean that if GDP is still growing emissions could go up. They've now moved to commit to an absolute target.

The bottom chart here shows what that would mean for China and you can see that the yellow line is where China has been progressively heading based upon an intensity target. To be able to achieve absolute emissions, the vertical axis here is absolute emissions, what they would have to do is the blue line or at least the yellow line, and that is a big change for China but that's what they've committed to. I should point out the scale on this chart is gigatons. For those of you who are not familiar with gigatons, we're proposing to introduce a new unit of greenhouse gas emissions that one gigaton equals a shit load. And so what you can see here is the world has a lot of shit loads of

greenhouse gas emissions and China, even if it caps out at 2030, would still be responsible for 10 shit loads of CO_2.

This changes the demand for fossil fuels. The same IEA Report talks about what this would mean. So it says that if governments continue their current proposed climate policies, that is the ones they propose to implement, then we would move from current policies to new policies. Top left-hand side shows what that would be and the bottom one shows what would have to happen to achieve the 450 degree scenario. That is the demand globally for coal. What that says is that between now and 2025/2030/2040 the absolute demand globally from coal will have to go down. The bottom right-hand side is the similar chart for gas. What that shows is the rate of growth for gas under the scenario would change significantly downwards. And so if you are an organisation, a company or a country that is exporting coal or gas, this is something about which you should be concerned because supposedly the world has committed to the bottom lines in each case.

Now for Australia this is significant because Australia last in 2013/14 exported 375million tons of black coal. This accounted we are the second-largest exporter of coal - Indonesia in total exports a bit more coal than we do although that moves around a little bit. Significant export earnings for this country from the exports of coal both metallurgical and thermal coal. And in terms of gas, whilst we are currently the third largest exporter of liquefied natural gas, the commissioning and initial start-up of the LNG Plants in Queensland, which have now already started and the first ship loads, I think there's about four or five of those ship loads of LNG have now left Gladstone for ports in Asia, they've already begun. That will build up very significantly so that Australia on the basis of most numbers would become the world's largest exporter of LNG within only a few years.

The problem is that if you look at the reserves of coal and gas that are behind these numbers for a country like Australia, the same International Energy Association says that if we're going to have even a 50% probability of meeting with the two degree standard, then the majority of the reserves that countries like Australia have of coal and gas will have to stay in the ground or that is they are unburnable. Now in terms of Australia specifically, one would think if we were a company we would have some form of risk management plan. If you look on the Department of Foreign Affairs & Trade website and other parts of the government's website, you will find a commitment that the current government remains committed to playing our part in achieving that two degree scenario, a global temperature increase limited to two degrees Celsius. The government has an unconditional target of 5% below 2000 levels by 2020 and there was currently a review underway by which Australia will make its formal commitments at the end of the year, but by mid-year they'll have to put those proposed commitments on the table to what our targets will be beyond 2020.

The Climate Change Authority, which is an authority established by the Labor government, the current government wanted to get rid of it, they've now given them the task of also having a look at what our target should be. They previously published a report that says Australia's targets should at least be 15% by 2020 and somewhere between 40% and 60% by 2030. So that's set a fairly high bar one would suggest. And the other piece of documentation that one can look at in terms of thinking about how does Australia as an energy superpower think about this is contained in Australia's what will be the Energy White Paper if it comes out this year, but there was a Green Paper published in in November of last year I think it was, and that said several things.

Firstly, the energy resources sector, coal, oil, gas, uranium, employs a lot of people and generates a lot of export income, but many analysts, if not most, would say that coal continues to be a major source of global energy for decades to come and that they're important for a strong national economy. But when it talks about the growth the coal and gas exports for Australia and what a wonderful opportunity that is, it only talks about the new policy scenario which is the scenario which gets us to four degrees, not two degrees. So I think there's a fundamental inconsistency and it will be, I would suggest, more than fascinating to see how the government resolves that conundrum because, as I said at the beginning, if Australia seriously is committed to the two degrees scenario and to play our part, the world in which we're going to be working in 2020, 2030 and 2040 will actually see an absolute reduction in coal demand around the world and a significant reduction in gas demand around the world. And so how this works and what international commitments Australia makes in terms of the 2020 target will obviously have serious implications for the composition of our energy mix, but also for the world's energy mix beyond 2020.

And with those comments I'll pass over to the more formal presentations from the panellists. Thank you.

MAXINE McKEW: Tony, thank you very much for that scene-setter and now to the first of our speakers tonight. Fiona Wild is the Vice-President of Environment & Climate Change at BHP Billiton. Fiona joined BHP in 2010 as Senior Manager of Environment and was successfully appointed to that role in 2013. She has over 15 years' experience in multinational oil, gas and resources companies. So Fiona, I'd ask you for your initial presentation. Thank you.

FIONA WILD: Thanks very much Maxine. Before we start, I want to refer you to our disclaimer on forward-looking statements. Given that it is so infinitesimally small I'm not actually expecting you to read it, but I do need to ask you to look at it so I can keep the lawyers happy. Have you looked? Excellent, we'll move on.

BHP Billiton is the world's largest diversified resources company and we produce a range of commodities including iron ore, copper, coal, oil and gas. As a company that's been operating in Australia for over 130 years, anticipating, planning and responding to change is something we're pretty good at. Take volatility in commodity prices. There's no better example than what we've seen in the iron ore market. For about 30 years the price of iron ore was around $20 a ton, it then rose rapidly to $150 a ton when demand from China outpaced supply, and over the last 18 months, as we know, it's fallen again. But we're not just exposed to uncertainty in markets, we're also exposed to uncertainty in technologies. Back in the 1970s we thought we'd experienced the end of easy oil, but in the '80s advances in drilling technology allowed us to move into deeper water and in the last decade we've been able to access unconventional resources, like shale. The point is that the only thing that is certain in business is uncertainty. The challenge for business is how to manage that uncertainty.

So tonight I'm going to talk to you about how we manage another uncertainty, climate change. Let me be very clear, I'm not saying that climate change is uncertain. The scientific evidence for climate change is overwhelming, warming of the climate is unequivocal, the human influence is clear and physical impacts are unavoidable, but what remains uncertain is the response from governments, industry and broader society.

