Natural gas: part of the problem or part of the solution? - Melbourne

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In the last couple of weeks, the G7 countries have committed to decarbonisation of the global economy this century and the global gas industry has argued that natural gas can contribute to this objective in ways that coal cannot. Can clean burning gas be part of the solution but as a fossil fuel also be part of the problem? This Policy Pitch seminar discussed an issue of critical importance to Australia, shortly to become the world's biggest exporter of gas.

Speakers: Tony Wood, Energy Program Director, Grattan Institute
Tim O'Grady, Origin Energy
Anna Skarbek, ClimateWorks
Robert Clark, UNSW

ELISABETH KERDELHUÉ: Good evening, my name is Elizabeth Kerdelhué, I'm the Partnership's Manager here at the State Library of Victoria. It gives me great pleasure to welcome you to tonight's seminar which is held on the traditional lands of the Kulin nation. I wish to acknowledge them as the traditional owners. I would also like to pay my respects to their Elders and to the Elders of other communities who may be here this evening. I would like to extend a very warm welcome to tonight's speakers, Tony Wood, Tim O'Grady, Anna Skarbek and Professor Robert Clark, the Grattan Institute members and staff, and our corporate members and Friends of the Library.

The Policy Pitch provides a platform to generate conversation, debate and ideas on key public policy for our future. It brings to the library new audiences, professionals and public policy makers in the fields of law, health, environment, energy, politics and higher education. The State Library of Victoria is delighted to partner with the Grattan Institute to present this dynamic series. This is one of a broad range of programs offered by the State Library and our partners, if you'd like to know more I encourage you to pick up our "What's on" brochure or have a look at our website to keep abreast of our range of free community programs. I also encourage you to join the Friends of the Library or consider our corporate membership program if you work for a large organisation. If you are interested, please pick the brochure available in the foyer or speak to our library staff to find out more about the benefits of both programs.

Tonight's topic is natural gas. Gas is a major part of our energy mix and Australia benefits from rich natural deposits, however where we get our gas from, how we get it and what we do with it are hot topics of discussion and debate. Coal seam gas (CSG) mining in particular has met significant public opposition spearheaded by anti-CSG groups such as Lock the Gate. The pressure shows no sign of easing, yet we still need and burn gas, so where does that leave us? I'd like to thank the Grattan Institute's CO John Daley and his team for the great work that they put into this series and for not shying away from difficult policy issues. Tonight we will hear from four experts in the field of energy. Tony, Anna, Tim and Robert, we are all looking forward to hearing your views on natural gas and whether it is part of the solution or part of the problem.

I am pleased to now introduce Tony Wood, Energy Program Director at the Grattan Institute, who will introduce our guest speakers and lead the discussion. Tony has been Energy Director at Grattan since 2011 after 14 years at Origin Energy. From 2009 to 2014 he was also Program Director of

Clean Energy Projects at the Clinton Foundation advising governments in the Asia-Pacific region on effective deployment of large-scale low-emission energy technologies. He was also an advisor to the first Garnaut Climate Change Review. Please join me in welcoming Tony Wood.

TONY WOOD: Thank you Elisabeth and thank you to the State Library. It's one of the most valuable partnerships that Grattan Institute has and, as Elisabeth said, just about every month now Grattan holds a public forum about what we think are some interesting topics and it's really the response from people like yourselves who are here tonight that indicate whether or not these are topics that are of interest to a broader public. I guess at this time of the year, particularly in Melbourne given that about a third of all the gas that's sold domestically in Australia is sold in Victoria and we use a lot of gas for heating, we actually appreciate our gas central heating. I certainly know that I do, although I do appreciate that as I'm sitting here and my wife and pet dog are at home the gas heater's probably blasting away and my gas bill is ticking over almost as I speak. So we'll see what it looks like at the end of the quarter.

The thing that triggered our interest in this topic tonight, even though we've covered gas in some other ways, has been what I think is quite an interesting almost, I don't use the word "explosion" lightly in relation to gas, but a real increase in the intensity of debate around the role of gas. In particular, I noticed out of the World Gas Conference in Paris this year some comments that suggested that the gas industry was desperately keen to put on a white hat and ensure that the coal industry had the black hat, and that's an interesting development in terms of the way the fossil fuel industry is seeing itself. So what I wanted to do tonight, before I go to each of the other three speakers, is to frame what I think some of the issues are in relation to how we think about this, and our objective tonight is hopefully to provide you with a better understanding of the perspectives. I'm not sure that we'll come with a definitive answer, but hopefully it'll help you develop your own thoughts about how you see the role of gas into the future.

We have this evening Tim O'Grady, Anna Skarbek and Robert Clark, as Elisabeth said. Tim has had a long history in the energy industry particularly with Origin and speaks at a number of events and also is responsible for a lot of Origin's relationships with governments and policy. He has some interesting views about how a company like Origin sees the role of gas into the future, given that Origin is also involved in a large project in Queensland. Anna has been involved now for several years at ClimateWorks having previously spent some time in the UK involved in climate change finance and previously to that as an advisor in the Victorian Government. And Robert has been involved in I don't know how many things, every time I see Robert he's doing something different, but I got to know Robert quite well. He was an important contributor to a major piece of work that was done on the potential for unconventional gas in Australia, but also more recently he was the editor and absolutely the champion of a book which talks about the role of natural gas as a fuel for transport and that's a topic which we'll hear a bit more about this evening.

For me the thing that started some of this thinking, as I said, was that the G7 countries have committed to decarbonising this century. Now, I'm not sure that in 2100 that many of us, some of you might, certainly I think people like Robert and myself might not necessarily be having a debate about whether that turned out that way or not in 2100. But the interesting thing is that what we saw was for the first time major economies actually being much clearer about that direction and it almost in some ways doesn't matter what particular date, but there is clearly a direction and that's what I think is important in terms of establishing momentum in a particular direction.

Out of that World Gas Conference that I mentioned which happened shortly after that G7 meeting the global oil and gas companies started to mobilise very clearly around the importance of natural gas to the future of change in the way in which emissions are produced from fossil fuels in the world. But the difficulty is that according to the IEA (International Energy Agency) if we are to have a 50% probability of staying within the two degree limit on average global temperatures, that the global community has committed to and that decarbonisation target is part of, then the majority of the oil and gas and coal that we know about in the world cannot be burnt or certainly can't be burnt unless we come up with some pretty clever and much more cost effective technologies than we know about today to do something about the emissions. So the question then is what is the role of gas because many people would have seen gas as part of the solution.

Looking at a couple of numbers quickly, these charts come from the IEA's World Energy Outlook 2014 which was published in December and they released a very much more recent update on energy and climate change and the relationship between energy and climate change about a month ago. What this top chart shows is that if the world adopted the policies which have already been announced, the new policies to address climate change it shows what global emissions would be from the energy sector. And you can see the vertical axis here is 30, 40 billion gigatons of CO_2. Those of you who aren't familiar with gigatons, just shit loads will do in terms of the amount. It's a lot. The bottom line on that top left-hand chart shows what has to happen to global emissions from the energy sector if the world is to meet that two degree target and you can see the line bends over quite sharply starting in 2010 and continues downwards. Now, no real chart's ever actually followed those lines, but that's the projection of what would have to be achieved.

Just by way of comparison, the bottom chart shows what China will do if it meets the objective that the President announced last year in his joint announcement with President Obama, and that is that China is seeking to cap its absolute emissions, not just the intensity of its economy but its absolute emissions by 2030. And you can see there that that means going from the top line to the bottom line is a significant change for China, but the interesting thing about China is that they are already on a pathway to achieve that sort of target. And if there's one country in the world that takes targets seriously it's China.

