From offshore to onshore – the future of WA's gas market?

A shift back to onshore petroleum exploration and development globally has significant implications for West Australia's gas market. Natural gas plays a foundational role in the State's energy security and economic development. But this new "gas rush" has become a politically charged issue for environmental campaigners and has raised questions about the rights of existing landowners. This seminar will explore questions about the importance of new sources of natural gas (CSG and shale gas) in meeting our energy needs and the scientific, environmental, social and economic issues which need to be addressed to develop these resources safely and responsibly.

At this free public seminar brought to you by APPEA, Grattan Institute, International Energy Centre and The University of Western Australia's Energy and Minerals Institute, a panel of experts will guide the conversation and provide you with answers to these questions.

Chair: Babs McHugh, A/Executive Producer, ABC Rural WA

Panel: Tony Wood, Energy Program Director, Grattan Institute
Professor Robert Clark, ACOLA Expert Working Group on Engineering Energy
Professor Peter Hartley, BHP Billiton Chair in Business Resources, The University of Western Australia
Stedman Ellis, COO – Western Region, APPEA

BABS MCHUGH: Good evening ladies and gentlemen. My name's Babs McHugh, I work with ABC Radio, I'm actually the National Mining & Resources Reporter, it might say something different up on the screen but I was doing that for a short while. If you listen to ABC Radio you'll hear me fronting up for a bit of ritual abuse every morning with Ian Cameron while I read out the business figures, which I do get wrong probably more often than I get right on some weeks, to be perfectly honest. The first thing I'd like to ask you all to do is to put your phones on silent or turn them off please. It would be good if they weren't going during the speeches this evening. Now, I would like to begin by acknowledging the Noongar people upon whose country we do meet today.

Now, the theme of the seminar, as you no doubt know, we're taking a look at the shift back to onshore petroleum exploration in this state and the development globally as well, it's got significant implications for WA and the gas market here. Natural gas plays a foundation role in WA's energy security and its economic development, but this new, I suppose it is a gas rush has become politically charged, there's issues for environmental campaigners, it's raised questions about the rights of existing landowners. So this evening we're going to explore questions about the importance of new sources of natural gas in meeting our energy needs and the scientific, the environmental, the social and the economic issues which must be addressed to develop those resources safely and responsibly.

I'll just introduce the panel you'll be hearing from tonight, we'll hear a little bit more about them as they come up to give their individual talks. Tony Wood who is the Energy Program Director at the Grattan Institute; Professor Robert Clark, ACOLA Expert Working Group on Engineering Energy; Professor Peter Hartley, BHP Billiton Chair in Business Resources from the University of Western Australia; and we'll also be hearing from Stedman Ellis, the CEO for the Western Region of APPEA.

The format for this evening, the three speakers will come up for 15 minutes at a time, then we're going to have a panel discussion amongst ourselves, and then we're going to up the floor for questions. You've all been given a little pad when you came in this evening. What we'd like you to do is, if you have questions is to write them down during the talk and just as our next speaker comes up to speak we'll come up and collect those questions from you. There will be opportunities of course, the microphones will be coming out on the floor after, but just to keep it tight we'd like to keep everything on time, we'll take a few questions that we have already collated to get a feel of the direction in which you'd like to go.

So I think it's time to start. If Tony Wood would like to come up. Tony joined the Grattan Institute to lead the Energy Program in mid-2011 and since then he and his team have delivered four major reports on energy and climate change, and Tony's a regular contributor in major media on key energy issues. He also retains a role as Program Director of Clean Energy Projects at the Clinton Foundation, he advises governments in the Asia Pacific region on effective deployment of large-scale low emissions energy technologies such as solar and carbon capture and storage. And prior to those roles, Tony spent 14 years working at Origin Energy in senior executive roles that covered retail and LPG line management as well as corporate affairs. This is Tony Wood, thank you.

TONY WOOD: Thanks Babs and good evening. This is the first time I've certainly been in Perth talking on behalf of Grattan, although I used to come here a lot when I was working for Origin and previous to that what is now called Incitec Pivot. And unfortunately this trip is all too short, but hopefully we'll try and find good reasons to be here more frequently in the future.

What I'm going to do for the next 15 minutes is give you a bit of an idea about what's happening offshore and the impact it's going to have onshore, is already starting to have both in Western Australia and also in other parts of the country, to give you a feel for some of this. And the reason we started looking at this piece of work at Grattan was because it seemed to us there were many people who had no appreciation a) for what was going on overseas and b) for the impacts that was going to have on this country. So the sort of themes I want to talk about for the next few minutes are what does this mean in terms of exports for Australia, in terms of export earnings; what's causing that and what the impacts on Australia will be. It's a specific issue which has got a lot of publicity in the last little while and continues to get a lot of publicity on the east coast in relation specifically to New South Wales. I'll talk a little bit about some of the policy reactions we've seen from government, what governments should not do in our view and what governments could very well usefully do to improve the outcome; and talk a little bit about one of the interesting conundrums to come out of all this and that is what happened to the "dash for gas" that everyone was expecting would happen if we started to introduce a move towards low carbon futures?

