



Future Energy – *The future of clean coal?*

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Since the beginning of the industrial revolution coal has played a central role in building the world as we know it today. For Australia, coal has been a dominant energy source and a major export commodity. Yet in a world committed to global decarbonisation, as represented by the Paris Climate Agreement, coal will have a future only if its emissions are dramatically reduced. However, the case for “clean coal” may be hard to make in a world where alternatives are becoming increasingly cheaper and the cost of new coal plants or refurbishing old ones remains very high. In our first Future Energy forum of 2017, our Panel to explored whether clean coal is a crucial step in the transition towards a net zero emissions economy or an expensive and retrograde step that will be almost impossible to finance.

Moderator: Maxine McKew, author and Hon Fellow of the Melbourne Graduate School of Education

Speakers: Tania Constable, CEO, CO2CRC
Tim Buckley, Director of Energy Finance Studies Australasia
Professor Michael Brear, Director, Melbourne Energy Institute

TONY WOOD: This is the first of our *Future Energy* series for 2017 in a partnership that the Grattan Institute and Melbourne Energy Institute have had now for several years, and hopefully it'll be one that will continue the series into the future. I'm the Energy Program Director at the Grattan Institute and my very simple task is to welcome you all here this evening. I also need to acknowledge the traditional owners of the land on which we're meeting in this evening, this is the land of the Wurundjeri people and I certainly pay respects to their elders past and present.

If you've not noticed that energy and climate change is an active area of policy discussion recently at the moment you have been in another country, because it remains an extremely fertile ground for those of us who dabble in this area and fortunately it keeps us off the street most of the time. This evening we're going to be discussing a topic that three or four weeks ago was the topic of the year and now seems like ancient history because we've moved onto the next one. The topic of clean coal emerged from almost nowhere and seems to have almost disappeared, maybe the clean coal's sitting at the bottom of the Snowy Hydro Scheme, I don't know. It even seemed to me when I thought about it, if you use coal-fired power to pump water up to the dams in Snowy Hydro, does that mean you've got clean coal and dirty water? I'm not quite sure how that's going to work yet but I guess people will sort that out in due course. This evening the topic is to explore the issue of what is clean coal, what does it mean, how does it work and how does it fit, and we've got several speakers who will be introduced to you.

Our moderator this evening is Maxine McKew. Maxine is one of Australia's best-known broadcasters, politicians and now academics. I'm sure many of you have seen or come across Maxine in one of those three roles, and maybe some of you in all three. So my simple job is to hand over to Maxine and welcome you this evening. I hope you enjoy this evening's discussion. Thank you.

MAXINE McKEW: Tony, thank you. Good evening everyone, it's good to see so many of you here for the first of the energy forums for 2017. Our topic tonight, as Tony said, is the future of clean coal and, just to elaborate on what Tony said there, I think what we've seen recently is really quite interesting. It's a messy, noisy and at times, certainly if you look at South Australia last week, a pretty confronting public debate, but I think we can say that at least we've now had the sense that there is an urgency about alternative public policy options. Yes, it's taken a blackout in one state, extreme weather in others and the certainty of higher prices for consumers and businesses, but that certainly has put the issue of energy security at the top of the agenda where it should've been all along. I think everyone in this room would know that we have actually wasted a decade in terms of what's been proposed and then what's been reversed, and here we still are, so let's hope the period ahead is more productive and more active.

Tonight we're going to hear three different perspectives on this question of clean coal and the extent to which clean coal can or should be part of the mix. We have three speakers tonight, each speaker will give us a presentation of around ten minutes, I'm going to follow up with some questions and then it's over to you, so it's an interactive session. We'll hear from Professor Michael Brear, who's the Director of the Melbourne Energy Institute at the University of Melbourne and he guides the Institute's research in the technical, economic, environmental and social areas of energy systems. We're also joined tonight by Tania Constable, who's the Chief Executive Officer of the CO2CRC that's based here at Lab 14 at the University. She was previously an advisor in both Treasury and the Department of Industry. We've also been joined by Tim Buckley, who's Director of Energy Finance Studies Australasia. Tim has a 25 year background in financial markets experience and is going to be considering the critical question of the financing and whether it stacks up when we look at coal.

So Michael, I'm going to ask you to lead off for us. Please welcome Michael Brear.

MICHAEL BREAR: Good evening ladies and gentlemen and thank you for coming along tonight, it's a real pleasure to have you here. I'll lead off and I'll probably try and be the straight guy a bit on this one, but we'll see how we go.

Clean coal, what do we mean by that? Clean coal means different things to different people, and we found that out while we were canvassing this idea over the last month or so. I reiterate what Tony said before though of course, which was when we first proposed this Scott Morrison was there in Federal Parliament holding a chunk of anthracite and all those other good things and we thought, "This is going to be the red hot topic for the next month or so". So are batteries and so is pumped hydro and everything else. Wowee, what a week! Clean coal means different things to different people, so if we talk to different people what do they take it to mean? Here's a phrase that many of you would've heard over the last month: high efficiency/low emissions (HELE). What do we mean by that? Here's a beautiful supercritical coal-fired power station, it's sitting outside Copenhagen in Denmark. I won't pronounce the name because I know I'll get it wrong, but I actually saw that power station when I was at a conference there about seven or eight years ago and it looks like a Frank Gehry building almost

doesn't it? That's a supercritical coal-fired power station, which means it basically operates at higher pressures than the ones we have in the Latrobe Valley, supercritical pressure.