We address uncertainty with good planning, which underpins everything we do. To inform our planning we develop scenarios, these provide a snapshot of how the world might look over coming

decades. Our scenarios incorporate long term uncertainty in things like geopolitics, macroeconomics, technological innovation, as well as responses to climate change. Our scenarios are designed to be divergent but also plausible. They give us possibilities against which we can test the resilience of our portfolio. It's a little bit like a great big BHP Billiton crystal ball. For example, we consider a scenario where there is a very strong consumer pull for green products and services. We also consider a scenario where action on climate change is not a priority. Across the range of scenarios our analysis shows that our portfolio is robust because of its diversity. For example, in a severely carbon constrained world our high quality metallurgical coal and iron ore assets, plus copper, uranium and potash mitigate the negative impacts on our other commodities. Our portfolio diversity makes us more resilient than many others, but we still share the same challenge of how to continue to provide access to affordable energy while limiting climate change.

As Tony mentioned, energy demand is expected to increase as the global population grows and living standards improve. By 2030 an additional 1.7billion people will have gained access to electricity for the first time. Our analysis, which aligns with leading international forecasts and the information you've seen from Tony, shows that fossil fuels are likely to continue to supply the majority of that energy. Given this future demand and the continuing role of fossil fuels, how do we minimise emissions, maximise energy efficiency, and deliver economic growth?

We believe there are four parts to the solution. The first is mitigation, reducing our own emissions. Unlike many other resources companies, we have an absolute target to limit our greenhouse gas emissions. As we grow our business this target encourages us to continually look for opportunities to improve our energy efficiency and implement additional greenhouse gas reduction projects. Last year our businesses implemented projects that delivered 800,000 tons of greenhouse gas reductions. For example, at one of our aluminium smelters in South Africa, operational improvements at the plant and in the pot lines delivered reductions of around 120,000 tons. At our coal operations in Queensland productivity improvements at the coal handling facility delivered reductions of around 65,000 tons.

The second part of our approach is adaptation. Given the long life of our assets, we must build the resilience of our operations to the physical impacts of climate change. Our assessments show that climate change will exacerbate existing risks and expose us to new risks. For example, cyclone management is already a critical requirement for our West Australian iron ore business. Existing practices will allow the business to respond to the expected increase in cyclone intensity in the Pilbara as a result of climate change. At our Worsley Alumina asset in the southwest of Western Australia climate change has already resulted in less and more variable rainfall. To address this we've developed a new water discharge regime from the plant which mimics this changing natural environment.

The third part of our approach is technology. Technology and innovation have the potential to help all of us use energy more efficiently, develop large scale step-change technologies, like carbon capture and storage, scale up renewables and improve energy storage. But these technologies must be available at scale, lower cost, and much, much faster than the usual commercial timeframes to meet the challenge of climate change. Industry has a significant collaborative role to play with government, academia and community to facilitate this step-change.

Since 2007 we've spent almost half-a-billion dollars on low emissions technology research, development and deployment across a number of projects ranging in complexity and scale. One

example comes from our Illawarra coal asset in New South Wales. We implemented a project to capture fugitive methane emissions from our underground mining operations and used them generate power. This project was a partnership between government, business and academia. This type of collaborative effort allows us to combine investment and resources and helps to achieve outcomes more quickly. Working with others to leverage our investments underpins our support for CO2CRC, which Tania leads, as we believe this is one of the world's foremost collaborative research organisations on carbon capture and storage. Our current focus is on building a long term road map for our investments, so we can play our part in accelerating global deployment of low emissions technologies. Although using technology to reduce our own emissions is vital, finding technologies that can reduce emissions form our customers' use of our products offers a more material opportunity and why working in partnership across our supply chain is so important.

Stakeholder engagement is the fourth part of our approach. We believe this is necessary to build an effective long term climate change policy framework and drive the changes needed to deliver a measured transition across energy systems and markets. Business has a key role to play in the policy debate, sharing lessons learned and helping to identify solutions that can drive emissions reductions at the lowest cost. We remain firmly committed to engaging with industry, government and civil society to contribute to the broader conversation. What I've tried to do this evening is show you how BHP Billiton thinks about climate change and describe the action we're taking. We know there is still much more to be done, but we are encouraged by the results we're seeing today and the innovations we're working on for tomorrow.

So to conclude, exactly how countries will provide access to energy and limit climate change is uncertain. We have a robust corporate planning process in place to help us think through uncertainties like this and we are taking action by focusing on reducing our emissions, building our resilience to climate impacts, working with others to support effective policy development and accelerate the deployment of low emissions technologies. Thanks for the opportunity to speak and I look forward to the panel discussion.

MAXINE McKEW: Fiona, thank you very much for that and to our next speaker Tania Constable. Tania is the CEO of CO2CRC and, apart from her vast background in this area, she's a very lucky lady because her funding for her research institute is continuing, has been renewed. We can be thankful for this. Tania has been instrumental in her career in the development and implementation of policies and regulations applying to Australia's both on and offshore mineral and energy resources. So please welcome our second speaker, Tania Constable.

TANIA CONSTABLE: Thank you very much Maxine and good evening ladies and gentleman. The science related to the impact of greenhouse gas emissions has again been made fundamentally clear in the Fifth Assessment Report of the Intergovernmental Panel on Climate Change released late last year. That action is required if we are to limit emissions to two degrees Celsius and carbon capture and storage (CCS) must be an option for markets to consider, otherwise the cost of mitigation without CCS is 138% higher. However, CCS costs are still high and investment is critical to drive down costs and ensure that CCS is a real option for the energy and industrial sectors.

So where do we sit on global greenhouse emissions? Since the 1970s global carbon dioxide emissions have continued to increase with larger absolute increases in more recent years. In the last decade alone annual greenhouse gas emissions grew on average by one gigaton of carbon dioxide

equivalent compared to 0.4 gigatons of CO_2 equivalent from 1970 to 2000. Fossil fuel combustion and industrial processes contributed about 78% of the total greenhouse gas emission increases from 1970 to 2010, with a similar percentage increase from 2000 to 2010. Tony set the scene on the 450 scenario, but to go one step further the 450 scenario assumes a target of cutting energy-related CO_2 emissions by more than half in 2050 compared with 2009 levels. There is no doubt whatsoever that this scenario is very ambitious.