Then on the right-hand side you can see there some of the commitments that have already been made and, of course, since the American and Chinese governments announced their broad objectives we've seen quite a few countries announce their specific commitments that they'll take forward to the Paris negotiation at the end of this year, part of the international negotiations that Australia currently is expected to announce the formal target that it will adopt some time in the middle of August. There is a Climate Change Authority recommendation, but there's also a Prime Minister's Taskforce which is expected to make its recommendations to Cabinet sometime in August and the Prime Minister indicated publically last week that he expects the party room to consider that recommendation and I would expect that would be announced subsequently.

So, what does this mean when you look at the impact of that sort of outlook on fossil fuels?

Firstly, it's not the major topic for tonight, but for coal it's a serious change. What it means is that global demand from coal starts to decrease in absolute terms from about 2020 and continues downwards, and you can see significantly what that means in the top left-hand corner with the bottom line there being that 450 scenario, 450 being the concentration of CO_2 equivalent in the atmosphere,

that would equate to a two degree scenario. And remember that's a 50% probability of achieving two degrees, not a certainty by any means.

Interestingly also in that scenario, coal only retains that share of the world's demand for fossil fuels if carbon capture and storage is adopted on the coal-fired power stations in the world that would be responsible for 80% of the electricity generated from those plants, around the world. And right now there's only one plant in the world that is equipped to do that, so there's an enormous challenge. More interestingly for tonight however is the bottom right-hand corner which shows what happens to global gas demand. In this case the change from the top line, the current policies to the new policies to the 450 scenario isn't as dramatic, but it certainly shows that the rate of growth in gas consumption and gas demand in the world is much less than it would be if the world did not adopt. So this is a big deal for countries like Australia I would suggest for the following reasons that I'll come to.

So in terms of the sort of things that the World Association's talked about, and Tim may pick up some of these, firstly, the point that is made is that when it's burnt natural gas produces about half the emissions of CO_2 and, as a result of that, the emission that are produced in the United States have been falling in recent times partly as a result of the development of the unconventional or shale gas industry. So that's obviously been significant in the way that's occurred. Secondly and I think particularly interestingly is that global energy companies are now formally accepting the need to reduce CO_2 emissions in a way that I don't think they ever have before and publically, and they're now calling for the governments of the world to adopt policies. And that's an important development.

Thirdly, the point that's made is that in many parts of the world it isn't just the CO_2 emissions from gas that are important, it's the other pollutants that come from coal-powered generation, particularly if any of you have been to China in the last couple of years you'll have seen how bad the pollution is there in many of their cities. Gas produces a lot less of those sort of pollutants and those pollutants have been a serious impact on public health for many, many years. Fourthly, gas is arguably amongst the fossil fuels the cleanest to operate as a backup to renewable energy, particularly when you've got variable solar and wind. Finally, and this is a topic that Anna will touch upon I suspect and Robert will certainly cover, and that is the role that gas will play in the power sector.

Then you've got the importance to Australia. Australia is a significant exporter of gas already, about 24 million tons a year of natural gas, and we are already a significant exporter and within the next few years we will be most likely the largest exporter of LNG (liquefied natural gas) in the world. And that 62 million tons a year, which reflects the expansion in Queensland, is about the sort of expansion we're also seeing in the United States out of some of the major facilities built there to supply natural gas into Asia. So clearly from an economic perspective Australia has a very significant interest in this game. From a climate perspective, and therefore gas as part of the problem, however you can look at it somewhat differently and that is that however you position it, gas is a fossil fuel. The burning of natural gas, whether it be in power stations or whether it be in our homes for cooking or heating, produces CO_2 and lots of it. Even if it's half the CO_2 that we get from burning coal, even if all the world's coal-fired power stations were converted to gas tomorrow, even then the reduction in total CO_2 emissions would be about 5 billion tons, the reduction, whereas we have to get down to 5 billion tons. So just converting to gas does not get us there.

At some point I think it's almost unarguable that in the next 20, 30, 40 years the use of gas will have to start falling. Now how quickly it falls to near zero depends upon a whole range of policy and political

issues which have yet to unfold, some of them there will also be technical issues associated with the role that gas can play. But as the head of the Queensland Resources Council said only quite recently, there is no future for coal and gas without carbon capture and storage technology, and carbon capture and storage technology remains problematic. That's a very strong statement from the resources sector itself.

Finally, an interesting question that's becoming more common is do we need gas as that source of energy when we're worried about the intermittency or the variability from wind and solar, or would we be better off spending all of our time rather than going down what might turn out to be a blind alley and developing what could end up being stranded assets, are we better off putting all of that effort into renewable energy that's not variable, such as tidal and geothermal energy? So there are I think some important questions around this. I'd like to raise those questions, leave them with you and then ask the other speakers to give you their perspectives of how they see the role of gas in the way the world's going to unfold.

After each of them have given you their perspectives, we'll have a short discussion amongst the panel and then we'll turn it over to you, the audience, for a Q&A. Thank you.

TIM O'GRADY: Thank you to the State Library, thank you Tony for hosting tonight and thank you everyone for attending and for your interests in the wonderful world of gas. It's a great question, is gas part of the problem or is gas part of the solution and, dare I say, some people may even pose a similar question about Origin Energy. No? It's entirely plausible and I suppose that's because really Origin Energy fundamentally began life as a gas company. Just to let you briefly know where we're going, we've got three business areas and priorities attached to those areas and I think it gives you an insight into where we see the world going as well.

We strive to be Australia's leader in energy markets and I think we've done that quite well. We're the largest energy retailer in Australia with 4.3 million customers and one of the largest electricity generators. We want to be a regionally significant player in natural gas and LNG export and to grow that business. We're currently one of the largest gas producers in Australia and with our export project at Gladstone close to commissioning we'll soon be a major exporter of LNG through that project as well. The third priority we have is a significant and growing presence in renewable energy in Australia and internationally as well. So they're our three platforms and some of the things we're doing in the third area include recently a project we're part of commissioned a large grid-scaled solar farm in Chile, that's about 160 megawatts, a very impressive project.

In Australia we're very proud of our zero upfront solar product that we launched recently because it breaks that barrier for a lot of people to take solar that you don't need to pay anything upfront, so that incredible success story of solar PV on rooftops continues to grow. We're also trialling battery storage and electric vehicle options as well, clearly they're going to be a big part of the future, and we continue to be the largest by far in pioneering green power. So we've got a pretty clear idea about which directions the future's going and we certainly see ourselves, Origin Energy, as a large part of the solution. But it's not about Origin Energy, it's about gas and I think the story with gas is very interesting. Tony mentioned a very important World Gas Congress meeting last month in Paris and Grant King, the Origin Managing Director, gave a keynote presentation there and I've just taken a few slides to make a few key points in my opening remarks. Tony alluded to this and I'm talking about the demand for gas, the use of gas globally.

It's not my numbers or the industry numbers, but really the credible international body here who looks at climate change scenarios is the IEA and they have an annual World Energy Outlook that they put out in various updates. The IEA is very pro finding solutions to climate change and meeting the UN's goal of limiting the temperature increase to two degrees, and Tony alluded to their scenarios last year. They gave an update also in May and it just continues the trend, which I think is very significant for this question and the May update has the same numbers as Tony's slides, they have the current policies. In this case the current policies include all the commitments that have been made leading up to the Climate Change Conference in Paris at the end of this year. So it includes America's target of reducing their emissions by 26% to 28% by 2025, it includes China's target of peaking their emissions by 2030 or sooner, and a lot of other countries made commitments as well.