Some of you may be aware of this chart, what's causing some of this, and this is what's happening in the United States. In the United States only a few years ago the price of gas was something around $8/$10/$12 a gigajoule, three of four times what the price of gas is in Australia today. What happened? Well, what happened is what normally happens when prices go high, new supply came into the market, a combination of technologies: 3D seismic horizontal drilling and this lovely term called fracking, or fractious stimulation, were introduced and shale gas really took off in the United States. As a result, the black line, you can see the prices have come down dramatically. They're still around $4 or less per gigajoule, the United States is now starting to export and will start to export gas from large LNG facilities, and you can see on the background to the slide what that means in terms of where the growth in gas from coal seam gas, in particular shale gas.

This is a very simple cartoon diagram that shows some of the differences between traditional natural gas and shale gas, but also coal seam gas. And you can see the shale gas tends to be much deeper and drilling into shales tends to be very much below the depths of conventional gas and also for coal seam gas. One of the things that really has however been causing a lot of the concern has been what's been happening financially as a consequence of this change. For the first time in a long, long time – and this chart goes back to about 2000 and even before that – global gas prices tended to follow each other around the world. But in the last little while they've diverged quite dramatically. As a result of what I just mentioned, the price of gas in the United States has gone down a lot, the price in Asia has gone up a lot. Two factors: one, economic growth in Asia and the need for gas; two, the fact that Japan shut down more than 50 nuclear power stations. That was in the end of February 2011. The last of those plants that was up for a while has been shut down again and Japan is paying a very high price for their gas, as you can see from that chart. That is not sustainable. Markets don't do that for very long. That's defying gravity in one sense and that will change. The United States is now, as I said, looking to export gas to take advantage of that market in Asia. The Japanese are starting to try and put downward pressure on price and the Canadians and the Africans are looking to export gas into Asia. So this will not be a free lunch for Australia for very long, if it ever was.

But one thing that is happening, both on the east coast and on the west coast, is the beginnings of an enormous boom in gas exports, LNG, traditional natural gas on the west coast, coal seam gas developments on the east coast. Starting in 2014 will be the first of three very large facilities on a

place called Curtis Island near Gladstone in Queensland. And you can see there just the staggering uplift in volume of gas. This is a very significant issue.

Now, why is this important to Australia? Well, Australia has a relatively small domestic market, but we do have an unusual market in some sense relative to the rest of the world. We use a lot of gas in electricity or relatively compared to many parts of the world, but we also use a lot of gas for industry. On a geographic basis, Western Australia is a very gas-intensive economy. This goes back to the days of when the northwest shelf first took off and a lot of gas was used to develop industry. As it turned out over time, the price of that gas relatively has moved up and down, but Western Australia uses a lot of the gas that's consumed in Australia. So gas plays a fairly important role, but it's often misunderstood. But the consequences of high prices, particularly arising from exports, are particularly important in certain circumstances.

Now, for residential consumers it's not such a big deal as electricity, but in some parts of Australia it is. So for example, two-thirds of the gas in Australia that is sold for residential purposes, domestic purposes, is in Victoria. The reason for that is it's heating, home heating, and when I was in Queensland at the beginning of my career in the gas industry, Queenslanders use so little gas that it would actually have been better to simply send them a single bill a year and never even bothering measuring the stuff. There wasn't enough gas to even be worth doing that. And you can see here the impact on Queenslanders as a result of an increase in gas price is much less, Victoria it's a whole lot more. The reason for Tasmania being so low by the way is there's very little penetration of natural gas into homes in Tasmania.

Now, on the east coast what's happened, interestingly, over the last 10/15 years is the east coast gas market has become very connected and, as a consequence of that, gas price matters and physical things matter. So if you look at this slide, this one is showing cartoonish-wise in a typical winter's day in 2011 everything's in balance and just a couple of numbers there: Queensland's using 516 terajoules per day, New South Wales 600 terajoules per day. So everything's in balance and the whole system works and the grey lines are pipelines. You move that forward to 2016 and this very large number in the top right-hand corner is the LNG exports, 4,000 terajoules a day. All that means is, as Ian MacFarlane described, a dirty great gas vacuum cleaner sucking gas out of the east coast of Australia and everyone gets very nervous as to what's going to be left for the rest of them.

And that's what's behind the concern that's being raised about the future of gas in New South Wales. People are saying "We can't get gas at any price. We certainly can't get gas at a price we'd want to pay any more" and companies who want to develop coal seam gas in New South Wales are absolutely running a very strong campaign to try and put pressure on the New South Wales market to allow them to develop that, because they're saying "Unless you let us develop coal seam gas you are going to run out of gas in only a few years' time". That may happen, but on the other hand, there are other solutions. For example, the pipeline you can see there, the 288 terajoules a day coming from the Gippsland Basin in Victoria into New South Wales could be expanded, but that would take some time. So unless this whole coal seam gas issue in New South Wales is resolved one way or the other to say "Yes, we're going to allow it" or "No, we're not" or "If we are going to allow it, here are the rules", it's the uncertainty that means people don't go off and do what might otherwise be the next best investment. And that's what's potentially creating more of a concern that the fundamental shortage of gas. This is not about a shortage of gas, there is more than enough.