In 2010, 81% of energy demand and 67% of electricity production was sourced mostly from oil, gas and coal. From 2005 through 2011, China added roughly two 600 megawatt coal plants a week for seven straight years. US Government projections suggest that China will continue to add the equivalent of a new 600 megawatt plant every 10 days for 10 years, making the fleet 50% larger than it is today. While China, the US and EU have already committed to non-binding reductions in emissions, further global negotiations to limit greenhouse gas emissions are expected and, irrespective of any global agreement, there'll be pressure on individual countries to significantly constrain their emissions and we've got, ladies and gentleman, another "Oh shit" moment coming.

Australia's total emissions last year were approximately 542million tons. This is an important implication for Australia's energy sector and shows Australia's vulnerability. We have a wealth of energy resources and it positions us as a prominent global energy exporter in the Asia-Pacific, but we differ from many other OECD countries. Coal plays a much larger role, reflecting our large low cost resources located near demand centres. Currently Australia's coal exports' annual value represents 15% of Australia's total goods and services trading, while the penetration of gas in Australia is similar to that of OECD and world averages, as is that of wind and solar. In terms of scale, this slide shows how important the energy industry is to our country, and Tony covered this area very nicely. Australia could be exposed and resources like coal may be at risk of being stranded due to likely changes in a number of major overseas energy markets in a carbon constrained world market. In addition, our aspirations to export brown coal may not be met as the use of lignite for electricity generation in Victoria can only be achieved with the application of technologies that can reduce carbon emissions. In this case CCS will be needed.

As I mentioned earlier, the IPCC found that if CCS technologies were not deployed in achieving a 450 outcome then it would increase the cost of mitigation by 138%. To enhance our export potential and from a climate change perspective, this presents a strong case for developing CCS as a real option. This will require additional technological breakthroughs for some industries, fully integrated demonstration projects, regulatory support and community acceptance. It's not the total answer to greenhouse gas emissions concerns and it will need a portfolio of technologies including wind, solar, nuclear for some countries, but for as long as society continues to choose to use fossil fuels as a power supply or for fertilizers or cement or steel, then we will need to consider CCS.

Indeed, we can potentially move over to renewables for power generation, but there is no way we can make steel using renewables and I accept this is a conundrum for some, that we need to continue using fossil fuels in order to increase the use of renewables to manufacture the materials for wind, turbines and for photovoltaics. Therefore, developing CCS will support renewables; it's not a competition. And CCS is not pie in the sky, it's here and now. CCS is a safe and proven technology in the upstream petroleum sector. Across the world there are 13 large scale projects operating capturing about 25million tons per year. Nine additional confirmed projects are under construction and this

would increase the total to around 40million tons per year captured in 2020. China currently has 11 of those projects in various stages of planning and development.

Let me tell you briefly about five projects. The Sleipner Project is a gas development and located in the middle of the central North Sea, near the border between the UK and Norway. Sleipner was the world's first demonstration of CCS technology in a deep saline reservoir and remains the only development where the CO_2 is both captured and injected offshore. At a rate of 1million tons per annum, more than 10million metric tons of CO_2 have been safely stored underground over the last 10 years as part of this project. The SAS Power Boundary Dam Project in Saskatchewan, Canada, proves that technology works and can be retrofitted to an existing power station. Boundary Dam is a brown coal fire power station with post-combustion capture that commenced in October 2014. This project has capacity of 1million tons per annum.

Closer to home we have demonstration and the reality of a commercial project at scale to come online in 2016. Over the last five years the Callide Power Station Project has largely flown under the radar, but CO_2 has been captured during Callide oxy-fuel trials, then transported and stored at the CO2CRC Otway site at Port Campbell in Victoria. This was the first time emissions from a coal-fired power station had been captured and stored in Australia. Ladies and gentlemen, CCS works. Now we need to get it to scale.

When injection operations come online in 2016, the Gorgon Project will be the first facility in Australia to significantly reduce emissions by the underground injection of carbon dioxide and represents the single largest greenhouse gas reduction project undertaken by the private sector globally. The project will set a new global benchmark for the underground injection of carbon dioxide with between 3.6 and 4million tons of carbon dioxide being injected annually. Over the life of the project it's anticipated around 100million tons of carbon dioxide will be safely injected. Putting aside the sheer scale of the project, the Gorgon Joint Venture can claim a couple of important world firsts which may assist other greenhouse gas storage projects: the world's first greenhouse gas storage specific legislation in the Barrow Island Act Western Australia; and first CO_2 injection project to undergo detailed environmental impact assessment, including public review and comment.

The CO2CRC Otway Project, a world class sub-surface pilot demonstration and research facility, has been running for the last 10 years and is one in which Australia can take great pride. It's an outstanding example of a carefully monitored site where it's been possible to model and verify the behaviour of more than 65,000 tons of CO_2 which has been injected approximately 1,500 metres underground. This research will improve understanding of the way CO_2 is trapped in the rocks and the monitoring program is key to lowering costs and helping commercialised CCS. As Maxine mentioned, we recently received grants, one from the Commonwealth Government of $25million and Victorian $5million, that will allow the next stage of Otway monitoring and verification to occur. As we speak, scientists are installing over 900 high resolution geophones, each about the size of a tennis ball, and 11 kilometres of fibre optic cable in narrow trenches over an area of one square kilometre. CO2CRC can also lay claim to a number of world firsts that include this high resolution monitoring program. These real world activities are valuable to industry in understanding the steps necessary to lower costs.

I'd like to now share with you some of the work being taken on under examining the economics of CCS. This next slide looks at nth of a kind economics and highlights some important examples of

work undertaken and our understanding about CCS costs in Australia. I'm not intending to go through all of these because I think that that is a real lecture in itself, but it is something that I'm happy to answer questions on later on.

So what are the next steps? The economics of CCS must be re-examined with a view to bring together first and nth of a kind costs compared to other technologies in energy. This will provide a realistic and up-to-date picture of energy technology costs. Capture projects should be about developing prospective capture technologies for Australian conditions and developing field pilot facilities to support assessment and development. However, Australia should continue to play a much bigger role in storage technologies to achieve reliable, safe and low cost storage through long term monitoring and verification to manage risk and uncertainty and to support our flagship projects, such as Gorgon, South West Hub in Western Australia, and CarbonNet in Victoria. It's also time to better communicate to the public our learnings about CCS to-date. Great work has been done in the last decade, but we've not been very effective in getting this information out. We need to win the hearts and minds of the public that CCS technologies are safe and reliable. We also need to resolve legal uncertainties for carbon capture and storage.