Then they have a fourth scenario, and they've always done this and they call that "the 450 parts per million scenario" and that resolves to get to the target of 450 ppm. And that is not put into the scenarios as an achievable scenario in terms of the policies that they can see that are on the table, it's a forced outcome. So it includes things like an international carbon price of greater than $100 by 2030, it includes huge amounts of energy efficiency particularly in China, and it includes huge amounts of carbon capture and storage for coal and for gas. That's what they need to do to get to the outcome that we have. Then they have a bridging scenario which kind of says, "Okay, what can we do to do more to get closer to that outcome?" So I think they're quite good balanced scenarios, but the point is that under all these scenarios the use of gas increases in absolute terms from now every year out to 2040, the end of the scenarios. So under all of their credible scenarios world demand for gas increases a lot. Under their scenario which is an idealistic scenario, the 450 ppm scenario, the use of gas also increases.

So I think the facts from the IEA indicate that gas is a part of the solution today and, in fact, has a growing future. Now, this slide just shows the total trade in gas and that's divided into pipeline trade, which is going down a bit, and LNG trade, which is growing quite strongly. I suppose perhaps a more relevant question is, given this growth in demand for gas globally that we're looking at, what is Australia doing about it? And that's where this next slide is very interesting. The blue line is Australia and you can see that a few years ago we were a relatively small player in terms of export of LNG. We've had the offshore Western Australian projects for over 20 years now but we were relatively small, and most of the LNG development in recent years globally has happened in Australia and all of those projects, there are seven of them altogether, are all well-advanced, being commissioned or they will be commissioned over the next two years.

So the Australia-Pacific LNG project at Gladstone that Origin is a part of, is over 90% complete and we'll be commissioning its first train towards the end of the current calendar year and then the second train follows after that. And three of those seven projects are in fact together at Gladstone, so it's very exciting for the east coast of Australia that Gladstone's becoming an LNG trading hub of global proportions to go with the northwest shelf in Western Australia, which is well-established, and Darwin as well. And there are additional projects that are going onto the northwest shelf and onto Darwin as well. So, again, this is not something that is hypothetical, this is a decision that Australia has made and is close to moving to completion that that enormous growth in global demand for gas over that period, 2015 to 2020, a lot of it has been picked up by Australia.

A little bit about Australia's gas resources. Apologies, this is a bit of a complicated slide but it's using mainly international data and Australian Government data and it shows the gas reserves and then gas

production. For some reason they've done it in 2034/35, which is basically all of the existing projects and some other modest growth, but a few key things to point out. If you look at the blue circle on the far left, that's the reserves of gas, the gas resources in fact, and that's a very big number, 819 TcF, and then in 2034/35 the government's projecting that our annual consumption will be around 6.3 TcF. So it kind of reinforces a point which I think is becoming increasingly clear to many in our industry and keen observers, that Australia is not going to run out of coal, Australia is not going to run out of gas, and the same can be said for the world. In 2034/35 the government's projecting that about two-thirds of our gas will be exported and about a third of our gas will be used domestically.

Another couple of key changes in terms of the production of gas, some of you will know that some of the older basins where we produce the gas from, like offshore Victoria and the Cooper Basin, and the first exports, like in Western Australia, were conventional gas. A lot of the growth in recent years, which is in the yellow on the chart there on the map of Australia, has been in CSG, so natural gas which is contained in coal seams. Then a lot of the future reserves, if you look at the chart in the middle there at the bottom you can see the blue part which is roughly half of the future resources, is another type of unconventional gas, as it's so-called, which is natural gas that is contained in shale, like is produced in the US. So we have an enormous opportunity to continue to participate in gas development.

There are a couple of brief points about that. When we do produce gas here in Australia we increase emissions here in Australia, but when we export it to places like China the emissions in China and globally do decrease. That's one of the main reasons why a country like China is using more gas. It also has incredible advantages that it's very flexible, it's easily transportable, gas means you can have more renewables, gas gives you that backup for solar and for wind. When there have been issues, like the Fukushima earthquake in Japan, then they tend to turn to gas because they can increase their gas quite quickly. But also if you're going to use fossil fuel then gas does have around half the emissions of coal and, in fact, as we grow our gas here, Worley Parsons did a study and found for each one ton of emissions where we increase our emissions in Australia then if that gas is used in place of coal in coal-fired generation in China then global emissions go down by 4.3 tons. So gas also is part of the broader solution there.

To finish up, it is very exciting in terms of the opportunities from gas and what is happening with Australia on the verge of becoming the largest global exporter of LNG. And there's no doubt that gas is not the whole solution. we need all of these different technologies and fuels as part of the solution, but over the next 25, 30 years and more gas is certainly a growing and ongoing part of that solution and Australia, again, is in a good position with our high resources and our proximity to the growing Asian markets to continue also to be part of that solution. Thank you.

ANNA SKARBEK: Thank you very much, thanks Tim and Tony. Good evening everybody. I'm going to present to you this evening a short extract from some major research that ClimateWorks, my organisation, undertook with ANU and the CSIRO last year as part of an international project looking at the challenge that Tony has posed of how can we decarbonise our economy to stay within the emissions limits that the two degrees climate change goal require of us? I'll share with you the results of the scenarios that we looked at and the role that gas plays in those scenarios. The research is called Pathways to Deep Decarbonisation in 2050 and it's available on our website.

Certainly I think Tony has framed the challenge well and you mentioned that the G7 has committed to decarbonisation and it's not just the G7. Here in Australia the BCA (Australia's Business Council) and a number of other major peak bodies, the AIG (Australian Industry Group), the unions through the ACTU and the community sector through ACOS joined with the green groups just last month to issue a major statement to show that there was a common view around this issue. And in that statement they agreed that they acknowledged the two degrees goal, which is the United Nations' goal that all countries have committed to, and acknowledged that that goal means that all countries including Australia must reach net zero emissions. That's a real breakthrough I think to hear, firstly, the common translation of what does the science mean practically for our economy and also to see the common recognition across all of those groups that that's what it means for Australia.

The good news is when we studied this with others the answer is we can achieve net zero emissions in Australia and we can do that using technologies that are already invented. In answer to is the role of gas part of the problem or part of the solution, my answer to that question would be it's both. The role of gas indeed will remain part of our energy mix, but it will shift from the way you think of it today. And I'll explain shortly a framework to help you think that through but in short, given that we are heading now into a future where we must potentially reach net zero emissions, then the ability to emit any greenhouse gas emissions, CO_2 and the greenhouse gas emissions, becomes a very finite and scarce resource, the ability to emit. So when you're asking yourself, you have a product, a service or an energy source such as gas then the question becomes does it have a lower emissions substitute and, if so, we must use the lower emissions one because, as Tony mentioned, the numbers get so tight in getting to zero that wherever you can substitute you should.

So when we think about how we use gas, and I'll step through this in my presentation, we use gas for electricity. Is there a lower emissions substitute? Yes, there is, in renewables particularly. We also can use gas in transport. At the moment we mostly use diesel and petrol in transport. Is there a lower emissions substitute for that form of energy? Yes, there is and it's gas. We also use gas in manufacturing, not just for electricity but as a feed stock. Is there a lower emissions substitute for the way that gas is used in some of the projects that go to building a lot of the infrastructure that we utilise? In some cases the answer is no and so there we accept that gas may be the most appropriate fuel source, but it carries emissions with it so we must sequester those emissions, either with carbon capture and storage technology or planting trees that absorb what emits.