In Western Australia the system in some ways is less developed. You don't see as many pipelines, you don't have as many intensive residential consumers. What you do have are some very large industrial consumers in Western Australia. The focus in Western Australia has been much more on very large products and, of course, as many of you would know in this room, there's been a particular focus on worrying about whether we should keep some of that gas for ourselves to protect our own manufacturing, and that's what's called the Gas Reservation Policy. And there are those who would argue on the east coast we should do the same thing, that the result of high prices is just because of all those money-hungry organisations who are exporting all of our gas and there won't be any left for us, and if there is it'll be too expensive anyway and so there's going to be large implications for manufacturing and job losses. In Western Australia there is already a domestic Gas Reservation Policy.

And finally, what happened about the "dash for gas"? Because some of you would know, that when you burn gas in a power station it produces somewhere between a third and a half of the greenhouse gas emissions compared with coal to produce electricity. And so you would think, other things being equal, that if we started to be worried about that there'd be a move to gas and, for example, people will tell you very passionately and very accurately that in the United States right now greenhouse gas emissions have been falling. And the reason for that isn't because President Obama has been introducing regulation, it isn't because of the renewable energy sector in the United States; it's because of gas. Because of the point I made before about this enormous shift towards low-cost shale gas, one of the consequences has been producing more electricity from gas, emissions have come down in the United States. And the United States looks like they'll achieve the target that they set for themselves under the Copenhagen Accord to reduce their emissions by 17% by 2020. Somewhat ironically, one of the consequences is the coal that otherwise would have been used to produced power in the United States is being exported to countries like Germany who don't want to produce their power from nuclear, who've got a lot of renewables and don't want to have fracking for gas, they're going to produce electricity from coal and their emissions have been going up. So you get some really strange outcomes in the world as a consequence of this interplay.

In Australia it's very different. In Australia what's been happening is what's shown on this chart. Electricity demand, which was growing very steadily for decades and decades, by the middle of the last decade started to flatten out. And no-one saw this coming and so the people who provide projections of gas demand kept saying the gas demand was going to keep going up and it kept going down. The reason? Several. Firstly, changes in economic circumstances, industrial output going down; secondly, price matters, electricity prices, as I'm sure you would know, have been going up in Australia; and thirdly, to some extent the fact we've got a lot of solar, more than 1million homes in this country now have solar PV and that's reducing the demand on the main system, if you like. And so what we've been seeing is demand going down. But of course, what's also been happening is demand is going down in the electricity market, gas prices have been going up, for the reasons I mentioned before, and renewable energy across Australia as a result of the Renewable Energy Target has been forced into the system.

Now, you can argue whether that's good or bad, but the consequence of that, when you force new supply into a market where demand is falling there's only one thing going to happen and prices are going to go down. What's been happening, particularly in South Australia and New South Wales, is that black coal fired power stations are the ones that have been withdrawing their capacity. And it's because of the withdrawal of the capacity of black coal fired power stations that emissions from the electricity sector in Australia haven't been going down, whereas most people thought the objective of putting a price on carbon was to shut down the dirtiest brown coal fired power stations. That isn't what's happening at all. The brown coal fired power stations in Victoria are absolutely going gangbusters, it's the black coal fired power stations which are in trouble, for the reasons I mentioned. Because brown coal is worth two-thirds of stuff all in terms of no other application for it and black coal is the one that's suffering. And so as a consequence, gas is not finding its way into that market and so the outlook for gas for power generation is quite confusing.

So, when we look at this overall picture of what's going we come to a few observations. Firstly, there's a lot of investment going on, about $160billion is being committed. That's going to create in excess of $50billion worth of export earnings and gas would most likely become Australia's biggest export earner. We'll be the largest LNG exporter in the world. There are consequences I mentioned before, but it's very important, we argue, that governments resist calls to cap prices or to reserve gas for the domestic market. There are perverse outcomes that come as a result of those sorts of things. And people will call it all sorts of things, but fundamentally Australian governments generally had learnt over several decades that protecting Australian industry from international competition is a bad idea. Basically it never works and it has other consequences which are almost always bad. Secondly, unconventional gas development brings conventional problems and, in the case of gas, an unusual alliance. There are people who are very passionate about renewable energy – and I am as well – who thought that gas was going to be a fuel of transition to a clean future. Well, it's not at the moment. It looks like being a fuel of destination in some places. Governments must end this problem in New South Wales, they really must move towards creating a more transparent market. The industry has to be part of that.

But, in summary, there is no shortage of gas; the issue is how do we get the gas to the market? One interesting consequence is how are we going to burn all the gas we've got in the world if we are seriously going to address the problem that climate change presents us?

Thank you.

BABS MCHUGH: So, some people will come around and collect questions if you do indeed have any. Our next speaker this evening is Professor Robert Clark AO, he's the Chair of the Energy Strategy & Policy at the University of New South Wales. Professor Clark was appointed Australia's Chief Defence Scientist and CEO of the Defence Science & Technology Organisation in 2008, that's a post he held until October 2011, and previously he had been Head of the Australian Research Council. In 2008 he was awarded the Eureka Prize for Leadership in Science for his pioneering role in making Australia a world leader in nanotechnology and quantum computing.