In conclusion, ladies and gentlemen, fossil fuels will continue to play an important role in Australia's economy and increasingly in exports. Australia's energy resource abundance needs to be underpinned by investment in supply and integration of renewables and technologies, such as CCS, to best manage our energy systems for the future. Governments, industry and the science community around the world need to work together to continue the rapid scaling of CCS. Australia will play a small but important part. To this end it's time for researches to consolidate and focus our efforts on what matters to Australia. In conclusion, limiting a global temperature rise to two degrees Celsius and reaching the 450 scenario is possible, but the option of CCS must remain on the table so that this can occur. Thank you very much.

MAXINE McKEW: Well Tania, thank you very much for that and from CCS we going to flick and consider now the whole issue of solar thermal and to do that our next guest, our third speaker is Keith Lovegrove. Keith is a Senior Consultant in solar thermal at IT Power Group based in Canberra. He comes to that job after a long background of 15 years of teaching at the ANU as Leader of the Solar Thermal Group. So would you please welcome Keith Lovegrove.

KEITH LOVEGROVE: Thanks Maxine and good evening everyone. So my introductory slide hints at where I'm going here. I'd like to introduce an idea that might seem a little bit visionary but I suggest is closer than it may appear, which is the idea that we could continue as a fuel-exporting nation but try to de-carbonise our fuels and even make them renewable.

But to begin with, I'd like to show a few contextual slides, some of which reiterate points that have been made before. In particular, Tony pointed out the sort of money we earn from our key exports of coal and LNG, and the numbers don't quite line up because I'm afraid mine are about a year older but the principle is the same. This is how Australia's bread is buttered. We make money by selling coal, iron ore and, interestingly, overseas students, and here it is, coming up the running order, natural gas. Natural gas is, I think Tony you quoted 16billion and at this point it was about 12billion, so it's growing fast and may well have actually overtaken our overseas students at this point. Traditionally coal has been our winner but, as Fiona pointed out, we've had this period during the resources boom where

iron ore was up there thanks to the Chinese and maybe it's now fallen below coal, I'm not sure, but it's right up there anyway.

What you'll also notice is what a great big bar uranium is. Can anyone spot the uranium bar? No. It's way down here somewhere, but that's interesting because in terms of gigajoules exported, units of energy exported, we already export uranium fuel to about the same energy amount as our coal. What that tells you is dollars per gigajoule uranium is a really, really low cost substance, the advantage of nuclear power for those who own a nuclear power station is it's all capital cost, very low fuel cost. So for a country whose business is selling fuel, that's not a good turn of events necessarily. How do we spend all this money that we make from digging holes in the ground? We buy Japanese cars historically but we're shifting to Chinese ones, we buy iPads, we buy oil. Oil is one of the big elephants in the room at the moment, it has been for a long time. There are projections that our bill for oil could blow out considerably by about 2030, but of course that all depends how much oil we choose to use and what price oil is, and that's the $64,000 question at the moment.

So it bodes us to also look at where does this stuff go? The coal goes to Asia and notice this, Japan is our number one customer taking about 43% of it. The LNG goes 70%-odd to Japan and here's an interesting thing, Japan is 90% dependent on imports from various countries for all of its primary energy. It's completely dependent on importing stuff and a lot of it comes from Australia. And this huge search in LNG demand and the new plants that Tony was referring to that are really driven by that demand and the price increase that's followed that demand, a good deal of it from Japan can be directly linked to the fact that they closed their nuclear facilities following the Fukushima disaster. So rather interestingly for Australia, the switch to LNG has actually increased our earnings considerably and is continuing our trajectory in that directory, so I think that underpins what we need to think about.

Now I'd like to just think about that elephant in the room, which is oil. You may not realise it, it doesn't get talked about enough I would say, but it's still the single biggest primary energy source in the world. It's about 30% of the world's primary energy and so far no-one's really predicted that that's going to change. But more importantly than that, given the higher value that the stuff has when it's traded in terms of dollars per unit energy, it kind of represents about 70% of the money that changes hands in energy in the world, so it really is the big end of town. It is actually really convenient stuff and it's convenient because it has a very high energy density and it's a liquid and, you may not realise it, but the biggest advantage of that is if you fill a tanker up with it you can sail halfway around the globe and by the time you've got there with all your energy you've burnt fuel oil of about 2% of that energy. That means it's a 98% efficient way of moving energy across the whole globe, and nobody has come up with a better way than that as yet. So a liquid fuel is an extremely attractive thing and really where I'm heading to is the idea of why would we move away from that, let's just make our liquid fuel emissions free.

Continuing the elephant in the room, unconventional oil, the shale oils, the fracking that you hear about, coal to liquids potentially, tar sands out of Canada, people argue about the values and the access, but this supply curve that was reproduced from the International Energy Agency a while ago clearly indicates that the unconventional stuff, there's lots of it but it is more expensive. Okay. Have a look at Australia. We continue to have growing demand for oil, but our domestic production is declining, that is inevitable. There doesn't seem to be any sign on the horizon of an explosion of cheap oil domestically in Australia and, alarmingly, we had this trend of very sustained international price growth and it went right up to $110 a barrel and so forth, and the IEA was predicting it might

level off and slowly increase from there but, lo and behold, this happened. More or less starting this time last year we've had a complete crash in the price of oil, so it's now halved, what does that mean? You cannot really reconcile that halving with this supply curve. Really it has to be a supply and demand thing which better brains than me seem to be struggling to unpick, but the physics tells me that that stuff's running out and these people, the Saudis may be able to turn their pumps lower or higher, but they're not actually the future, they're the past, and it's either this stuff or something else and you can't keep doing that at $50 a barrel. Am I wrong Tony? He's agreeing. Okay, so there's something that sets the scene.