So let me share with you the results of the research. This first chart here is from the IPCC scientists group and particularly a Melbourne university-based scientist, who shared this with the IPCC group and it has now become a really core part of our understanding of this concept of the carbon budget. What's happened is the scientists have worked out what is the chance of getting to two degrees and how much greenhouse gas emissions can we emit into the atmosphere until we will have warmed the planet beyond that two degrees limit. That maths has been done and it's illustrated for you here with this orange chart. Globally the orange shape here represents the total volume of greenhouse gas emissions that we can emit into the atmosphere until the atmosphere has so many emissions in it that the warming will exceed the two degrees limit. The two degrees limit has been agreed on by all the countries in the United Nations and it's recognised by the scientists as the dangerous tipping point. We're already in warming of almost one degree, about 0.8 roughly, and we're experiencing some of the impacts of that, but the scientists have advised policymakers and it's been accepted that the impacts are not linear beyond two and it's considered a dangerous level. So that's the agreed goal, the maths has now been calculated, the orange shape represents the total volume.

Given it's a mathematical shape you can see that we can change that shape beyond the vertical dotted line which is the point in time, which is today. So that chart there represents time horizontally since the Industrial Revolution and you'll see in the last 50 years emissions have risen and you know that. The vertical line is the point of today and the orange represents how much we can continue to emit. You see that if we allow emissions to keep rising, the paler orange, then the orange triangle comes down more steeply. If we manage to turn emissions around sooner the red bit of the wedge at the end represents the extra decade we would allow ourselves to continue emitting until we've reached zero, until we reach the point where no new emissions can enter the atmosphere in any one year without us netting out the same amount.

And with some of those technologies where we haven't developed a substitute yet or not a cost effective one for the use of fossil fuels, that extra decade could be hugely valuable. It's a really helpful way to think about does the next 10 years matter? Yes, it does because the emissions that go into the atmosphere stay there and once they're there they contribute to the time at which we hit that two degrees limit. So if we can avoid putting them there as quickly then we've got longer where we could still be emitting and stay under that limit. So hopefully that helps set the context for the rest of this modelling which has been, as Tim referred to, the scenario to solve for this emissions outcome. So the analysis that we undertook was to look at what if the world agrees to its goal, which it has said it will do, and therefore enacts policies to achieve it, what would our economy look like?

Firstly, we drew on the Climate Change Authority's advice which is what's Australia's share of that orange triangle? Unsurprisingly, it's roughly a triangle. There are a number of different ways to calculate our share. They all come out at a broadly similar number and so treating it in a straight line you see that, like the rest of the world, we must turn our emissions around and head them gradually to zero. We don't have to head gradually to zero, we could choose to just keep emitting at our current level, so it could look more like a square, but anyone can do the maths, it's a finite shape. So if we keep emitting at today's level we'll have to get to a net zero level much, much faster, hence why it's generally drawn as a straight line.

Our research showed that we can turn our emissions around while continuing to grow the economy at the rate that it has grown. So the red line there is the economic growth that was the result of the scenario that we ran, which was a scenario where all the world stays within the two degrees. So there is less use of fossil fuels, there are fewer customers for our coal exports, but there are a lot of customers for our uranium, our lithium and other products that we mine, as well as our services and the rest of the economy that we already provide. On the right-hand side you'll see the red line represents our emissions and what the emissions pathway might look like if we use the technologies available to us to gradually reduce our emissions over the next 30 years to zero. You'll see that the grey represents fuel combustion, so that's the burning of fossil fuels, and the blue is other emissions, and you'll see that at 2050 the red line is at zero but emissions are not at zero. But in this modelling it was actually cheaper for Australia to plant more trees and absorb emissions and allow us to keep producing emissions, particularly from gas and from some uses of diesel, for example in jets where we can't entirely run aviation on biofuels, and there are continued emissions from agriculture. The good news for a large country like Australia is we can still reach net zero emissions even when we are actually emitting provided we harness our land mass, which turns out to have fantastic other environmental benefits as well when done appropriately.

How do we do this? In short, it rests on four pillars, three of which involve the energy sector and the fourth is sequestration. As Tim has already mentioned, the energy sector pillars are ambitious energy efficiency, so that is thinking about all the equipment that uses energy and make it much more efficient with technology advancements that are already underway. So that is whenever we upgrade equipment, appliances, cars, trucks, vehicles, airplanes, all of our energy-using equipment, manufacturing equipment, mining equipment, whenever it is upgraded it is upgraded to best in class performance so that it can be as efficient as possible, because the thing about substitutes for fossil fuels, the least carbon-intensive fuel we have is that which we don't use. So as a start, let's harness the power of technology that's already available to us to be so much more efficient with the energy that we currently use.

Step two is focusing on electricity because it's the one where we know we can get to zero emissions already, largely through renewables but also could be through nuclear or could be through carbon capture and storage. We modelled three different scenarios which I'll share with you. When you have reached zero emissions electricity, which we can do, greening the grid as some would call it, through renewables and/or CCS and nuclear, you then switch to that zero emissions electricity wherever possible. And this is where we'll see some switch away from gas. If we're currently using gas for heating and cooking and we could instead switch to an electricity appliance and run the electricity off a green grid then we should because thinking about that orange triangle, the total emissions that we can produce becomes a finite number and wherever we can avoid them we must. There are some opportunities though, as I mentioned, where we can't switch to electricity. Very large big double trucks can't run on batteries yet like a Tesla car can, but there what we can do is think about gas as being a lower emissions technology than the existing diesel fuels that are used. Similarly in ships which use diesel, they could switch to gas.

So looking everywhere, can we do this in a less emission intensive way and what we'll see is in electricity we shift away from gas and in transport we shift towards it because we're using heavier and more intensive fuels there, in short. We can also switch to biofuels and bioenergy and that also holds a lot of promise in Australia. Finally, as I mentioned, we're not able to eliminate every source of emissions under current invented technologies, so the fourth pillar is to sequester the rest. Sequester means either absorb through trees which can absorb the CO_2 out of the atmosphere, or capture through equipment, such as carbon capture and storage, on industrial equipment or power plants that can actually catch the emissions before they enter the atmosphere and then bury them underground using technology that's well proven, but is not considered commercial of about 10 more years, which was the timeframe we used for this research.

So the results of these scenarios were when we solved for staying within the two degrees budget, which means reducing our emissions down to net zero by the middle of this century, what we find is in the built environment on the left we can switch to basically entirely electricity-run buildings and eliminate fossil fuel emissions from our buildings. In transport what you'll see is we can't switch entirely to electricity and, in particular, for cars we can, but for freight and aviation we haven't yet got the technology to allow us to do that. So on the right-hand side, I haven't shown the cars graph where we can get to a much lower emissions profile, but on the freight and aviation chart what you'll see is we can use a little bit of electricity in what we consider smaller trucks, the green, being bioenergy, is the opportunity to use biofuels for aviation and jet fuel.

When the Garnaut Review, as you would know Tony, first studied this in 2008 it was considered not possible to fly a plane on bioenergy so it was ruled out, it wasn't commercially feasible. But in 2012 a fully bioenergy powered flight on Qantas flew from Hobart to Melbourne and others have done since. So our modelling with CSIRO has estimated that by 2050 half of all aviation fuel could be bioenergy. Then you see the light grey wedge that grows is the shift towards gas and the dark grey, being oil, is where the shift comes from and that's for larger freight and aviation, particularly larger trucks and ships. This chart here summarises all the sectors and in particular what happens to the role of gas when we look at what is the energy source under this scenario. Again, it's a scenario in what we call the solving for the two degrees limit, so there's an assumption that our emissions are capped. Whether that's an emissions trading scheme or a set of rules and regulations that stipulate certain technology performances, it could be any set of policies, but the effect of that is the emissions become priced in some way, either ruled out and banned or priced through an emissions trading scheme or any other set of policies.

We weren't specific about what the policies were, but the price effect makes its way through the modelling so that the equipment that's lower emissions becomes more attractive. We then allowed that to run through the model and let the technology race determine the outcome. And this chart here shows that we'll continue to use gas in particularly mining and manufacturing and we'll see an increase in road transport and a decrease in buildings. The increase in gas use in mining and manufacturing is probably less than what you see under the business as usual because growth in those sectors, so the demand for more fuel, is offset by the use of more efficient technologies and fuel-switching away from fossil fuels to bioenergy where possible.