ROBERT CLARK: Thank you very much. It's very nice to be here in Perth and I look forward to sharing with you the work of this committee that's in front of you in this slide. I should say that I'm representing a group of people and the group of people, our Chair was Professor Peter Cook who's a Geologist and this committee, we produced a report that has been presented to the Prime Minister's Science Council now on two occasions and the Office of the Chief Scientist has now made recommendations. The subject of the report is quite broad, it's called *A Study of Shale Gas in Australia* and what I'm going to do in the next ten minutes is just tell you a little bit about that and, to complement Tony's financial overview, my overview's going to be a little on the technical side to give you an idea of what this really is all about technically.

So this is what the report looks like, it's actually a very heavy big beast, passes a weight test at least, and really in blue here on the left-hand side what we set out to do was to say just exactly what have we got in Australia in terms of shale gas; where is it; and how do we both technically and economically extract it but, in particular, how do we extract it in a way that we can manage the impact on the environment? And there are lots of issues associated with that and at the very end there's a lot of governance that's due there as well. So that's the essence of the report.

Tony showed you a slide similar to this. Coal seam gas and shale gas are often conflicted in peoples' minds. As Tony mentioned, coal seam gas is shallow, it's generally hundreds of metres but down to 1,000m. Shale gas is deep, in the United States it's 2km, in Australia it's 3km, very deep. But there is a bigger difference technically. To get the gas out of the coal seam, the gas is held in there by the pressure of the water table and so to draw that gas out you have to literally de-water the coal seam. Now, there are issues there if that water is hydraulically connected to aquifers and there's a lot of water comes out. So coal seam gas has got a different set of technical problems. That's not the case for shale gas. Shale gas occurs in this shale layer which is very impermeable, that means the gas just doesn't really like to flow. And so to get the gas out there you have to do this technique called hydraulic fracturing, which I'll tell you about, and you also have to do that for a thing called tight gas. We don't talk about tight gas very much in Australia, but overlying and underlying shales the sandstones contain gas that also is quite impermeable and you have to fracture at that depth to get that gas out. And in fact, tight gas initially could be almost as important as shale gas in Australia.

What have we got in the world? Well, you can see these numbers are in trillions of cubic feet, these are technical recoverable estimates and you can see a very big number for Australia, about 400trillion cubic feet. That was based on four basins by a US study. It's been expanded to six basins and now the number came up to 437trillion cubic feet. In our study we looked at 26 basins and the number was in excess of 1,000trillion cubic feet. Now, to calibrate that, we use 1.4trillion cubic feet per year in Australia in totality, so we're talking many hundreds of years of supply. However, let me just say with a West Australian theme to this, you might think that this number's just scaling with the number of basins. Actually that number got to 1,000 almost entirely due to the Canning Basin, so 900 of that 1,000 is actually the Canning Basin and it's not just dry gas, it's also wet gas which can be more valuable.

Now, it's important to say something about these numbers. They sit at the bottom of a triangle, they're just technical estimates of recoverable gas. You have to work these up into a thing called proven and probable reserves or 2P reserves and calibration, again, the total 2P conventional gas reserves in Australia is 103trilllion cubic feet, most of it off the northwest shelf. Only a little bit left in Gippsland by

comparison. So you can see that nevertheless, it's a very big resource here that can be worked up into a substantial 2P resource. This is the coal seam gas resource, 33trillion cubic feet that Tony was talking about, that's our export base.

Where is it? Well, the red circles broadly are where it is. Here in Perth, in the North Perth Basin and the Carnarvon Basin and the Canning Basin. The Cooper Basin is really quite important, I'll have a few words to say about that, because that sort of typifies all the technical issues. And I like to tell people that unlike, for example, coal seam gas, shale gas is in the middle of nowhere. Well, of course, the North Perth Basin is not in the middle of nowhere and indeed some of these little circles here are definitely not in the middle of nowhere. But if you go out to the Cooper Basin there's not a lot else out there.

Now, this is a complicated slide, as are the next two, and I'll try and simplify this. You hear about horizontal drilling and multistage fracturing and you have to be able to do both of those really to get at the real economic extraction of this. Now, what it involves is you drill down, in the United States' case 2km, and you start with wide bore and you drill deeper in narrow bore and you go in, and you put in steel casings and you cement those casings – there's a lot of technical detail, if you ask me later I can tell you about this – but the well integrity depends on those cement seals of these jointed steel casings that form the actual well bore. You turn on a 500m radius and then you drill horizontally out for 2-3km and the thing that is really important about this is you then, once you've actually put the well in place and you've got all your casings in place, you then lower this thing called a perforation gun which has shaped chargers in there and you basically punch through both the steel and the cement forming hole connections to the shale layer in the pay zone, in here. And that's how the gas gets into the production casing to come back up this well to the surface to extract it.

Now, once you've punctured those holes through – and they're only 10s of cm they go through – you remove the drill rig completely and then you bring in all of the hydraulic fracturing rigs, which I've shown here. It's basically a lot of trucks with big pumps on the back end of them, and you pump down that well, mainly water but mixtures of proppant, things that'll hold the cracks open once you've formed them and it can be sand or it can be ceramic, little balls of sintered bauxite is what is use. And that causes the shale to fracture and you can see here they're fractured in sequences of vertical plains and you do typically four at a time, and there might be 20-odd stages of four that you're doing along the length of this well, to form all of this contact with the shale to get this massive gas flow coming back up the well to make it economic.