Then there's ultra-supercritical, which is even higher pressure, so that's just basically saying conventional coal plants, in the sense that you burn coal to generate steam, but the higher and higher pressures you do that the more efficient it becomes and these are HELE plants. There are many variants of HELE plant, but ultra-supercritical and supercritical are out there operating. There are not many ultra-supercriticals in the world today, but they're established, workable technologies. So that's one type of clean coal plant as defined by others out in the community. But HELE plants, that is supercritical or ultra-supercritical plant, still burn coal, produce electricity and, in so doing, send the greenhouse gases up to the atmosphere through their flue gases, they just do it more efficiently than, for example, Hazelwood Power Station does. So there are still substantial CO₂ emissions if they're just running on coal, and I'll come back to that, so they're not zero emissions plant by any stretch of the imagination.

Then there's another kind of clean coal that some people would define as such, and that would be those power stations that are powered by coal but which have CCS on them, either with pre- or post-combustion capture; there are many different ways to skin the CCS cat. We have a fair idea of that, we grab coal out for the power station, we burn it, we grab the CO₂ and we stick it underground, for example. But CCS as a technology is not coal-specific, so you'll find generally people who are interested in CCS will not necessarily use the phrase "clean coal" because it's not a technology that's specific to coal. It can be used on the back of an ultra- or conventional supercritical coal plant; it can also be used on the back of an existing coal plant, we call that retrofit; it can be used on a natural gas field power station; it can be used on a biomass fuel power station. For example, that power station I mentioned previously outside Copenhagen can run on 100% straw or wood, and if we put CCS on that it would be a supercritical plant that was biomass-powered rather than coal-powered. The plant right now doesn't have CCS on it, but it can run on biomass. So CCS in power generation is not specific to coal, but it's also not specific to power generation. If you look at a lot of work that's been done on CCS it's looking particularly at steel production and cement manufacture, both of which are very CO₂-intensive processes as well. So by clean coal in this respect we would say a coal-fired power station that has CCS on it. So basically, clean coal, in my view, is either a HELE plant or a coal-fired power station with CCS.

How clean is clean? Why don't we just shut down every coal plant and replace them with a HELE plant, which was one person's idea. It comes down to how clean is clean? Here's a curve of the greenhouse gas emissions, what we call the emissions intensity on the left-hand side from zero up to two in this case, kilograms of coal per kilowatt hour of electricity produced, and then on the X-axis we have the efficiency of the plant that's generating that CO₂ and that electricity. So if we have a perfectly efficient plant, it's 100% efficient, zero, we get infinite emissions, we get no electricity out for burning CO₂, so not much of an achievement in that case. So how clean is clean for these different technologies? If we first look at what our references might be, a typical coal plant around the world right now, which are on average subcritical, so lower pressure plants, operate in the 30s of efficiency and they will have an emissions intensity above one, so 1.1, 1.2 is pretty common. The NEM (National Electricity Market) is actually an interesting thing, I was digging up last night what's the emissions intensity of the NEM and it's surprisingly hard to find it right now because some data is a

little bit old. But the NEM is lower than the emissions intensity of a current coal-fired power station because our NEM is not just coal, it's got gas in it and it's got rapidly increasing renewables.

So that's where we're at roughly speaking at the moment. In terms of a HELE plant, where would a HELE plant sit? Well they're about 50% efficient, give or take. That's where a conventional HELE plant would sit in terms of emissions and if we did co-gen, like that plant in Denmark, by co-gen I mean grabbing the waste heat and doing something useful with it and in Denmark in winter you take that heat from the power station and you use it to generate warm water which warms people's homes. So that power station in Denmark not only runs on biomass if it wants to, but it actually is used to warm people's homes in Copenhagen and surrounding areas as well, a substantial portion of the places. It actually gets 80% or 90% of the total amount of energy from that coal and uses it for either electricity or heating. We don't need much heating in Australia, certainly less than Denmark, so that's a bit of a problem for Australia, but what would happen if we stuck in some biomass, we put a little bit of wood waste in there? Our emissions would go down because we're replacing some coal with a renewable fuel and if we did the same thing with co-gen and biomass we're down there. So we're talking about, let's say, at best for a conventional HELE plant 0.75, a little bit lower than the NEM today but not a lot lower. But if we then did CCS on the back of a coal plant or natural gas plant we might get down to near zero, there's always a little bit of slip so we'll be, let's say, 0.1 worst case. Then if we did CCS on a plant that had coal and biomass or CCS on a plant that ran on biogas plus natural gas, because you could do that as well, you have the prospect then of not just having a zero or near zero emissions plant, but actually having a negative emissions plant. So we're grabbing CO₂ out of the atmosphere to grow trees, we're mixing those trees with coal and we're burying the lot. Some would say that the power sector needs to go to negative emissions if we're going to have a shot at getting down to where we need to get to by mid-century.

So what does this cost? Well, I'm going to use some numbers that came out of BRE a few years ago, they're the latest numbers that I can get hold of that are reasonably uncontroversial. Let's think about building anything, wind, solar, existing coal, new coal, CCS, retrofit and so on and so forth, and let's think about doing all that stuff relative to the incumbent, which we could say roughly speaking is a big black coal power station in New South Wales. That would be a reasonable reference. We could choose others, but that's one that's pretty reasonable. That big black coal power station in New South Wales produces electricity at around about \$40 a megawatt hour. It's a bit more at the moment, but that's for other reasons and the reference doesn't really matter much for this calculation. So we're going to say if we wanted to replace that with some new build anything or retrofit anything it would have a certain cost, and that's called the levelised cost of electricity, we won't go into the details of that now, and then we have this other thing called the cost of abatement. What's the cost of abatement? That's the effective carbon price that you'd have to charge to make that given technology compete on a level pegging with the reference. So if the carbon price is above the cost of abatement this thing will be scheduled in preference to the incumbent and if it's below it it won't be, roughly speaking. So the cost of abatement is defined as such. You can see an onshore wind turbine in 2025, roughly when we expect a CCS plant to be out there or a HELE plant, it'll provide a carbon price of about \$40 a tonne or more. Wind with these numbers would knock off a simple utility-scale solar, fixed tracking solar.