So overall, what we see is primary use of gas would fall because largely the use of gas really shrinks and almost disappears from electricity, but final use increases because we see more gas being used, particularly in transport and slightly more in mining and manufacturing. To the electricity story, these three scenarios were the three that CSIRO modelled for us, the first being a scenario where we try to be 100% renewable by 2050. Technologically it's completely plausible to do that. The second scenario is we assume that CCS enters the market in about 2025 and competes with renewables, but nuclear is not allowed. And in the third scenario nuclear is allowed but CCS isn't, just to keep it simple. Of course, there could be a fourth scenario which is a combination. Very interestingly we found that all three scenarios had a similar total cost.

What you find is the cause of that is that for about two-thirds of our electricity system renewables can do the job even though it's intermittent without investing in largescale back up, whether that's large batteries alongside solar and wind farms or geothermal wave and tidal-type sources. But for that last quarter to a third of the mix you do need the steadier power source. And what you see is in the first the dark green bar, the last third, is what we call other renewables, that's anything other than solar and wind that we already know about and that's mostly geothermal, wave and tidal, the newer stuff which is more expense than the already operational solar. In the second two scenarios that dark green bar is a lot smaller and instead CCS or nuclear provides that share. So what we find is that on costs, when we're pricing emissions nuclear and CCS cost about the same as what those less developed baseload renewables would, say wave and tidal and geothermal. That's last year's estimates of what costs would be in the 2040s when we would need these. You can see in 2030 we can largely power ourselves without much of what you call the new baseload renewables and it's in the 2040s that we need this. So we can't be sure of exactly what the costs will be, but on today's estimates they were roughly similar.

One unusual finding you might be surprised at, why is the use of electricity rising so much when we're in a world where we think we've actually flattened our electricity use? It's true that we have at the moment, we've become more efficient with our electricity use and we've seen some industrial slowdown recently post the GFC. The reason it rises so much is because if you think about the four pillars, we switch to electricity wherever we can in order to avoid emissions from other fossil fuels. That means all of the car fleet in the 2040s and 2050s is electric cars and hybrids and that's running off a green grid, and wherever industry and manufacturing might be using gas, say, for heating and they could instead use electricity and they can upgrade their equipment to use electricity instead of gas, they do. That demand is what you see in the rising bars in the 2040s and 2050s.

To draw it all together, a lot of people ask is that really possible, could that world ever eventuate? I like to reflect on how long do we have between now and 2050, which is when the science says we must have reached that net zero point or we will exceed the dangerous two degrees temperature increase. The time from now to 2050 is the same time as from the end of the Great Depression to the man on the moon and you can imagine a lot of industry has had a tough four years here in Australia at the moment and in 1933 you would have thought you'd had a tough four years. And if I'd said it's going to be completely possible to walk in the moon in about 35 years from now you probably would have not believed me. And yet it happened and back then in 1933 they hadn't invited the rocket ship that took Neil Armstrong there, but today we have already invented all of the technology that went into the model that CSIRO used for our research.

And similarly you can see already in the 35 years looking backwards from today how fast solar panel costs have fallen. Solar panels cost less than 10% now than what they did 30 years ago and half of what they did less than 10 years ago. You know less than 20 years ago none of us had email addresses and it was less than 10 years ago that we first got a smartphone, and now you can control your entire home energy system on your smartphone. So I'm fairly confident that the technological development will continue to help us out here. It's also interesting reflecting on the CSG story, it was less than 15 years ago, when I was a young banker at Macquarie Bank in the energy team, and I was sent up to near Gladstone where Tim was talking about, this time to sell a coal mine, we weren't looking at gas at that point. We were doing a due diligence, valuing all the parts of the mine and the future revenue streams, and there were CSG assets at that mine, one of the large multinational miners. And the banking team that I was in was advised by the owner of the mine, "Put a zero value on that, put a zero value on the CSG".

Less than 15 years ago no-one was talking about it. I'll leave you with it to ponder.

ROBERT CLARK: Thank you very much. It's very nice to be here and Tony's asked me to focus on one particular topic and I'm going to stick to the script, and that is to talk about transport fuels and the role of gas in that. A little while ago with Tony and other authors shown here we wrote a book on this subject, it's called *Transport Fuels from Australia's Gas Resources* and there are some 10 chapters that cover everything from strategy through to regulation, and I'm just going to make a bit of a summary of that in the next few minutes.

I'm going to start by saying the story for transport is not all about emissions, it's also about energy security, and coming from a defence background that's an important subject for all Australians. So if we look at our dependence on oil across all of our sectors what you'll notice is that the biggest dependence is in the transport sector. If you then go into the transport sector and show which is the

part of the transport sector that most use oil, it's road transport by a country mile. So at that stage we delved into the rather dry world of the ABS (Australian Bureau of Statistics) because from my background I need to examine the facts and I need to advise government and the advice has to be actionable, so that's where I'm heading in this talk.

This is a summary of the vehicles on Australian roads, all of them. There are 16.5 million vehicles on Australian roads and about 3 million of those vehicles are freight. If you look at how much freight is carried it's about 194 billion ton kilometres per year. So then you go into freight and you say what is actually doing the heavy lifting in the freight sector and you break it up into light commercial vehicles, rigid trucks and articulated trucks. What you find is that of those 194 billion ton kilometres, three-quarters of that is carried by this very lowly number of 87,000 articulated trucks which is a finite target. So out of 16 million vehicles you get down to 87,000 heavy trucks that are doing the heavy lifting and that's our most critical part of our freight supply chain that is oil-dependent.

So you say okay, how much fuel do they use? Well, these 87,000 trucks use just over 4 billion tons of diesel fuel, mainly imported oil, per annum and if we had to replace that with, let's say, LNG from Australian gas, this is where the energy security argument comes in, how much would we need? Well, we'd need 7 billion litres of LNG per annum and that corresponds to 3 million tons per annum of LNG. Just to give that a reference point, you saw from Tim the Gladstone's facilities, there are 3 x 8 million ton per annum facilities there giving you a total of 24 million tons per annum. So we're talking one eighth of that would fuel all of Australia's critical freight that's carrying three-quarters of our freight. So is this a doable task? Well it seems to be to us.

Then you say how much gas would you need to supply to liquefy that? And it turns out that it would be about 0.15 trillion cubic feet of gas per annum. To give you a reference point, how much gas does the whole of the eastern coast of Australia use? About 0.7. So we need a fair amount of extra gas to do this. Where will it come from and at what price? I have a private view there, I think deep shale gas, deep tight gas in the Cooper Basin is a very good starting point, but that's another story, I won't get into that in this talk. But we have plenty of gas, as you've seen from Tim's talk, and when the price goes to about $7 a gigajoule that will become economic. Then you say okay, if you're going to get this from shale gas how many shale gas wells will you need to fuel all of Australia's trucks carrying this freight? The answer is about 300. That's not a lot. You're hearing thousands of CSG wells in the export trade. So this is a very eminently doable, solvable solution for Australia.

So where are all these trucks going? Mainly all the heavy lifting is happening on the eastern seaboard between Brisbane, Sydney and Melbourne. These are old statistics but there aren't any more recent statistics than these - that's another plug for the ABS to be funded a little more on these subjects - but you see a lot in the press about the green highway and you heard a lot about this from Shell in particular and the long haul trucks that go between Sydney and Melbourne and we've heard about refuelling stations, but the interesting thing that we found in the study is they actually don't stop. They fill up and they go from one place to the other and they don't actually need to stop en route. In fact, there are a whole bunch of reasons associated with pay scales that are driving that.