Now, there's a very important technical point: how do we know it's going to fracture in that direction because if it doesn't, you're in trouble with this well? And the answer is, the United States is under a thing called extensional stress, so it's relaxed as a continent, and so this horizontal force with those little arrows is actually the weakest force in the stress down there. The biggest force is the weight of all the layers on top of it called the over-burden force. Now, the way it likes to fracture, it fractures at right angles to the least horizontal stress, so at right angles to those little arrows, in the direction of the biggest stress. And so you can see that the North American continent is perfect to set up those vertical layers, and so if you drill a horizontal well, because of the stress regime you'll get this great economic extraction. That is not necessarily the case in Australia. So although the technology carries over, we have a completely different deep in situ stress regime, as I'll show you.

Now, a lot of people worry about things they can't see. Where are these fractures going? How far do they go? Are they going near our aquifers? And we need to know this and the technology is there to sense this. In a deep offset well – shown to the right there – you can put geophones and accelerometers and as you're cracking the rock that noise hits that whole array and you can triangulate to within 15m of where the cracking is actually happening in the rock, and so you can accurately in real time show where your fracture's going. That's important because you don't want them to go too far upwards if your aquifers are close. Typically in the US the maximum vertical extent is about 90m and there's an awful lot of distance between where you're actually doing this and the overlying aquifers. Again, that's not necessarily the case in Australia, particularly with the Great Artesian Basin, as I'll show in the final slide.

There is an issue if, when you're doing the fracturing, you hit a local fault. If that actually happens you get extra seismicity as a result of that which you pick up, but the fracturing can actually then go, instead of 90m, it actually can move something like 300m. So these are the issues that you have to

monitor very closely. People talk about induced earthquakes. Well, there isn't really an issue with induced earthquakes that you will feel from the fracturing process. There is an issue if you've got hundreds of wells and you're recovering all of the water from those wells and you stuff all of that water down a wastewater well, that the sheer weight and the pressure of that accumulation of disposing of water from many wells can trigger faults and you will feel those. And that has actually happened in the United States, but it's manageable, you draw more wells, you manage the pressure, you dispose of less amounts of fluids in those wells and so on.

Now, coming to Australia. I'm using here the Cooper Basin and these blue horizontal lines are the deep aquifers of the Great Artesian Basin. It isn't just water down there, this is sort of water in the porosity of sandstone layers that we're actually showing here. And the separation between the bottom aquifer of the Great Artesian Basin is only 300-800m from the shale targets, and so we have to know what's actually happening in that band and so it's important that the measuring goes on. Now, the Australian stress regime is different. If you look at that little box there, you can see that in the Cooper Basin Australia is under compressive stress, not extensional stress, and so the greatest stress can actually be in the horizontal direction and it can even approach or exceed the vertical stress.

So going by what I said before, it fractures at right angles to the smallest arrow, so that's horizontal, in the direction of the biggest arrows, and that's also horizontal. And so there is evidence from the early fracturing in exploratory wells in Australia that actually fractures that start vertical twist to horizontal and there can be horizontal components. So it's not a given that horizontal wells and multiple fracturing will work everywhere in all Australian shales, like it generally does in the United States. People are going to have to be quite smart about this. It's not to say it can't be done, but there is a fall-back position and that is that overlying and underlying the shale layers is all this tight gas and you can fracture at different vertical heights in a single vertical well and achieve quite a lot of gas coming from all of these different layers. It's called an egalitarian strategy in that everyone contributes equally to the gas flow up the tube, you don't really care where it comes from, and in fact going for the tight gas in lots of these vertical layers is exactly what's happening in Australia.

That's what it looks like, this is a drilling site in the Cooper Basin. This is a drilling rig. This is a fracturing rig down the bottom. You're using 15million litres of water. Now, people will say "You're using a very small percentage of chemicals", that's true. The percentage is about 0.17%, most of it is water and the rest of it is sand or proppant. But if you take 0.5%, the top end of this, of 15million litres of water, it's 75,000 litres and that's two road tanker loads of chemicals that are going to be mixed with your water. And these chemicals can be now non-toxic, they're food additive chemicals, but you just need to know that they're the volumes that are going down these big horizontal shale gas wells. And you can even use saltwater wells, pull up the saltwater from the deep aquifers, clean it up a little bit, use it for your hydraulic fracturing fluid, when it comes back capture it, clean it and reinject it again in an overall aquifer management system.

So, at the end of our report we concluded that there's enormous potential for shale gas in Australia, I haven't been able to capture all of that really here. Technically there are issues in Australia and these are challenges, engineering challenges. Horizontal shale gas wells have been drilled in Australia but, to my knowledge, we haven't heard anything about the fracturing of these horizontal wells yet. We've heard a lot about vertical wells and that works quite well, although there are issues. But we'll need to carefully manage the impacts, the technology is there to do that, but there needs to be transparent and effective regulation and companion codes of practice enforceable. And with that, we concluded that this could actually be quite an important new energy option for Australia.

So, thank you.