What about new build anything without CCS? Combined cycle natural gas, we factored in gas price increases here, which is a hot topic on its own, and you're talking about \$86 a tonne. So \$86 a tonne

means it's a more expensive form of abatement than wind and solar, that's a natural gas plant today and those in the area would know that that's a pretty uncontroversial result now. What about building a new supercritical black coal plant, one of these HELE plants? The effective cost of abatement is about \$100 a tonne, so it's more expensive than three other options that we can do right now in terms of achieving abatement. What about retrofit and new build with CCS? We get similar numbers, these are just calculations using the inputs of the BRE data and you see that the supercritical new build plants with or without CCS are not our most cost effective forms of abatement. So we see the two green ones, the renewables - and this is subsidy free - actually come out as the cheapest forms of abatement and then we get some other stuff coming in, particularly you'll notice there CCGT with retrofit CCS. What are the pros and cons of, as I've defined, clean coal? In terms of HELE, pros: lower emissions maybe, a little bit lower than the NEM, yes; it does provide system security benefits, just like big spinning turbines of any form provide, so that's a good thing, but its emission performance is reasonably uncertain. Cons: it certainly doesn't get you to where we want to get to by mid-century, so would we really do it, but there are some other issues that we'll talk about a lot more tonight around financeability.

So not only for a HELE plant would you have to probably encourage somebody to give you money, like a big government-owned bank, for example, but the question of whether or not they actually would compete in the market once they're built is not obvious. Then, of course, if there's going to be a carbon price put on, would this thing actually end up a white elephant of an investment? Coal plus CCS pros: very low, including potentially negative emissions; system security, it's got big steam turbines in it, that works; it supports, I suppose you'd say, Australia's current export profile, we're digging up a lot more energy and sending it offshore than we are here and maybe we should walk the walk if we're going to talk the talk on some of this stuff, but also there's some complementarity with other industrial processes, so if we're not in favour of CCS for coal, is it then logical to be in favour of it for cement production or steel production? Cons: financing, once again, and then of course technical and regulatory risk. So that's me done and I'd like to hand back to Maxine now.

MAXINE McKEW: Thanks very much. Tania, I'll ask you to take up from there, thank you.

TANIA CONSTABLE: Thank you very much for having me this evening. I don't have a PowerPoint presentation, but at the end I would like to address some of the issues that Michael has put up tonight. Just a little bit about the CO2CRC. Who are we? We have been in operation for the last 15 years. We were a co-operative research centre under the Australian Government Co-Operative Research Centre Program until the end of 2014. We now are a company limited by guarantee trying to stand on our own two feet with membership and making our way in the world with new commercial opportunities. We still receive some funding from the Australian Government and the Victorian Government, but we also receive funding from some members in the power, oil and gas, and coal sectors, and we hope to diversify into other industry. The thing about the CO2CRC is that at the moment we are the only company in Australia that has been capturing and storing CO₂ over a period of time. To this point we have stored at our Otway site, near Port Campbell in southwest Victoria, 85,000 tonnes of CO₂, and as we speak today we have another operation in place where we are doing further research and development around CCS. So that's a bit about us.

Now I want to go to the big picture. First of all, if you believe the eminent scientists within the Intergovernmental Panel on Climate Change (IPCC), and some of those scientists are represented

here tonight, I would like to note and acknowledge them, then at a global level we must achieve a net zero emission outcome at a global level in this century. So what does that mean? That means that we need a diverse range of solutions, including clean coal technologies. I'm only going to specifically focus on CCS tonight. CCS is essential to a fast trajectory towards a net zero emissions outcome. It is essential and if we don't have it, it is going to be a much more costly option at a global level and here in Australia over the longer term. Importantly, a carbon-constrained world for all of us will affect every industry and every household, so we need sensible planning for this diversity and we need to start that now. Tony made a couple of comments about the debate that's been going on over the last few weeks, but I don't think that should've been the starting point. We've had four or five energy white papers over the last 20 years that have raised the issues that we have been seeing in the last few months and traversed those with great depth and with a comprehensive approach in Australia over a period of time. I want to talk a little bit about that later on in this discussion.

Back to CCS, we hear that CCS is an enabler for coal. That's true, it's an enabler for gas processing, but it is also an enabler for many other industries' industrial processes. Cement, steel, fertilizer: none of those industries have other cost effective options. There are options, but there are no cost effective options at the moment. CCS offers an opportunity, an option to decarbonise all of those industries at a faster rate, so we need to continue to work on those options, as we would continue to work on renewables. I am a big advocate for renewables, I think the more renewables we have in our system the better Australia will be and the better we will be at a global level. Let me return to clean coal just for a moment. What does it mean for Australia? We're a leading export nation of natural resources; it is and should remain our comparative and our competitive advantage. We have an abundance of natural resources, we're blessed with sunlight, blessed with wind, we have good hydro resources, we have uranium, we have coal and we have gas. We should be using them all to the best advantage of Australia. Our export potential every year runs to over \$80 billion across these natural resources on an annual basis and we shouldn't lose sight of that fact. But the energy policy as we see it hasn't really been focused on the upstream sectors that I've just been talking about. Over the last few years it has become an electricity debate on how we integrate renewables onto the NEM grid and other grids in Australia.