So two of my speciality, concentrating solar thermal systems, it's smoke and mirrors and stuff and hopefully rather less smoke, more mirrors. It's a growing industry, we're very proud of how it's growing, look at that, 4.5 gigawatts. Now, let me put that into context. So it's been managing about 30% per annum growth, that's a pretty good compound growth rate in anyone's terms, but before you get too excited I think it was Fiona who quoted how fast China is putting out coal plants. Basically China is building coal-fired power stations in about a month that the entire global CSP industry is adding in a year. Now what does that mean? That means there's a way to go, but compound growth is a wonderful thing, it's quite easy to actually turn that thing around and one of the things that will continue the growth is China getting into this field as well, which they're just showing signs of doing. So when China just decides to build less coal and build more of this stuff it can flip around quite quickly. So it's about different approaches of concentrating solar radiation to spots to get high temperatures and CSP, P for power, means to use that to make steam to generate electricity. The big advantage of it as a way of generating electricity is that in these little tanks at the bottom here you can store hot liquid salt, for example, as a way of storing energy and this actually is the world's first effectively base load solar plant, it runs 24 hours a day for most of the year.

So that's the background, but what I want to say to you is that Tania had a lot of very interesting and valid things to say, but she made one point there and she's going to be surprised when I say this. You can make steel with solar energy, you can, and you do it with this kind of approach of solar chemistry. And just to make it clear to you how you can do it, there is a process that at least has been taken to commercial pilot scale called hot briquetted iron which is making iron not using coal, not using coking coal, but using natural gas as the way of reducing the oxygen from the iron oxide and getting iron. You can equally do that with pure hydrogen, you can make hydrogen from renewable energy, you can make steel from renewable energy; it is actually possible.

Solar fuels means starting with this concentrated solar energy, which we're currently using for power generation, and saying it can be temperatures, a thousand degrees if you want it, whatever you like. You could make electricity and use it to split water and get hydrogen. You can do more imaginative things where you split water using high temperature reactions. You can do high temperature electrolysis. You can actually split CO_2 using solar systems. Also, interestingly and maybe controversially, is the idea of hybrid systems. You can use solar energy to carry out reactions that are typically done with fossil fuels and you can make a fuel that is a hybrid of a fossil and a solar or a hybrid of a biomass and a solar, and there's a lot of really interesting arguments to be had around that. So that's the principle of it.

Do we do any of it in Australia? There's a little bit of work that I used to lead at ANU, but I really highlight this effort in Newcastle by CSIRO. They've spent many years showing at different scales that you can use solar energy in a reactor at about 800 degrees to convert natural gas into a mixture of

carbon monoxide and hydrogen, which you normally do in industry by burning more natural gas to do it. So by doing this you effectively de-carbonise the process of making hydrogen from natural gas by about 50%. So this has been running for years and years and it's probably the closest thing to a commercial process in this field and could be done quite quickly. Would it even make sense economically? Well, we've got our old elephant in the room again. If you compare options to oil at $100 a barrel, that's equal to $16 a gigajoule, when it's turned into diesel it's $20 or so a gigajoule, that's our current technology for fuels, it's of course reasonably high in greenhouse gases.

What if we did some of these things with solar energy? Well we can consider an input fuel cost that might be a dollar a gigajoule for brown coal, God knows what the price of natural gas is going to be, rather less than $10 a gigajoule I guess the way things are headed, maybe it's $6 maybe $7, biomass arguably can be delivered for about $10 a gigajoule, and a water of course is reasonably free. By the time you've converted it with solar energy, what do you get? You get some numbers that are in the ball park of our conventional oil. Of course, the pure water splitting is challenging, it is rather expensive and has zero emissions. It's the long term holy grail if you like, but it's not completely unaffordable and at the sort of costs for avoiding CO_2 that we are going to have to deal with if we are going to reach the positions of emissions reduction that people say we're going to do, then this is actually quite affordable. But, interestingly, here's this biomass route that allows us to get to zero greenhouse gas intensity for something that is quite comparable to conventional oil, as long as conventional oil doesn't stay at $50 a barrel. There's the elephant in the room again.

Okay, remember Japan is our number one customer for all these things we sell. Don't bother reading the fine print, just let me say Japan is really serious about hydrogen now and really it's about what is Japan's policy in this space? That's really the determinant of a lot of things for our country and for the world. They are serious about hydrogen. Very large companies are becoming serious about hydrogen and, Tania didn't mention, but I would believe that this study is still going on, Kawasaki heavy industries are seriously looking at gasifying brown in the Latrobe Valley and I guess sequestration is part of the Otway Project is it, indeed linked to that, and then they want to liquefy the hydrogen and send it back to Japan.

So this is technically workable and they're doing a study at the moment and that's a very large company and it's driven by a policy from our largest customer country. I happen to think it's not exactly the optimal solution. This company here has another idea; they want to combine their hydrogen in a complex reaction like that. But there's a range of other things that you can think about and there's at least one person in the audience tonight who agrees with me that this one is worth a very serious look at. Ammonia means combine your hydrogen with nitrogen out of the air, make NH_3. It's one of the biggest industrially produced chemical products in the world and it's already traded globally, already shipped around the place, and Japan is a very big player in that, so it's an existing approach.

Let me end with this vision for you, red and pink is supposed to indicate places that are fairly sunny. It may come as no surprise to find that Australia's fairly sunny. You might be interested to know that Japan is fairly not sunny, all of China where the people live is extremely unsunny, mainly due to the pollution from burning all the coal that they buy from us. These are the places that we ship LNG, there's Gladstone up there somewhere, here's the Pilbara over there and I think Darwin is targeted as a place. So I draw arrows to say if we did clever stuff in sunny places, there's our customer right up there who wants hydrogen, they want to clean up things, they maybe want less coal, and it wouldn't

take all of our country to do it. That's what you would need to meet all of Japan's primary energy using current efficiencies of current technology once you got it out of the pilot scale, took it through the process of commercialisation and had the nth of the kind of plants and so forth.

So thank you very much.

MAXINE McKEW: Thanks very much to all of our speakers. Look Keith, I think you get the prize tonight for the most colourful and the busiest graphics, and we will have a visual retention test at the end of the seminar. Actually, just picking up on your last slide there, you're pointing to the centre in the Territory somewhere, so explain what would have to happen in that area for your scenario to be a reality?

KEITH LOVEGROVE: Alright, so the square is entirely notional, you would never do it in one place, and in fact the arrows are probably more reflective of the vision in that we currently have export facilities, in the Pilbara, for example, where the Gorgon Project more or less is, that's where we're sending LNG out right now. We've also got ammonia plants up there that are leveraging the natural gas as well, so we're already shipping ammonia from a place like that. So it makes sense to find export facilities that are already in operation but are in very sunny areas, and then try to build up infrastructure around that.