BABS MCHUGH: And some people will come around and collect any questions you may have for Professor Clark. Our final speaker this evening is Professor Peter Hartley and he's currently the George & Cynthia Mitchell Professor of Economics at Rice University in Houston, Texas. He's also a Rice Scholar of the James A Baker III Institute for Public Policy at Rice University where he is affiliated with the Energy Studies Program. Professor Peter Hartley, also currently the visiting professor right here at the UWA where he holds the BHP Billiton Chair in the Business of Resources. Peter is the immediate past president of the US Association for Energy Economics, currently a member of the Council of the International Association for Energy Economics. He previously worked

for the Priorities Review Staff as well as the Prime Minister's Department in Canberra, Princeton University and the Tasman Institute of Melbourne. Thank you.

PETER HARTLEY: Thank you very much. So I'm going to make a few remarks that actually complement what the other two speakers have said, and so I'm going to skip through this a little bit, some of these things.

So the six main issues that I was going to talk about in my presentation, the first one is how real is the unconventional gas boom? We've already seen some work about what's happened with the increase in gas production in the United States, but there's been some debate about how sustainable that increase in gas production is from shale gas, so I'll say a little bit about that. Another issue of interest to Australia in particular is exports of LNG from North America, the US and Canada, as a result of unconventional gas development, and I'm going to talk a little bit about that and some other implications of unconventional gas development. And then also pick up this question about whether the North American experience is going to be able to be replicated elsewhere, and then I will say a few remarks about this non-gas issue and restricting natural gas exports.

So we've already had some talk about what is the difference between unconventional and conventional gas. Basically, the idea is that we've had this combination, as the other two speakers have said, of horizontal drilling and hydraulic fracturing is what's made this resource available in North America. Actually, hydraulic fracturing is not new, the first hydraulic frac job was done in 1949 in Duncan, Oklahoma and actually more than a million wells have been hydraulically fractured in the US alone and, in fact, hydraulic fracturing has been used in Australia for many, many decades in some of our conventional wells, including all of those in central Australia. The element that's new here is that combining the multistage fracs with horizontal in-layer drilling and, this was already mentioned, about 95% water, 5% sand and <1% chemicals go into the fracturing fluid.

A big difference, I grew up in northern New South Wales and I visited home, I know there's been a lot of talk, I went to some public meetings, people talking about coal seam gas and a lot of them taking the information about fracturing in the United States and assuming that it applies to coal seam gas. A major difference of course is coal seam gas, as already mentioned, you're pumping the water out; with shale gas you're pumping water in. So there's a lot of difference actually between the two. And actually in some of these areas in northern New South Wales, for example, there's actually conventional gas as well as coal seam.

There was a picture in the previous presentation of the Marcela shale, I've got a similar picture here, this is 2,000 wells from Texas where, again, they measured - at the top we've got the deepest aquifer and on the bottom you've got the wells that were fracked. And you can see the little bits going up and down from that show how far the fracking migrated above and below the frac zone, and you can see there's a huge difference between the frac zone and the aquifers. In fact, there's no known case, no proven case, of hydraulic fracturing ever leading to contamination of water from the fracking process itself. You might have heard otherwise, if you've seen the *Gasland* movie. Those of you who've seen that, you may not know that the movie maker was asked at a conference in Chicago – so the critical scene in that movie is where you catch the tap water alight because there's methane in the tap water – and he was asked the question did he know that that water has been known for many decades, in fact it was reported to the EPA in the 1930s? And if he did know that fact, why didn't he report it in the movie because wasn't it a relevant fact? And his answer was yes, he did know that fact, but he didn't report it in the movie because it didn't fit with the story he wanted to tell. And so the point here, there's a reason why in court of course you're asked not only to tell the truth, but the whole truth. So in this case the movie didn't actually lie. It's true there was gas in the water. It's also true that the area had been hydraulically fractured. But the inference he wanted the public to draw, namely that the hydraulic fracturing caused the gas in the water, was not actually correct because he didn't give the whole truth.

There are also two cases recently in the United States where the EPA decided to try to prosecute Range Resources for gas in the water. Range Resources did an isotopic study of the gas and showed that in fact the gas in the water was, again, from organic material. Another name for methane or natural gas is swamp gas. Any environment where you have organic matter that's decaying without much oxygen is going to produce methane and so you get methane in groundwater. In this case they could show it wasn't coming from the shale gas itself because it had different isotopic composition.

When the EPA saw what Range Resources had done in terms of the scientific work they dropped the case and didn't contest it in court.

So another question is, how persistent is this shale gas production going to be? There's been a lot of debate in the United States about whether the decline rate on these wells means that they're going to be sort of a shot in the pan. And we've done some work recently with the Rice University and also the University of Texas looking at what's called the decline rate, how quickly the production rate declines in these wells and, using some new theoretical analysis of the flow of gas and oil in the fractured well, the scientists came up with this new formula for the decline rate. So you have a very long, slow decline rate. We studied this with over 16,000 wells in Texas and found that theory works very well. So the bottom line here is that you're going to be able to get a long period of production out of these wells and we also have the cost estimates down the bottom for the typical wells for the shales in the United States they're talking about.