In providing domestic energy to Australia on a daily basis, coal makes up around 85% of total electricity and that is after the deployment of renewables onto Australia's electricity grid. Coal has and will continue to have a place in our energy mix as long as it can decarbonise by using technology such as CCS. The quality of the public debate suggests that there is a lack of understanding of how the end-to-end operation of the electricity industry works, the money involved, and the commercial risks faced by industries. The focus in the press is on the cost to mums and dads and how solar PV and batteries are going to save us a fortune. However, what is unsaid is that this sector is less than 30% of the energy traded overall. There is also an energy cost to industry. Heavy industry and the commercial sector make up the other two-thirds of the debate. When climate and energy decisions are made to support specific sectors we send a corresponding negative signal to investors in the other energy sectors. Investors who have sunk billions of dollars of capital within Australia; investors who can make alternative decisions to take their manufacturing businesses overseas, and they do and they are continuing to do that right now; and to investors who choose to close up shop due to lack of political and policy support. Hazelwood Power Station closes in less than eight days.

I'm glad that some of you clapped, because you're here in Melbourne as we're having this debate. The people that I talk to in the Gippsland region and in the Latrobe Valley are employees of that particular power station and other power stations. They are in high value jobs and they have around them high value service jobs. The power stations in those regions and the industries that sit around them are the mainstay of those particular regions and we see this around Australia. They don't have to disappear. The people in that community don't want them to disappear. Regions that have coal-fired power stations around Australia don't want to see them disappear. What they do want and what they should expect is for those industries to decarbonise along the way, and those particular communities, as we speak, are en masse visiting Canberra politicians, ministers and their shadows, talking to them about what the opportunities might look like when the lights of the Hazelwood Power Station switch off. We think there's a pathway through and we've been doing a considerable amount of work to try and look at how we might decarbonise some of these power stations.

Michael talked about the levelised cost of electricity around some of the industries. Work that we did in the CO2CRC with 45 other organisations across Australia, including from industry, government and the research sector made up of renewables, coal, gas and other industries, looked at the levelised cost of electricity across all of those sectors and we came up with a range of costs. Michael wasn't using those numbers, he was using 2012 numbers, but they were comparable to those numbers with some updated figures. We've seen some learnings occur across renewables and across coal and gas with CCS retrofitted around the world over the last couple of years. In particular, CCS retrofitted to a range of industries, first of a kind, and also to the gas sectors are starting to come down the learning curve, as we're seeing still with wind and solar that are fast also coming down the learning curve. What we didn't do in that report in 2015 was provide information around retrofitting brown coal and black coal power stations. We've sought to update that information and only in the last week we've put out a new study about retrofitting CCS onto black coal and brown coal. What this report shows, and they are conservative numbers according to companies that we have talked to in the US and here in Australia, is that CCS retrofitted on part of a brown coal and a black coal power station can help decarbonise those power stations and get an industry up and running, so we have it available for full retrofitting power plants but at a reasonable cost and at a cost that is comparable to solar PV single axis right now. We're right on the money in terms of solar PV.

Oil, gas and manufacturing can also be retrofitted with CCS and utilise the existing hub and storage infrastructure available. Work that we continue to do across industry and across the research community is looking at how we might share the resources that are here in Australia and share the infrastructure in a hub approach with a range of customers to decarbonise. Coal and gas-fired power stations will form part of those hub opportunities, particularly in the Latrobe Valley, particularly in Queensland in the Surat Basin and in North Queensland when we're talking about gas processing. So how do we get CCS up and running? There are a number of policy changes that would need to be made to achieve investment for CCS in Australia. These changes include lifting the prohibition on CCS under the Clean Energy Finance Corporation. That would be a good first step. The unfortunate thing about that prohibition is that it doesn't prohibit HELE coal-fired power stations; it just prohibits CCS and nuclear activity. So that's a good first step. Expanding the RET (renewable energy target) to include other low emission technology including CCS would be the second step, bipartisan support for an emissions intensity scheme and expanding ARENA's (Australian Renewable Energy Agency) mandate to include CCS all offer opportunities without detracting from the renewables sector. CCS should be just sitting alongside the renewable sector as an opportunity to decarbonise.

My final point before I move on is that CCS is an enabler of these industries that we've been talking about and should take its place alongside renewables. I look forward to a roundtable in which government, industry, fossil fuels, renewables and manufacturers start to work together to achieve a better, reasonable cost energy and climate outcome for all Australians. I think that will place us in a much better position than we have been over the last couple of years where we have had this debate raging around renewables versus coal and gas. I think that it is time for these industries to start to work together because the bigger picture is about making sure we decarbonise at a global level including in Australia. Thank you very much.

MAXINE McKEW: Thanks Tania. Tim, I'll ask you to give us your presentation. Thank you very much.

TIM BUCKLEY: As the Head of Rio Tinto's Coal Division said three years ago, it is a Sputnik moment. Technology change is rapid, far faster than anyone thought possible, and action is needed now. Rio's board has spoken. Rio has exited thermal coal globally and in that same three year period the cost of renewable technologies has halved. I'll touch on Kemper. Kemper is a US clean coal plant, US\$7.1 billion of capital expenditure and it's a white elephant. Three times the original budgeted cost, they finally turned it on last month. This month their CEO announced, and admitted, that the Kemper clean coal-fired power plant is up and running at long last but it's burning gas; he can't make coal work.