But actually just in these metropolitan areas there's a lot of freight haulage going on and so we went into the statistics a little bit more and we said okay, of this 182 billion ton kilometres per year of road freight, how much is going on around the cities? And it's a fair amount actually and this is sort of back to base, out and back in our tunnels, and I see them every day in Sydney coming out of Port Botany,

but also out of Port Melbourne and Port Brisbane. So when I looked further into this it turned out that 80% of our road freight is transported over distances of less than 100 kilometres. So the message there is the long haul freight between Sydney and Melbourne and Sydney and Brisbane is important, but actually the freight going around those metropolitan hubs is arguably the place to start.

What does it look like? Just to give you a feel, this is a small micro-plant in Tasmania for the logging trucks, and anything to do with logging believe me is a rat's nest of intrigue, so we won't go there. But just in terms of its fuel here we've got a 50 ton per day plant, this is an LNG plant, then the fuel is transported from that plant to five refuelling stations, this is an 80,000 litre storage tank, each of the five have got these. At these refuelling stations you have a normal pump and into this 450 litre tank of a truck goes the LNG at a rate of 150 litres a minute, so it takes three minutes to fill just like a normal diesel truck. The LNG can be used by modifying a normal diesel engine. There's a whole argument about should we use high density CNG or CMG, I'm just going to finesse over that in this talk, I can come back to that in question time, and just focus on LNG which has got a higher energy density and is more appropriate for heavy road freight.

So the story there is wouldn't it be good to get off Middle East imported oil and to get onto Australian gas, that's the energy security part. Can we do it? Yes, of course we can do it, but it's the economics of it and it hasn't happened and I want to give you an insight into why it hasn't happened and what it might take to make it happen, which is all in the book. But I'll just touch on emissions. If you do the number of well-to-tank and tank-to-wheels and come up with well-to-wheel emissions there are reductions. These numbers are US numbers. Actually the figures more generally are 16% to 23% more reductions in greenhouse emissions in lifecycle, that's right from extracting gas including all the fugitive emissions right through to filling up the tanker etc. So yes, it's greener. Less well-known is it's quieter, about 50% quieter, so think about trucks in tunnels that you've sat next to, and that's because the way that the gas burns in a natural gas engine is a less violent process.

What about the particulate emissions? Well, I'm sanguine on this point, people will tell you that natural gas trucks will give you up to 80% less emissions, but quite frankly the Australian design rules are now getting so tight on our normal trucks that that's getting a lot better and yes, the natural gas trucks will be better, but how much better is not really the issue. I think it's the greenhouse gas that's the issue and the energy security argument. This is a very complicated chart, but what I want to point out is the economics of it. There are two factors that are involved, the first is if I own the truck and somebody says to me, "We want you to go to gas" the truck's going to cost me a little bit more and a little bit more is $35,000, $70,000, $100,000, it varies depending on which truck you choose. But the cost of the fuel is cheaper and over here it can be how much per gallon or how many cents per litre, in Australia it's about 35 cents a litre cheaper, and how many miles do I travel or how many kilometres do I travel, what's my fuel efficiency? And what I want to know as a truck owner who leases this truck for five years is if I don't get my money back on this within one or two years I'm not even going to go there. So the regulations have got to be that the fuel's got to be cheap enough and giving vehicle rebates so that they can get that vehicle difference down to make it economic to repay that truck over one or two years. That's where the government regulatory hands-on believers would come in to make that happen.

The other side of the story is if I'm now the fuel supplier building that LNG factory, I've got to say I'm not going to put all that money into LNG for transport unless all those truckies convert their natural gas engines and go for that payback period. So there's this chicken and egg situation that arises.

That's why it hasn't happened. There are too many people in the loop that all have to be coordinated and the market is not driving that. Arguably the market has sort of failed in that sense. But if you look at the technology that's around now, the cost of an LNG plant is about $1,000 per ton per annum. If I come back to Port Botany, where there are only four big truck companies, so you can do a deal, as it were, and these are the trucks in the Sydney metropolitan area, in our tunnels, so we want quieter trucks, greener trucks, indeed, more modern trucks with the Truck Industry Plan, what is required out there? And what's required is you could do about half of those trucks by putting in a 50,000 ton per annum plant. Now that's $50 million. Is $50 million a big number in Australia? I don't think so, but to drive that there's got to be some coordination between government, industry and some understanding with the Australian public.

In summary, replacing diesel with LNG as a transport fuel for heavy articulated trucks will give us a significant energy security. Let me just say one thing about energy security. I'm not talking about the interdiction of our sea-lanes by a foreign threat. What I'm talking about is a mass disruption in the Middle East region, which is a bit unstable as we know, you've seen what's going out there in the world news, of the supply itself. You'll hear about, "Oh, we've got diversity of supply channels" well yes, but 54% of it comes from Singapore and it comes through the Straits and so on and so forth. How much supply have we got? We're not compliant with our IEA 90 days holding of supply. We're meant to hold 90 days of our daily use from the previous year. If you look at the numbers depending on which numbers you look at, this is on the NRMA website, some of these holdings get down to about 25 days and in fact I've heard some slightly scary stories about that. So there really is a problem here that has not been addressed by governments. Not this particular government, by every government.

Payback period has got to be less than two years so we've got to get on the regulatory levers. We need to be building LNG plants that do our trucks basically. There are really no technology issues, all the engines, LNG plant etc., GE now makes these modular plants maintained etc. It's not the only company. There are emissions, there are noise reductions, but it's still below the line. Basically the big recommendations that we made was that there needs to be a compact between government and industry to convene a taskforce of supply chain stakeholders and that taskforce really needs to determine whether there's a case for intervention by regulation and government investment, is that appropriate? And this is like an insurance policy on our energy security as well as reaping this side benefit of emissions. Don't look so much in my opinion at the long haul Melbourne, Sydney, Brisbane route, just get it right at the ends so if you've got something going on in Port Melbourne and something going on in Port Botany for the metropolitan hubs, of course, they can go from A to B and they probably won't stop. If we're going to have 87,000 natural gas trucks in the future let's make sure that they're made in Australia. Thank you.

TONY WOOD: Okay, you've had very broad comments and very specific comments. Together the four of us have used up the time we were going to use for our own conversation. We often in these events find we run out of time for Q&A from the audience, so I think we might start with Q&A from the audience. I've got a couple of questions that were submitted to us online. Rather than go to those, which I'm more than happy to do so we won't offend the people we put them in, but why don't we start with any questions from the audience and we can go to our pre-submitted ones after we've done that.

AUDIENCE: My question is directed to Tony in relation to CSG and the emission intensity of CSG. You talked about how LNG is 50% less emission-intensive than coal. I understand that there are

some emissions in the extraction process for gas. I'd just like your thoughts on that and also the outlook for CSG in Australia.

TONY WOOD: I think both Tim and Anna also referred to some of their history of CSG. There are two issues I think with CSG, one is the fugitive emissions or the emissions that are produced in two ways. One is in the actual extraction of the gas in the first place, and that's what's called fugitive emissions and it results in the emissions of methane. They can be burned to produce CO^2 but of course, again, you've got emissions problems, so there's that question.

So the issue is to what extent in a well-regulated efficient CSG operation do you end up with fugitive emissions, because obviously it's in the interests of the commercial organisation to reduce that because obviously they're wasting a product they'd otherwise make money out of and, secondly, you have got the environmental impact because if there are emissions they need to be taken into account in the full lifecycle emissions of the CSG. The second issue of course is that in liquefying that gas for LNG and then export, if that's what has to be done before it then gets subsequently combusted in another part of the world, there's obviously energy used in the liquefaction of the gas and, depending on what the source of that energy is, you may also have emissions in that part of the cycle as well.