Next issue I want to talk a little bit about is this question of exports. The critical point here is that as a result of shale gas, what the economists call the elasticity of the supply curve, the slope of the supply curve of natural gas in North America is very, very flat. In our own modelling work we've shown that in fact the presence of shale has increased the elasticity of the supply curve by a factor of five. And the result is with a very flat supply curve and a fairly steep demand curve in Asia and anywhere else for natural gas, the consequence of exports will be that the price will come off in the demand market much more than they'll increase in the supply market. So a major consequence here is there won't be big increases in the price of gas in the US as a result of these exports. There will be some, but the major factor is it will reduce the spot price in Asia and, of course, as a result of that, that fall in price will itself limit the amount of gas exports from North America.

Another factor that's going to make it harder for the North American deposits to compete or the LNG to compete with places like Australia is the high transport cost. One thing people have said is well, we need to open up the Panama Canal, that's going to be a lot cheaper way of getting gas from the Gulf Coast of the US into, say, Japan. But actually, you've got to ask yourself the following question, I always say, if you're the government of Panama and you are going to decide how much you're going to charge to use the Panama Canal, how much would you charge? What I would charge is the cost of the alternative minus, let's say, a buck. So it's not going to make a huge difference to the cost of transporting natural gas and, in fact, Panama is relying on the revenue they're going to recover for using the Canal to pay for the expansion. So it probably won't lower transport costs a lot.

The net result is that the sorts of numbers people are talking about for exports of natural gas from North America to Asia we think are greatly overstated. We also take account of the fact that there's been a big increase in the demand for natural gas within the United States. A whole bunch of gas-using industries are moving back, things like steel mills are using natural gas now where they weren't using it before. There's been a big shift to natural gas in the power industry, as was said, and also transport companies are getting into trying to use natural gas, so trucking firms, shipping companies and trains.

This slide was already put up. Basically what this shows is that we had this period, for a long period of time, where the gas prices were moving together. With shale gas you see the blue line at the bottom is Henry Hub, it's separated off. The separation between the red and the green occurred after Fukushima, that's where you had this big increase in demand for gas in Japan. It's really a short run phenomenon and it's also equivalent to what we'd call a basis blow out in the pipeline system. You have a very temporary increase in demand, it'll have a big increase in price but we expect those prices to recover back as was mentioned before.

What else might happen as a result of the shale gas? I've got some other straws in the wind here of what's going on in the LNG market. Basically the bottom line is that we've seen a big increase in spot and short term trading. We're also seeing a lot more arbitrage of prices around the world using LNG. Down the bottom here I talk about this growth of what's called branded LNG where companies like British Gas now are signing contracts to sell natural gas to customers and they source the gas from multiple locations. So it's the British Gas gas is what they're kind of selling and where it comes from the customer doesn't care. So we move into this world where there's a lot more of this trading from multiple locations to multiple locations, a lot more short term trading, and this is going to be exacerbated by the US exports in particular, the sorts of deals that the US exporters are signing, what

are calling tolling arrangements where they're basically have the customer buy the gas at Henry Hub price and they're just charging a fee to liquefy it and ship it. All of that means that Australia is facing a very competitive LNG market environment and it's going to put a lot of pressure on projects in Australia if they can't control their costs because of this very competitive environment.

Another issue I wanted to touch on here is the significant geopolitical effects of shale gas. So we did a study for the Department of Energy where what we did was looked at the world with shale gas and then the world without it, and what we found is significantly if you didn't have the shale gas developments in North America who would be the big winners? Russia, Iran and Venezuela. All good friends of the United States, of course. And why would they be the big winners? Because they are the marginal sources of conventional gas. So without shale gas, Russia's market share in Europe falls from 27% in 2009 to 13% in 2040. The shale gas reduces the opportunity for Venezuela to become a major LNG exporter and it limits Iran's ability also to be a bigger exporter. It also reduces competition between the US and China for Middle East resources.

This has also already been touched on by other speakers. Some critical features of the US market that enable the development of shale gas. It was all done by very small independent oil and gas firms, one of them being the Mitchell Energy, which I had the Mitchell Chair at Rice University. So one of it was the resource access, mineral rights owned by individuals – all the development of shale gas in the United States has been on private land, not on public land. It's been nothing to do with federal government; it's all been to do with deals between the oil and gas companies and the private land owners. The other thing is that you have access to the pipeline system, the capacity on the pipelines is a traded market so you can buy access to that capacity and it's been critically important for facilitating these kinds of developments.

Another issue that's already been touched on, water. I've been to some of the shale gas fields in the United States and the big development now of course is there's a terrific amount of recycling of the water. So what happens is that they inject the water for the fracs, when the produced water comes back they treat that and recycle it, and so you only need to dispose of a very small percentage of the frac water actually. And as has already been mentioned, people have talked about concerns over earthquakes or seismic activity, there's no issue really, no known issue. You can't even feel the micro seismic effects from the fracturing itself. It's the reinjection of the waste water which is an issue and you have to be careful where you chose to put the waste water wells.

Actually, it turns out Australia is the next country out of North America where we've had commercial shale gas. There actually is a commercial well in the Cooper Basin right now producing shale gas and there are lots of things about the Cooper Basin that we think make it the most prospective place for developing shale gas in Australia in the short term. The shales are very similar to the Haynesville and Barnett shales in the United States in terms of their geological properties. We have had extensive operations in the Cooper Basin giving us a lot of seismic information, just like you've got in the US. Over 300 wells have been drilled into the shales or through the shales and we have more than 400m of cores of shales in the Cooper Basin. More than 700 wells have already been fracture stimulated in the Cooper Basin in the past, as I mentioned. They have rigs to drill horizontally and they're actually doing that and so on.