Now I could just rest my case there, that's clean coal in a nutshell, it doesn't work according to the CEO of the biggest clean coal plant in the world, the most expensive coal plant in the world, but China. China's entire electricity system growth since 2013 has been supplied by zero emission technologies. Coal use in the Chinese electricity market has declined since 2013, but one then might ask why would China have built 200GW of new clean coal technology plants in the last four years, \$200 billion of investment, in idle new capacity? They got it wrong. Their power utilisation rates for thermal power generation hit an all-time record low of 47.5% in 2016 on average, in other words their coal plants are operating less than half the time. Europe, we're talking stranded assets and Europe epitomises that. In the last week we've seen what used to be the two biggest European utilities, RWE and Eon, take a collective €21 billion write-down on their power assets. Ng, EON and RWE all commissioned new HELE coal plants in the Netherlands in 2015 and all three of them wrote them off 12 months later. So in light of the evidence of the three biggest European utilities writing off their clean coal investments that were only commissioned in 2015, I would ask what sensible commercial bank, absent taxpayer subsidies, would fund the next clean coal experiment?

Turning back to Asia and in India they've built 100GW of coal-fired power plants this decade. Almost none of them use ultra-supercritical technology. Now Energy Minister Piyush Goyal has announced that India does not need to build any new coal-fired power plants in the coming decade. India was the last big bastion of global growth for coal and the Energy Minister has said no new coal-fired power plants are required for at least a decade and then we'll see. Asia is now considered the last bastion of growth and I would argue that, absent government subsidies, coal-fired power plants in Asia won't occur. You might ask why, coal is the low-cost source of energy? Let's just take one power plant proposal, the Rampal Power Plant in Bangladesh. Rampal, a 1.2GW coal-fired power plant, was going to cost US\$1.2 billion, now it's US\$2 billion but it depends on US\$3 billion of subsidies; US\$1 billion of financed from Export-Import Bank of India, US\$1 billion of Bangladesh Government funding of the dredging to get the imported coal in, and a 15 year tax holiday, another \$1 billion

subsidy. So a US\$2 billion requires US\$3 billion of subsidies, but at least it's clean coal. That's right, it's not, it's supercritical and it's using ten year old technology from India.

Let's turn back to China. Shanghai, the cleanest, most efficient coal-fired power plant in the world has a net thermal efficiency of 46.5% net, but the AFR reported on this six months ago, they quoted the Professor of Engineering who built the plant and he says it runs on Indonesian lignite. Not high quality Australian thermal export coal, but lignite. In other words, it's the technology in the power plant not the coal import, so we should be talking clean power plants not clean coal. Japan is pushing for a renaissance in coal if you talk to their utilities. I was there a month ago and while I was there Marubeni Corp announced that they were building a 1.2GW solar plant in Dubai, US\$24 a megawatt hour. There is not a coal plant in the world that can compete with that, US\$24 a megawatt hour. The IEA this week has said that non-CCS coal power needs to be phased out globally by 2035, they said that this week. If the world is to deliver on our climate agreement from Paris, 2°, all non-CCS coal must be phased out. Absent taxpayer subsidies, clean coal is non-bankable. We only have to look at the cost of wind and solar in an ever-larger number of markets, it's US\$24 to US\$50 a megawatt hour, no subsidies. India just did a US\$44 a megawatt hour solar plant, US\$750 million, 1% indexation for 25 years. Not a single new coal plant in India can compete with that and the cost is dropping 50% year on year, coal can't compete. I would ask what is the cost of CCS HELE electricity, and then compare it to solar or wind at US\$25 to US\$50. Thank you.

MAXINE McKEW: Thank you all for very comprehensive and clear presentations. We're going to come out to our audience fairly soon, but let me just kick off. Michael, you talked about Denmark and you've just talked, Tim, about Kemper. How do these two marry together? Does it work? Michael, you were saying Denmark works?

MICHAEL BREAR: The power station functions, it's running higher than 47.5% of the time and it's providing electricity and district heating to the people of Copenhagen. That's a supercritical coal plant, it's not the ultra-supercritical but it's there and it's running. Maybe in terms of super-clarity, by clean coal I opened by saying is it HELE plant or is it coal plant with CCS? Maybe we need to be very clear about which of those we're talking about in this discussion throughout.

MAXINE McKEW: And the Kemper one is?

TIM BUCKLEY: It's supposedly an ultra-supercritical gasification plant. I'm not an engineer, I just look at the numbers.

MICHAEL BREAR: correct me if I'm wrong, it's what's called an IGCC (integrated gasification combined cycle) plant with CCS and I think that's right is it? Yes.

TANIA CONSTABLE: It's a 582MW electricity generation plant. It is certainly over budget, it was over budget and over time, just like any other first of a kind technology anywhere in the world, and part of the reason it is over budget is it could've been better project managed. There was a lot of learning as the project went on and also there was a lot of gold-plating. Because the company didn't want to make mistakes in terms of risk, they made sure that they gold-plated every part of the plant. That means that the next time that one is put in place around IGCC it will be cheaper. Everywhere in the

world, including Kemper County, is saying it'll be about 30% cheaper to put the second of a kind on a particular technology into play.

MAXINE McKEW: Okay, but is anyone going to do that given that you've said they've gone to gas?