I think there is certainly some evidence I some parts of the world in early stages of the industry when the industry hasn't been well-regulated, when there wasn't a concern necessarily about fugitive emissions, that they've been high enough to be of a concern to such an extent that some people would say that when you take into account the full lifecycle of emissions gas doesn't actually meet up to its own claims that it's cleaner than coal. I think there's evidence now that suggests that, provided the industry is well-regulated, provided we do have regulators to keep on top of that and the operators operate the way they should, then they get much closer to the claims.

Tim, you may want to comment on that as well from your own knowledge as an operator.

TIM O'GRADY: Yes, a couple of points to add. We do report on the emissions from the CSG wells and have done for some time under the government's national greenhouse reporting scheme. It does use some American factors which are not necessarily applicable in Australia. But increasingly we measure more of our emissions, the CSIRO are doing some studies and it does find that those emissions come in at about or lower than the American factors that we use. I think it can be a bit of a distraction. There are some studies, there was a famous one Howarth from Cornell University a few years ago, and because, as many of you would know, methane is a much more greenhouse-intensive gas than CO_2, and he assumed quite extreme leakage rates, like old Russian pipelines, and came out with gas emissions being very high.

But I think, whether it be used in Australia and whether it be CSG or conventional gas or whether it's export, you've got a lot of energy into the liquefaction. When you do use those lifecycle costs, gas in replacing power generation is around a half here or a bit less and it's around a half overseas as well, and I think that really is the key frame. Obviously over time we need to get to zero, but if you want to build a new power station or if you want to reduce carbon emissions, then coal's up there at a certain level, gas is around half and obviously renewables are close to zero.

AUDIENCE: Robert, the table that you presented did not include LPG and I appreciate that you're working on natural gas but, nevertheless, in the suburban and distribution of goods LPG would be far

more important than natural gas is going to be. And the emissions from LPG are very, very good whereas the emissions from natural gas are a cause for concern, particularly aldehydes. I'm wondering what you think in respect of those emissions?

The other thing is that natural gas is very expensive to liquefy the way they do it at the moment. There is better technology not being applied, but the cost of the one in Perth I think was $132 million, and that's extraordinary, and the one in Tasmania has gone very badly.

ROBERT CLARK: Thank you for that comment. LPG obviously is an interesting fuel and has been used in our taxi fleets, for example, and people would be aware of this. The comment I would have on LPG, I think it's got the same energy density as LNG so there's not an issue there. Just to clarify for everybody the "P" in LPG. Most people will think because it's got a petroleum in it that it's actually an oil-based product and therefore we've got another energy security issue here. That's not really true either because about 80% of our LPG comes from our wet gas, but the point being that the fraction of our gas that is wet gas is actually quite small.

So if we're looking for volume we have an issue, particularly if you're going to really expand this out, as I pointed out, how much gas we'll need to fuel all of our trucks. I think there's a volume issue there and I also think if you did the economics of it the economics of LNG is becoming very competitive, particularly with these small modular plants that have been developed in the US as a result of the shale gas revolution. But your point's well-made and in all of these studies you have to do comparisons between these, but I think LNG will come out ahead of all that on the basis of volume, economics and so on.

AUDIENCE: This one's a little bit from left field, but I was wondering what role rail has to play in transport and why it is that we're focusing on trucks and continuing to use that technology instead of other infrastructure?

ROBERT CLARK: Rail's interesting for freight and in our transport committee that's advising the government at the moment rail for freight and particularly inland rail for freight is being looked at. The issue with rail is that rail just goes to a rail head and you've then got distribution issues. So I think the mixture's important, but I think in Australia road freight is always going to be extremely important. In terms of getting off our dependence on the electrification of rail and so on is interesting, then it gets down to the point of how do we produce the electricity, are we producing it in a green way or are we still producing it from coal if you're getting into an emissions argument.

So I think road freight is really the thing that we have to be concerned about, that's not to say that rail freight is not important, it is, but it's the distribution from there to everywhere else that the freight has to go that then goes onto trucks basically.

TONY WOOD: I may not look it, but I used to be a trucker once and the issue for the road freight, as Robert said, is quite interesting. There was a view probably 20 years ago that Australia should really move from road to rail for a lot of our transport, but it turns out that an awful lot of the distribution role that Robert's talking about actually is much more local than that. Secondly, even more so in recent times with the emergence of the internet as a way we buy stuff, and so a lot of short haul transport is what dominates the freight rather than the long haul and the extra problem of distributing the stuff once you get to the other end means that it turns out to be very uneconomic in that sense.

There have been trials for LNG for rail and there has been some success in that context, but I'd have to say that at the moment Robert's numbers would suggest that overwhelmingly if we're going to have a major impact on transport and the stuff that isn't going to be going electric, that Anna was talking about, then the LNG for road is more likely to make a bigger impact on the challenge that we have ahead of us.

ANNA SKARBEK: We also looked at rail in the decarbonisation research and it was particularly helpful in slowing the growth in demand for transport more generally, particularly short haul flights where in fact there it a passenger focus more than the freight that made a big difference there, along with an increasing trend of the use of videoconferencing, for example. So the rate of increase in flights that we're taking slows down in the 30 years modelling exercise that we looked at. So rail is absolutely an integral part of making sure our economy has the least emissions possible, but we came across the same issue that there's a lot of road freight still required.

TONY WOOD: I've got a couple of questions that were already submitted and one I think might challenge one Anna's point just to understand it better. Anna, I think you said that the modelling you've done indicated that we can achieve the decarbonisation that's necessary and maintain economic growth. Is that without any reduction in economic growth? The Garnaut stuff that I was involved with said that there would be an impact, relatively small, on GDP over the next 30 or 40 years, but that would be more than offset by the benefit of avoided climate change in the future. But yours seemed to be suggesting that it's even better than that, that we can maintain economic growth as a result of decarbonisation without any impact?

ANNA SKARBEK: Not without any. We'd be consistent with Garnaut. The reason we can say maintaining economic growth at the average of what it's been over the last five years is because economic growth jumps around quite a lot. If you're interested in the numbers, the difference is that on average the economic growth rate in our scenarios was 2.4% per annum real, and in a scenario where you assume you do nothing to reduce emissions you can reach 2.6%.

What that means in reality is in 2050 our economy is more than double the size that it is now and we looked at how much slower would our economic growth be if we didn't do this decarbonisation. And what we identified was you would reach the same increase that economy, that's more than double the size of today's, in 2048 instead of in 2050.

Now we know models can't be that perfect and we know even Treasury often doesn't get the Australian economy prediction across the four years. That's the level of error margin that the action on climate change costs you and we found that we were unable to value a lot of the benefits. So it's a very conservative assessment. We've been very public with the data and said yes, we admit there's possibly a two year delay in reaching a point of massive economic growth in 2050 but we didn't take into account improve health benefits, improved productivity or wellbeing benefits, not just trucks are quieter, cars are quieter when you go electric.

There are a vast number of other benefits, not least of which are the avoided climate change benefits which, I'm sad to say, have still not been able to be easily put into an economic model in the 2050 timeframe. So we weren't able to say in that 2.6% growth where you don't do anything to reduce emissions, that scenario is also the scenario where there's no impact on the economy from increased temperature. And we know already that that impact will be an increase in natural disasters, in longer

heatwaves, in greater health costs and the risks of perhaps insect-borne diseases moving further south. None of that's costed in the scenario where you hit the economic growth in 2048 instead of hitting it in 2050 in our scenario.