So if you were trying to export from the Pilbara you might tend to go 100 kilometres or so inland to get the best solar resource, get away from the cyclone dependants, and there you might have big fields of concentrators running little chemical reactors that they focus and doing exactly the reactions that Yarra Fertilizers are doing in their plant by burning natural gas right now. That's the vision. It would be a free market, people would develop whatever they develop, plants would start small and get bigger as the industry matured.

MAXINE McKEW: Quick reaction, Tania what do you think of that?

TANIA CONSTABLE: I think that's absolutely correct in terms of how you would go about that, the placement of it, it does need to be near an export facility to be making sense of the solar placement.

MAXINE McKEW: Fiona?

FIONA WILD: I think one of the things that Tania said really resonated for me, which is it's not a competition between different sources of energy, we need all the options we can get. So, let's go.

MAXINE McKEW: But it's kind of a case of this goes with this goes with this?

KEITH LOVEGROVE: Yeah, in fact they're either hidden. Implicitly in my presentation they were talking about hybrid fuels that, for example, if you did something in Pilbara what you'll be doing is making less CO_2 but still some CO_2. So why not combine it with a sequestration solution and look for a least cost way to go forward?

MAXINE McKEW: Okay, before I go out to the audience, I just want to talk to all of you and press you on this issue of the changing external environment. I mean, you've all addressed this question of risk and uncertainty as you all see it, but I'm just wondering if I can pin you down on that. Again, as Keith was showing with those graphics, we are hostage when it comes to our energy exports to decisions

that are being made and will be made in Tokyo, in Beijing, in Delhi. If we see a shift quite quickly, how do you rate that risk if that were to happen, high, a medium, low? Tania, how would you tackle that one? And we could see quite big shifts?

TANIA CONSTABLE: We could see quite big shifts. The supply/demand scenario is quite well- known at the moment and all of the big companies do work on this every single year, so you can see what it coming at us. I don't think that we're going to see too much of a shift right at the moment in terms of China, India, Brazil, it is well-known. So what isn't well-known though are the policy settings that go with that. The uncertainty does actually lie in the policy settings that need to accommodate that supply/demand scenario and I think the policy settings – what we see coming out of Paris and we talked about, and I used the "Oh shit" moment, I think that December 2015 we need to be a little bit ready for what might be coming at us in terms of a shift there in terms of policy. If we see some certainty coming from those new policy settings I think that we will be better placed. So I think get ready for 2015.

MAXINE McKEW: But are we? Because, just excuse me for a moment Tania, we were caught flat - footed in November last year, weren't we? The announcement by US and China to make big moves, announced on the eve of the G20 Meeting in Brisbane, judged by the reaction of the government sort of came out of nowhere, we were not prepared for that.

TANIA CONSTABLE: Well, we should have been prepared for the EU, the US and China making those sorts of statements. I don't think that Australia is in that boat in 2015. There's not the movement that there was in Copenhagen in 2009. We believe that it's less frantic around the current position. So I think that we are ready for 2015. We've got a note what those policy settings might bring us and be ready with the changes that are coming. We've talked about CCS, we've talked about solar, we know what the supply and demand factors are looking like in the future, and the policy settings need to reflect that in Australia and elsewhere in the world.

MAXINE McKEW: Fiona, can I get your comment on this first of all - sorry, I'll come back to you Keith - how are you and your colleagues at BHP looking at this. As we said, from November last year to December, Paris, what are you factoring in?

FIONA WILD: I've stopped betting actually on climate policy because –

MAXINE McKEW: No.

FIONA WILD: I wish I knew what was gonna happen, but I actually don't and it's notoriously volatile. So I think what it says to me is you don't know what's gonna happen, the only thing you can do is test to see that whatever happens you're ready. And that to me is the beauty of the scenario planning work that we and other companies do is you can create those bookend scenarios of well, the world could move down this path, we could have a very integrated approach, we could have coordinated global action, we could have a global price, but we might not. And so for a company like ours, we have to create a plan for being resilient regardless of what happens.

MAXINE McKEW: Okay, do you have scenario plays that go along these lines, that will move to a situation where it's almost everything but coal?

FIONA WILD: We have scenarios that look at very, very different outcomes in terms of what technologies might be available, what the mix might look like in terms of energy and what the coordinated action on climate change might look like, absolutely. And as I said in the speech before, the important thing for us is having that diverse portfolio because it gives you the adaptability and the flexibility to be able to shift as you see those changing energy demands and the changing societal expectations. But jeez, if I could see what was gonna happen I would love to know. I can't, I can't forecast.

MAXINE McKEW: Keith, there's this question of reading the externals in the run of Paris.

KEITH LOVEGROVE: Reading externals. What I'd like to offer are two comments. One is that in a sort of comforting way to encourage us to be lazy, our customers like Japan in particular, who I've highlighted tonight, has a history of major investments, upstream investments in developments in Australia and I think there may even be an investor in the Gorgon thing, I'm not entirely sure. But they tend to follow their energy supply to its source and make the investment, so if they decided they wanted solar hydrogen they would probably come here and start investing. So that would make the job a whole lot easier for us than it might seem when I just draw things up on a map like that.

But what I would say and it's something where I think our Government policy has been lacking is that there's a concept of an nth of a kind of plant and I think you use that phrase. When you have these technologies they have to scale up and usually you go in factors of 10 if you're sensible, you build a little one and then 10 times bigger, 10 times bigger, until you finally get to a full commercial scale. But your first of a kind plant so-called is going to be maybe 20%, maybe 100% more expensive than what is called nth of a kind. Nth means you've done enough of them, maybe it's half a dozen, that it's a mature industry now and from that point actually costs then keep on declining as you build more and more of them, but that's your starting point.

And I think more could be done in some of these technology areas to get us to nth of a kind so that we're ready for when the demand comes. And, I mean, what my little graphic at the end showed is that there's not actually a shortage of land area in the world to do these things and it may actually be that countries like Saudi Arabia beat us in the race to solar fuels ironically.

MAXINE McKEW: Did you want to make another comment on that, Tania?