TIM BUCKLEY: The CO has just announced this week he's using gas, he can't use coal. And you say it's a little over budget. It's US\$7.1 billion, so it's 300% over budget. No financier in the world is going to finance a US\$5 billion...

MICHAEL BREAR: Could I add a little bit in there? On the technology, IGCC, you get coal, you gasify it, you turn it into a mixture of hydrogen and carbon monoxides and then you run that through a turbine. That's a different beast to just burning coal directly in a boiler and grabbing the CO₂ from the exhaust. The gasifiers on their own are widely used and they're very scary, very expensive devices, and personally I don't understand why they did an IGCC plant with CCS. There are much lower risk ways of achieving CCS. They really bit off a lot to chew on in that first...

MAXINE McKEW: Michael, can I ask you then, because I want to talk about this question of global markets and what's happening, how you see the US market? Are there going to be more Kempers, as Tania suggests, and they will learn from what happened there?

MICHAEL BREAR: Well, any technology you learn by doing and that's a well-established thing, but they have to compete and if you've got something that's three times over budget that's going to be harder than if it was much less than that. But I remind the audience, I think state government when they built the fast rail to Ballarat budgeted for \$300 million and spent \$800 million. So it's not just Kemper County that gets big Capex plays very wrong, we do that all the time.

MAXINE McKEW: Okay. Tania, can I get a reflection from you on what Tim said, which is basically he went around the globe looking at Europe, looking at Asia, and the overwhelming message there seems to be that these things do not stack up financially, the clean coal argument?

TANIA CONSTABLE: Again, I'd come back to these are first of a kind power stations or CCS on industrial processes. There's a range, there's 21 commercial projects around the world on different types of industry. Of course, they're going to require subsidies but, as I said, we see that across a whole range of technologies. We've seen it with renewables and renewables continue to be subsidised. They will need to be subsidised both on Capex and Opex until they get up and running on their own. I would like to say on Boundary Dam in Canada, where there are commercial opportunities involving other industries, enhanced oil recovery, they become much more commercial, so the view by the project manager at Boundary Dam is that if they were to build that again they would need very little, if any, subsidies on the next brown coal-fired power station. So that's saying it's becoming more and more commercial and where opportunities exist where you can add in enhanced oil recovery then it's a commercial opportunity. So I'll probably disagree with what you're saying on that one and say that yes, I think that we're getting better, the learnings are getting better around the world.

MAXINE McKEW: Yes. Tim?

TIM BUCKLEY: Boundary Dam is a great one and, as you say, if CCS is going to work anywhere it's enhanced oil recovery. But let's put a few numbers on Boundary Dam, it was CA\$1.3 billion for, what,

110MW? So it's about 12 times more expensive than your average new coal-fired power plant anywhere else in the world, 12 times. So if we get a 30% learning, then it's only going to be nine times more expensive than your average run of the mill coal plant being built as we speak in the world. That's why Boundary Dam, even with a CA\$100 million government subsidy, is non-viable. There's no way it's going to ever deliver a return on that investment other than if oil prices were \$100.

TANIA CONSTABLE: Which we do see oil prices fluctuate. I think this could become a debate between Tim and I here.

MAXINE McKEW: Well there's a clear point of disagreement there. Tim, I think the interesting question too is what are the internal conversations that the banks and other largescale financial institutions are having? Even if governments choose, say, the Bangladesh situation when financial institutions look at the risk in that, what determinations are they coming to?

TIM BUCKLEY: There is not a single dollar of commercial bank funding in the Rampal Power Plant. In Indonesia they've talked about 20GW of new coal-fired power plants being built, they're only five years behind schedule, and all of them rely on Japanese, Korean, Chinese or Malaysian ECA (Export Credit Agency) finance. The big debate in Indonesia, and we're about to put out a paper on it, Japan's Government is funding 100% of the debt finance. There's limited private finance in there, they are insuring the power plant that they're building and then they're turning around to the Indonesian Government and saying, "We want a sovereign government guarantee from Indonesia - as well as the Japanese Government guarantee - before JCF can go in and fund it using public money".

MAXINE McKEW: Okay, so is that viable for this transition period?

TIM BUCKLEY: Well Indonesia's all mine mouth coal, so if you can't make coal work in Indonesia at the mine mouth for the biggest growth market in Asia I don't see how it's going to work with expensive imported coal. But let's roll back to India, you mentioned that renewables have relief on massive subsidies in the last five/ten years, Germany subsidised renewables enormously. I agree, it was a massive 20 year subsidy by the German Government, it's the most altruistic thing any government's done in energy in 20 years. But we're not 20 years ago. India is not providing a dollar of subsidy for its renewable energy. The Indian solar option of last month was done at \$44 a megawatt hour fixed for 25 years flat in nominal terms, so declining 4% real per annum for 25 years. So deflation, they deem contractually for 25 years not a dollar of subsidy. A month later India announced a \$1 billion wind option, 1GW, not a cent of subsidies and, again, the wind price came down 20% to 30% on what it was a year ago. No subsidies. So I think we're beyond subsidies and in fact the IEA has been saying, "Let's stop subsidising everything and let's have a technology-agnostic view" but the only way CCS is going to actually be funded without subsidy is a very high carbon price. So I'd call for a very high carbon price and let CCS stand on its own two feet.

MAXINE McKEW: Yes. Michael, can I get a comment from you on that?

MICHAEL BREAR: I think that's reasonable. I'm not sure if I agree with all the stuff about \$44 and whatever in India. The other example in Dubai, there's some really very sophisticated financial engineering that's going in to structure those PPAs.