Final thing I would say a little bit about is this question of restricting gas exports. So basically the idea is that restricting exports is basically the mirror side of tariffs to restrict imports. Both of them are a tax on trade. Taxing trade means you tax the comparative advantage of the country, you make the country poorer as a result. You don't exploit your comparative advantage. This picture here, people say "Well, isn't it true that domestic use is going to give you much greater value out of the gas?" The point of course is that, I've got here a demand curve, these are the domestic uses of the gas, you'll use the gas domestically up to the point where the marginal value that's used just matches the price. What that means is that the value of all the things you've used gas for up until the margin actually exceeds the price. So yes, it's true that the value added from using the gas on average exceeds the marginal value added from exporting, but that's not an argument for subsidising. It's confusing averages with margins. So on the right-hand side we've got what happens if you subsidise the gas is actually a blue triangle of loss because all these extra users domestically now are less valuable than the export. So this argument that you get greater value out of using it domestically is true on average, but it doesn't have the implication that you want to subsidise, it still means if you subsidise you'll lose money, you'll lose value out of the resource.

Final point here was a lot of the opposition to gas I believe is because it makes renewables less attractive, but I'm out of time so I'll leave that slide.

BABS MCHUGH: I think that's something Professor Hartley that we can take into the panel discussion we're going to have. If you've got any questions that you've written down for Professor Hartley put your hand up, they'll get collected. Right, we're going to have a chat for the next 15-or-so minutes and then we're going to take the questions from the floor.

I'll introduce someone else to you this evening, Stedman Ellis. Stedman will be joining us for the panel discussion as well as taking questions from the floor after. He's the Chief Operating Officer with the Western Region of APPEA, he heads Policy Development & Advocacy in WA, South Australia and the Northern Territory for APPEA, that's the peak body that represents our oil and gas exploration and production industry. Stedman's worked in regulatory policy, stakeholder engagement and advocacy areas of the resources sector for more than 25 years, that's in here, in PNG as well as the US. He serves on the boards of several WA research, education and cultural organisations. Stedman Ellis has a degree with a major in anthropology from UWA.

It's Stedman that I'm going to put my first question to. Stedman, you've heard a lot over the last 35 minutes-or-so. If we could just start with your perceptions of what you've heard?

STEDMAN ELLIS: Thank you Babs. I think what we heard was that WA has got enormous opportunities. We've got significant resources of natural gas onshore and offshore; we've got five decades of operational experience and knowhow; and we're currently the focal point for much of the global oil and gas industry as a consequence of the scale of investment that's currently taking place here. So there's a significant opportunity for the natural gas industry to underpin the next wave of investment, economic growth and regional development of Western Australia.

I think we also heard that we face some challenges. I think on one hand the challenge lies in the costs in Western Australia and the growing competition to attract investment in natural gas that we're seeing around the world. I think the other challenge is really a challenge for the industry and it's how we work effectively with policymakers and the community to deliver the sort of robust and transparent regulation and the companion code of practice that Robert talked about. Also how we work with farmers, pastoralists and traditional owners to deliver land access and native title agreements that deliver mutual benefits. And probably finally, how we work with all of the above to work out how we maximise the value of natural gas in the global energy mix so that it does contribute to displacing coal and reducing CO2 emissions. I think that's possible to do.

In Western Australia, we're right at the start of the journey, but if you look at what's been achieved elsewhere, if we look in Queensland we can see there's now 30,000 jobs in the onshore gas sector, most of them in regional Queensland; there are 4,000 land access agreements signed with individual farmers in the CSG industry in Queensland; and more than $100million has been invested in community organisations. And if you visit places like Roma, Chinchilla, Dalby, Gladstone, you can see a revitalisation occurring in these towns as a consequence of that industry.

The other example I'd point to briefly is the one talked about, the United States. A couple of years ago, as was mentioned, they were looking to import natural gas from Western Australia. Today, the development of their onshore natural gas industry is employing 1.7million people in the United States. It's also attributed with being responsible last year for a decline in CO2 emissions in the United States by 3.8%, that's equivalent to 200million tons. Over the last four to five years the US has reduced its CO2 emissions by between 400 and 500million tons, that's double what the rest of the world has done since the Kyoto Protocol. So there's an enormous prize there if we can work out how to capture it, and a good basis for that is a really informed dialogue with those who have an interest in the industry, and I really thank the contribution that Tony, Robert and Peter made to this discussion tonight.

BABS MCHUGH: Stedman, if we can just clarify something: who owns the gas that's in the ground?

STEDMAN ELLIS: So the constitutional settlement between the states and the Commonwealth means that the gas beyond three nautical miles off the coast of Western Australia is Commonwealth gas, it's owned by the Commonwealth on behalf of all the citizens of Australia. Inside three nautical miles and onshore it's owned by the state government on behalf of the citizens of WA.

BABS MCHUGH: So if you're a leaseholder or a freeholder or you have native title, that particular resource –

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