TANIA CONSTABLE: I'll just make a comment on the nth of a kind and I'll look at CCS there. Because we're talking about such big projects and very expensive projects, when you do that first of a kind there's so much learning that comes with that, the costs can come down quite dramatically. And I mentioned Boundary Dam as one of those projects. From what we've learnt from Boundary Dam straight away with that project, the project itself is estimating that the costs will come down as much as 30%, and that's a huge reduction in terms of costs for these sorts of technologies with something that is so big, because we're not dealing in small units here, they're substantial, they're billions of dollars because they're such large plants.

MAXINE McKEW: Let me come out to the audience at this. Just say who you are, if you're representing an organisation, and if you could keep your questions nice and succinct. Thanks so much.

AUDIENCE: Thank you for your presentations tonight. I'd just like to correct something that was said, I'm not sure who said it but somebody said, "If we are to reach 450 parts per million". We're actually trying to avoid reaching 450 parts per million. Keith, I like your presentation on concentrated solar thermal power. Why don't we actually export the high grade energy in the form of electricity into South East Asia though, similar to the process that is being proposed by the Desertec Organisation.

KEITH LOVEGROVE: A very good question. If I could magically bring up my last slide I'd talk to it. You would have noticed that my heading was Australia's Desertec and I was actually alluding to this concept that you're talking about, which involves looking at North Africa, Middle East to North Africa and considering connecting high voltage DC across various parts of the Mediterranean and into Western Europe. And it's actually a very sensible idea, but the advantage is when you look at the map what you'll see is that the distance from Morocco to Spain, for example, is less than the Bass Strait. We've got a link from Tasmania to Victoria, so doing hundreds of kilometres, if you go from North Africa to the bottom of Italy it's in the hundreds of kilometres.

Our main customer is Japan, they're 4,000 kilometres away and any cables like that would have to go from the north of Australia, where we don't even have a grid at the moment, they'd have to go through Indonesia, pass through Indonesia and then somehow get their way up to our main customers. The idea that the Indonesians would buy electricity off us I find pretty hard to believe because they can still put the PV panels on their own house roofs. And the world deals in tankers with liquid fuels, we can get the energy to Japan at 98% efficiency, the high voltage DC won't come anywhere close to that.

So on cost and efficiency and the fact that it doesn't bring you inherent energy storage, I don't think it quite works for Australia to follow the high voltage DC path.

AUDIENCE: Can we expand our world horizons from exporting energy to exporting products made with our convenient energy? Why do we have to continue to export iron ore, rather than some high grade products made with iron ore? Why do we have to continue to export wheat rather than high class biscuits, and why don't we export cars made with our cheap energy, local iron? Why don't we export fertilizers made with the process that you implying? Why are we committing ourselves to being a primary producer after 200 years?

MAXINE McKEW: It opens up nicely our historic dilemma. Who wants to take that one?

FIONA WILD: I have no idea how to answer that question. I don't know, I honestly don't know.

KEITH LOVEGROVE: I'll have a go if you like, I don't want to hog the microphone. I mean, it's a valid question for us to ask as a society and I don't know the answer, but I'll talk anyway.

How about this for an idea? It seems to me when you look at the reality is that we've lost the manufacturing race to places like India and China, yet we've won the primary production race. And part of it is we are a wealthy country with high costs of living, high costs of labour and a small domestic market. So it's really hard for us to make cars and compete with a place like China. So is it so bad that we embrace what we're good at, which is more to the primary end? But having said that, I don't see any reason at all why we shouldn't aspire to at least creep a little bit further up the value chain. We may not make the cars, but why can't we make the steel? That's a pretty fair question, I reckon.

AUDIENCE: You may be interested we did a report very recently on this exact subject looking at what was the impact on Australia of moving from the new policy scenario to the 450 scenario. And one of the things that I'll point out initially is that 450 scenario where there was a very steep divergence in coal consumption, in the future that did include CCS in the assumptions of the IEA, and there was still a huge decline in the use of coal. And what we found is there is a very substantial shock to Australia, even the forecast from the Australian government are not just in line with the new policy scenario of the IEA, they're actually more in line with the current policy scenario which is highly over the top of the new policy scenario. And what we found was that the difference by 2030 was in the order of $100billion per year.

MAXINE McKEW: So that's the scale of the economic shock?

AUDIENCE: That's the difference in gross export revenue to Australia in the declining gas, coal and a little bit of a decline in iron ore as a result of efficiency gains.

MAXINE McKEW: Yes, they're arresting figures, anyone want to comment on?

TANIA CONSTABLE: I would agree with you and I made the point in my presentation that we need to be very clear and careful about what the impact on Australia might be and be preparing to play our part. So we're not going to do a lot in Australia in terms of big projects, Gorgon is here for LNG, we may not see too much on coal, but we've got to be prepared for what might be coming at that international level and be playing our part.

We'll do more in storage in Australia, so when the costs do come down then we'll be ready for that. But I do agree, there is potential for stranded assets as it relates to, particularly coal in Australia. It's not something we want to see and that's why technologies such as carbon capture and storage, because there are not too many options right at the moment, need to be very clearly looked at. The costs need to come down in terms of the investments, the technological breakthroughs, but really very importantly around the world what needs to be addressed are those legislative, regulatory concerns. We have done extremely well in Australia. Other countries haven't done so well. So the United States and Europe in particular and the Asian countries need to address that before we're going to see some significant projects coming online around the world.

MAXINE McKEW: Does anyone want to look at that in a wider context though? Because what's just been said there has, if that is even remotely right and comes to pass, massive social and economic implications for the country in the kind of lifestyle we've all come to expect. And if you see that kind of reversal, again, where would you get the innovation and investment in all of the other things that we want to create, a prosperous future? I had to be catastrophizing here but, you know?

FIONA WILD: We spend a bit of time catastrophizing about these sorts of things in developing these scenarios, because you have to push the boundaries and you have to test. You have to make sure you've really thought through what the plausible and potentially the more implausible things could be.

So coming back from our perspective, when we look at all the current plausible scenarios we see that energy demand is going to continue to increase and it's because of growing populations, it's because of increasing urbanisation and that fossil fuels will remain a significant part of our energy mix for decades. The exact percentage may change, but current plausible scenarios show that fossil fuels are going to be around for a while. So then it leads you to the logical question of well, how on earth do

you continue to provide access to energy and also limit climate change? And it's a really, really tricky challenge, there is no obvious solution to this. We also don't know exactly how people are going to respond.