TIM BUCKLEY: No subsidies, zero subsidies. There's a 25 year PPA.

MICHAEL BREAR: Yes, but who's providing the debt and at what rate compared to, for example, in Australia?

TIM BUCKLEY: Japan's providing the debt.

MICHAEL BREAR: Well, if we're translating some of this stuff to Australia, if we did an IEA play and got rid of all subsidies we'd get rid of the RET and what would happen to investment in renewables in this country if we had no RET? That would be pretty scary I think for renewable investment. But if we switched over to a carbon price and we had a high enough carbon price to stimulate CCS investment we would first stimulate renewables investments for sure.

TIM BUCKLEY: Correct. So get rid of the RET, get rid of all the subsidies for coal, just have the best person win and have a price on carbon to price in some of the externalities of all technologies. I'd agree to that solution tomorrow.

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

TANIA CONSTABLE: I think if the governments had their way they would get rid of the RET right now and I think it's fair to say they probably won't want to see it extended past 2020 on renewables, and renewables are saying they're standing on their own two feet. But there's a tail-off right through to 2030, so renewables in Australia will continue to be subsidised through to 2030. What we don't have is a level playing field for the power stations that are in play right at the moment. Industries have invested in those coal and gas power stations now and we're getting baked in carbon that is occurring over a period of time, but at the moment the RET is not being utilised to the full extent. Why not, if it's going to stay there for a little while, open it up to other low emissions technologies and let them compete on a level playing field with renewables? That gives us the best opportunity on a whole range of options. It's actually having those options. It's not replacing renewables, it should sit alongside renewables in terms of a least cost approach to energy and electricity in Australia and internationally.

MAXINE McKEW: Let's go to the audience.

AUDIENCE: As far as I understand, there are only two significant CCS power stations operating in the world, Boundary Dam and Petra Nova, which are sequestering 2.5 million tonnes a year of CO₂ and if Kemper ever gets cheap coal then we'll be up closer to 6 megatonnes a year. That might sound a lot for the \$10 billion that's been spent so far, but next week when Hazelwood closes it'll abate 16 megatonnes a year, so more than every CCS power station in the world, and that'll join the nine others since 2012, bringing our total abatement from coal closures to 30 megatonnes a year for Australia. What's your prediction for the year where power station CCS will abate more CO₂ than coal station closures?

MICHAEL BREAR: I'll go first. My prediction, that's a good question. If we go back to this, ignore political pressures and other things, we whack on a big carbon price, let's call it \$100 a tonne or \$80 a tonne or something like that, let the best technology win and then there are other markets for providing system security and other things, you might get Snowy 2.0 or batteries in Adelaide or pumped hydro in South Australia or whatever filling that mix. I generally am agnostic on that. When does CCS come into that? Well, it'll come into it when the system requires it to come into it. I don't

know of a technology that can provide that kind of system security that we do need that we can really say with confidence can do the whole job without requiring big lumps of spinning metal. That might be synchronous condensers in pumped hydro, it might be combined cycle gas, it might be a biomass-fired sugar cane power station in Queensland, but to take CCS off the table forever is to me a brave statement. It's an option that I think we need to consider.

AUDIENCE: That's not my point...

MICHAEL BREAR: I know. It comes down to how long we can securely and reliably operate the system without using it, and that's a deeply uncertain problem that I don't have the answer to.

MAXINE McKEW: Do you want to make a stab at it?

MICHAEL BREAR: For example, if we have three very, very hot days of 45 degrees in a row next February, as we did in the depths of our terrible drought, without Hazelwood Power Station sitting there, okay, we've abated a lot of CO₂ but will we have a secure and reliable system? I haven't done those numbers, but from those people who have they are, I think, concerned about that.

MAXINE McKEW: Tania?

TANIA CONSTABLE: At the end of 2015 the situation that we faced in South Australia was predictable. As we have added renewables onto the system there have been challenges with that and the way that we have gone about our energy policymaking in Australia, both at a state and at a Commonwealth level and them not working together, has not accommodated those changes that are being made. What we haven't got with more and more renewables coming onto the system is that balance, that flexibility, the 24/7 reliable energy that coal and gas add to the system that we need to balance out the system. So I don't think any of this is going away, there will be changes that will be made to our energy rules and regulation within the Australian Energy Market Commission, there will be changes made to the way that the system is regulated and operated to accommodate those challenges as we've seen in different phases around the world, and there are three or four different phases that are in play around the world; we just happen to sit in the second phase of all of those challenges here in Australia. That will continue, but we can't lose sight of the fact that Australian people want 24/7 reliable energy. They don't want blackouts, they don't want brownouts, and they want to achieve that energy at least cost. So we need a combination of these things, which means that we need to decarbonise our coal, our gas and our industrial processes right now.

So I think that we're going to need a lot of policy support and overt policy support coming from governments and captains of industry with public-private investment occurring at the same time before we see CCS as a natural course of operations within Australia and around the world. But we are starting to see the change, 22 big commercial plants around the world are now in play and I think that we will start to see that very shortly in Australia, at least LNG gas processing next year. That is a CCS. It's the biggest project in the world, it will be 3 to 4 million tonnes of CO₂ per annum that is abated off gas processing, and I think that we will see something applied to a coal-fired power station retrofitted in the not-too-distant future.

MAXINE McKEW: Okay. Tim?