TONY WOOD: Yes, the economic benefits of avoided climate change. The other one which I think is interesting is when you look at the export numbers there was a piece some of you may have seen in the Saturday paper recently that talked a lot about the discussion last week in relation to the Clean Energy Finance Corporation. And whether you talk about the specifics of that organisation, but a perception that there was a consistency of criticism of renewable energy and the argument being put forward was that this was a big threat. The reason that the government's doing this is of course they've got friends in the coal industry.

I think an interesting question for me that emerges from some of this discussion is the challenge to the coal industry and the gas industry isn't domestic, it's international. You can see what's going to happen potentially in switching our energy, as Anna said, and if it goes the way it does we still use gas as a key feed stock, we use gas for transport. But the real interesting question is if those numbers that I put up before are right then the impact for Australia's exports become very significant indeed and if this was a business you'd think you'd have a strategy for addressing that.

I don't know whether Tim you or Anna have got some comments on the numbers, but I think it was Beyond Zero did some analysis that took those IEA numbers a bit further and said that that absolute reduction in coal demand and that relative reduction in gas demand such that gas, even though, as you said, it grows until about 2030 or something and then is flattening out a lot, and presumably after that it starts to go down but it's still grown from now. The impact on that from about 2030 is the best part of $100 billion a year to Australia's export earnings. That seems to be a significant challenge.

Are they the sort of numbers that would be consist with what you'd expect and how does the energy industry then talk about this in the context of the challenge this is creating? This isn't just what we're going to do in terms of climate policy, it's what's the rest of the world is going to do? Anna, would you or Tim like to comment on that perspective?

ANNA SKARBEK: We did look at that and indeed our scenario was where all of the countries do act. So we took into account the IEA scenario where the rest of the world is not buying as much coal or as much gas as it used to or it would have otherwise and still even we found that our economy growth, because in our scenario there is a strategy, a national response, and our economy continues to produce the other exports that we currently produce. We will also still need a lot of the other minerals that we mine and we have growing education, tourism services, professional services, construction and property.

We've got a chart in our report of what's the mix of our economy by sector today and what's the mix of our economy by sector in the future. It is very, very similar, the reason being what we're talking about here is an upgrade of energy assets, not a rewrite of our economy as we know it. Coal and oil were the two sectors that go backwards in terms of their growth rates and there are a lot of other sectors that grow which then offsets the loss there and the economy is able to absorb that.

TIM O'GRADY: Just briefly, because obviously we hope to be a part of this change to decarbonise our energy system and get a lot of export growth from that as well as a country with solar and other

technologies. But with gas our gas exports are broadly tripling from a couple of years ago to a couple of years' time and that will make gas go from the fifth biggest export for the country to the second biggest export in 2018, and that continues with all the scenarios. That kind of gas that we're constructing now already has the customers for the next 25 years and probably beyond.

The question really is can we capture more of that future growth and continue to grow our economy and add jobs? Currently we've done very well at capturing this current wave of growth in world gas consumption and now it's very competitive and a lot of the next projects are happening in North America. So it's more can we make our gas industry even bigger I think is the key question.

TONY WOOD: One of the questions we had sent in and one of the technologies we haven't discussed is nuclear. Anna touched upon the question of a scenario in which nuclear was turned on. Robert, you've got a background in some of these technologies, would you like to comment on how you see that given what we're talking about in relation to gas?

ROBERT CLARK: I think the nuclear argument is a really interesting one. What I'm about to say is a very personal view, I don't know if it's shared by anybody else but I looked at some numbers and made my own judgments. Let me just take you through this personal argument and see what you think of it. Australia's total electricity use is around about 250 terawatt hours and if we were to say let's go nuclear. Would the government have the political courage to build the social licence? I don't know but let's put that aside.

Let's suppose it does and we all decide we're going to go down that pathway, what would that mean? If you look at the worldwide average of what going nuclear means, it means about 15% of your total energy is produced by nuclear. No more than about 15% and I think that's rightly what you showed Anna. So 15% of 250 terawatt hours will come from the nuclear power stations. How many? It turns out that that's five 1,000 megawatt reactors, so one big reactor per capital city. That's what you're talking about to go nuclear in Australia and achieve 15% penetration of the grid and you would say great. The driver for this is emissions and that's been the emotional argument, and I use the word "emotional" but it's factual because yes, you're talking about a zero emission technology. But you go to these conferences and they say, "We need to go nuclear because of emissions" and then the very next step is saying, "What type of reactor, how big?" and then you get into all that detail. I want to just go to a different place and say let me just test that logic of emissions.

What do we export? So when I went into the export, we export in a good year 12,000 tons of uranium oxide and in a bad year about 8,000 post-Fukushima and you say okay, Australian uranium is being used somewhere for zero emissions on the planet and global warming is global; you don't have to do the good on Australian soil. How much does 10,000 tons of uranium oxide correspond to in electricity? It turns out it corresponds to our total electricity use in Australia, 250 terawatt hours in a bad year and 375 in a good year; 150% of our total energy, not 15%. We we're exporting 150% of what we use zero emission to some other place on the planet and if we were to go nuclear we would only get 15% penetration, so a tenth of that good. So my argument is why don't we just dig up 10% more uranium oxide and export it and be done? We don't have to go nuclear. If it's just purely emissions you really don't.

We don't claim this good and the reason I suspect we don't claim it and say, "Look at all the good we're doing around the world" and it's a lot of good, is because then you get into arguments about

what about our coal and then people don't want to be dragged into that black space, as it were. But we are doing good through our uranium exports. So what's the role of a nuclear Australia in my view? I think the competitor is Kazakhstan. Kazakhstan is a pretty dangerous place and would I rather somebody bought uranium from Australia with all of its safeguards than from Kazakhstan? Absolutely, the world would be a safer place. We have stronger safeguards.

So at the moment we're limited, we're actually getting uneconomic in our uranium because we're restricted by legislation as to where we can mine and it's now becoming more expensive to get that uranium, we're not competing with Kazakhstan. So even though we've got a lot more uranium, the most in the world, Kazakhstan is the biggest producer. So we could produce more uranium, we could do more good if we were allowed to do it economically. So I guess my personal view is let Geoscience Australia find out where it's more economic and the second thing is ANSTO, we do things safely so yes, have a research reactor, train our students in universities about nuclear through that research reactor so that we can become advisors.

As a supplier of uranium to the world we can become, if you like, responsible exporters because we understand the safety and we'll export that safety culture as well. Wouldn't it be great if Australian advisors could advise the Japanese government on safety as they're arching up with nuclear", for example? Anyway, I'll stop there.

TONY WOOD: I think we may have touched upon a topic for a future Grattan forum. We're going to send you back out into a cold Melbourne winter's evening. One of the questions that was asked was in heating my home, which is cheaper: my reverse cycle air conditioner or my gas heater? Somebody said it depends upon the way you heat your home. If you have reverse cycle in a couple of rooms and you've got central gas heating I suspect you'll do pretty well with your reverse cycle, but you may not get the same level of comfort as having your entire home heated with ducted gas heating. So I'm not sure it's going to come down to necessarily just the cost.

The other question was what's the largest environmental footprint and to some extent it comes back to Anna's point, and that is if we had all of our electricity coming from a green grid then obviously that would be a very significant difference and you would move then not necessarily to reverse cycle air conditioning, but towards electric heat pumps and we'd end up with a very, very green outcome indeed. On the other hand, if we produce, as we do in Victoria, virtually all of our electricity from brown coal then it looks very different again. So I think the answer to that question, as with the answer to the question we posed at the beginning of the evening, that is is natural gas part of the problem or part of the solution, the answer may be it depends.

Can I finally thank the State Library for hosting the event, thank my fellow panel, and also thank the people at Grattan, included Alex Stott, who helped organise the evening. Thank you very much and good night.

END OF RECORDING