So I've talked a bit about the scenario planning process that we use, but I expect many others do the same thing. You've got to think through not just what's plausible, but also potential shock events. If there was an extremely rapid transition, would we still be resilient? Well, we've done that testing and we think we would be. Would Australia be resilient?

MAXINE McKEW: Yes. Oh good, I'm glad the question been asked.

AUDIENCE: Thank you to the panel, a wonderful series of presentations. One aspect that wasn't addressed by anybody and which is a stand out for me, because I have elements of a background in both resource development and also infrastructure, and that's the capital investment equation. When we're talking about new technologies, particularly risky technologies, CCS has the problem of finding suitable geologically stable reservoirs into which to put the CO_2; the new devices that Keith was talking about they start small, yes, and they get to demo stage and they get up and bigger and bigger. But when you ask a bank to debt fund the investments required for all of these technologies, they'll run a mile. They have historically and they'll continue to.

So are we not looking at a capital investment equation not just in Australia, but worldwide where, a bit like the origins of the nuclear industry in the 1950s and '60s, we're going to have governments step up and actually equity fund all of this if we are to meet the timescale that the 450 scenario seems to paint?

MAXINE McKEW: Interesting question, yes. Who wants to take tackle it, Keith?

KEITH LOVEGROVE: I don't think so, no. I think the world isn't actually short of capital per se, it's about certainty. Your point about banks looking for low risk is very well made and that comes to this talk about nth of a kind of plants. The role of government is to get enough out there so it's proven so that the banks know what the proposition is and know how to assess their risk, but if we had policies in place globally that were about meeting that 450 constraint I think you would find that the capital would be forthcoming. The private enterprise in the world would step up to the mark, that doesn't seem to be the limiting thing.

I mean, if you look at the growth of renewable electricity in Australia that accompanied the Renewable Energy Target, we're having an awful big problem at the moment politically because it was too successful. There was no problem meeting that target and the problem we have is the politics of retiring the old stuff. All of those things were built with private capital essentially, there was no government equity in any of those wind farms or anything else, it was a Government policy setting the policy to happen. It did happen because Denmark led the way and ironed all the bugs out of the wind turbines in decades before and Germany also, so somebody has helped get them up to the point where it is a reasonable investment proposition as long as the return's there.

MAXINE McKEW: Can I just come at that on a tangent though, if, as many say, the west is mired in a long period of low growth and, if you like, that's the new new and accompanying that of course is dramatically reduced business confidence, and this is the world we're living through now. Isn't that going to put a brake on investment in the kind of innovation you're all talking about?

FIONA WILD: I think it puts a brake on it, but I think it also highlights the importance of collaboration. So you can't expect one actor, one stakeholder to do it alone. So I think the importance is about –

MAXINE McKEW: But it will have to be led.

FIONA WILD: I think it's about finding those opportunities to leverage the investments that people are prepared to make. So you may need government support, you may need academics, you may need industry, you may need the investment community. You need to bring together groups of players who when they're together are more powerful than operating by themselves.

TANIA CONSTABLE: And I agree with that, I think what we're seeing in Australia is demand is such that we're not going to see too much more in terms of these major capital investments occurring here. So you look overseas, where is the demand occurring? It's occurring the non-OECD countries, in all of the Asian countries, all the BRICS, Brazil, Russia, India, China, South Africa. That's where we're seeing all of the demand coming from.

So the investment, there is plenty of capital there, it's actually making sure that the technologies that are required - and I've been talking about CCS - in terms of those big scale opportunities that the integration of those technologies are actually occurring quickly, and I think we'll see most of that starting to occur in China. It will be China that will make the major investments in technology such as carbon capture and storage and it's the integration of the capture technologies with the storage technologies, and once we see the first of a kind coming through then the nth of kind becomes so much cheaper and the banks will be forthcoming in terms of that additional capital.

AUDIENCE: Keith, can I ask you to just touch on ammonia and its role that it can play, renewably-generated ammonia, as both a source of fertilizer and as an energy carrier? And then can I ask Fiona, with BHP's commitment to potash and it's movement into fertilizers, have you looked at renewably-generated ammonia as a crossover that addresses your two main markets of energy and fertilizer?

KEITH LOVEGROVE: Okay, so when I was talking I did make the point that ammonia is a very large existing industry and it's about taking hydrogen and making it into NH_3, and the N basically comes form the atmosphere. I had a list of kind of options up there, so there's various ways we could send hydrogen overseas. Having it in a liquid is a great advantage. If we make it a hydrocarbon liquid then we've gotta get the carbon from somewhere and eventually at the point of use of the carbon's release. So if it's a closed cycle okay, but otherwise you're just delaying the release and maybe lessening the carbon intensity.

So ammonia has the advantage that you can literally burn it, you can put it in a gas turbine, you could crack it and get the hydrogen for a fuel cell if you wished, you can actually run internal combustion engines on ammonia. It's very interesting that there's a lot of research in these areas, but the point is when you do actually burn the ammonia fuel, however you do it, the nitrogen just goes straight back in the atmosphere which is 60% nitrogen already, so it makes a very nice closed loop. So I think that's one of the big pluses of ammonia. The smell is possibly its negative.

AUDIENCE: The question of capital, which you've all addressed, is already an issue because we've seen the World Bank removing funding approvals for coal-fired power plants globally, all kinds of retraction of capital, so-called green terrorists taking balance sheets etc. and, of course, hedge funds,

universities withdrawing their investment profiles from energy-exposed companies. Fiona, do you see that as a risk in your modelling?

FIONA WILD: It's absolutely a risk, yes, and we take that into consideration when we develop our scenarios and we spend a lot of time talking to our investors, talking to NGOs, about how we think about that risk and how we manage it internally. So it absolutely is a risk, but the scenario analysis that we do allows us to think through not only what you might call the more plausible scenarios but also those shock events, so a significant devaluation of fossil fuels, for example.

MAXINE McKEW: Thank you. That does bring us to time. I hope you feel that this has been an illuminating discussion tonight and could you please show your appreciation for our speakers, to Keith, Fiona and Tania. And my thanks to the Grattan Institute and the Melbourne Energy Institute for staging tonight's discussion. Could I just flag our next Energy Future seminar that will be in May and that will look at the subject of grid defection trends and associated issues, including electricity costs and energy poverty. So that is in May, so I guess if you check the Grattan website there'll be further details to come on that.

Thanks so much for your attendance this evening.

END OF RECORDING