TIM BUCKLEY: My two colleagues have talked about Australian system security. I might answer the question. The question was when. My view is never, but I'll just quote the IEA. The IEA's last report said, "We don't think CCS is a commercially viable technology before 2030". The world needs to move today to deliver on the 2° limit and the IEA has ruled it out in the forecast out to 2030, so they've said beyond 2030 CCS might have some role to play but it's not commercially viable and it's not being invested in today in any commercial way. There's \$1.8 trillion a year invested in energy globally and CCS is not even on the drawing board in terms of that level of investment.

TANIA CONSTABLE: But we are seeing the investments occur now. So 2030 is when we'll see it normalised, which means planning needs to occur now for long lead time. So 2030 in terms of large amounts of CCS, but the fact is - and I think we did answer the question - it is occurring now, we'll just see more and more coming on as mainstream in 2030. That actually gets to the heart of decarbonisation at a global level at that mid-century point because we've got so much coal coming on at a global level.

TIM BUCKLEY: Where?

TANIA CONSTABLE: China, India.

TIM BUCKLEY: China coal consumption peaked four years ago, 2013.

TANIA CONSTABLE: It's about the numbers coming on. It might've peaked but there are more and more coming onto the system as we speak. It's not a matter of all renewables. We have more and more coal-fired power stations up and running around the world in Asian countries right now.

TIM BUCKLEY: China is half the world's coal production and consumption. It peaked four years ago, it declined by 4.7% just last year alone.

TANIA CONSTABLE: It's not about peaking, it's a matter of how much we've got coming onto the system, so it's about volume rather than peaking...

TIM BUCKLEY: Peaked. It declined three years in a row.

TANIA CONSTABLE: And the more and more we have the more and more it adds to the carbon budget, and we only have a limited carbon budget. The more and more coal and gas we do have coming onto the system at a global level the more and more we will need to decarbonise. So it's not a peaking issue, it's a matter of decarbonising what's already in the system or coming onto the system or planned in the system right now at a global level.

MICHAEL BREAR: Tim makes a fair point. I'll give a more categorical answer. You're dead right, right now we should be going as hard as we possibly can and right now that means building lots of renewables. I'm a fan of the RET and it's a great thing, I'd extend it, do all those good things, that would be a jolly good thing because it's the cheapest form of abatement we have right now. We're not going to build and operate a CCS plant and have it running before the late 2020s, even if we decide to do one right now. Out beyond 2030 I haven't got a clue what the world's going to look like and this is where I'm going back to before. I can't see it happening much before 2030, actually operating, but beyond then if you've got a technology that can provide all these good things, allow us to even go to

maybe negative emissions in electricity, show it to me and I'll support it, but taking it off the table is something I'm not willing to do.

AUDIENCE: I'm missing the energy debate because energy is, as you highlighted, co-generation. We've been chucking away all the waste heat in our coal-fired power stations. Why are we not focusing on that 75%? It's off-the-shelf components, it's heat exchange, it's insulated pipes, you can heat and cool communities around those power stations. That should be the debate, in my opinion, and that should be highlighted. There are 5,000 of these projects around the world, the very large Australian superannuation funds want to have them happening everywhere and they're funding the big ones in Copenhagen as well.

MAXINE McKEW: Okay, anyone want to comment on that?

MICHAEL BREAR: Co-gen, I'm no expert in it. The brief numbers I've done on it says that in a warm country, like ours, it's much harder to make it work commercially than it is in a cold country. Now, you can provide cooling with the heat, I know all that stuff, but it's harder to make it stack up economically. No-one's going to argue against greater energy efficiency, of course that's a very good thing to do.

TIM BUCKLEY: I'd mention Colonial First State, our biggest superannuation investor in Australia, two years ago bought a district heating business in France. It's one of their biggest renewable investments to date and the vast majority is funded using renewable energy technologies, biomass, waste to energy and so on. So Colonial First State is betting that you're right, that district heating is absolutely key and it can be done with renewable energy.

AUDIENCE: A question to Michael. In your cost comparisons, and I think it was Oscar Wilde who said comparisons are odious, but we do have to do cost comparisons in this debate of different sources. Do your levelised cost comparisons in the case of the wind and solar factor in the cost of storage to deal with intermittency and also the cost of dealing with the lack of synchronous generation coming from some of those sources? Could you background us on the nature of the comparison costs please?

MICHAEL BREAR: No, they don't include those numbers. This is a levelised cost. You've got to be a bit careful using the LCOE number, but that's a fair point. The way I think about it, it might be useful, is we're incrementally changing the system every time we put a new plant in or take an old plant out, so unless there's so really substantial change required to the system when you put that next one in, that's the incremental cost and incremental benefit. But you can't keep doing that ad infinitum, I don't think anybody's suggesting that.

TIM BUCKLEY: The EIA (Energy Information Administration) of America, so the American Government, put out a paper two years ago analysing the Texas market. Texas is probably the biggest state in the world in terms of wind generation, 16GW, 18GW of wind, and the EIA highlights the variability of electricity prices both positive and negative, but the variability has shrunk by about 95% over the last five years as Texas has doubled the amount of wind and quadrupled the amount of grid interconnectivity. So the combination of those means the biggest wind market individually in the world is Texas and the variability of pricing has shrunk by 90%+ in the last five years. There are no

grid stability problems in Texas and the pricing absolutely supports that. That's information straight off the website of the EIA, happy to send it to anyone who wants it.

AUDIENCE: I'm just seeing that there's very little time-bound analysis, so it's as if it's all static, and we have enormously reducing prices on renewables where you have to think about that mythical god particle where you can't sell zero like Kodak. There's also the idea that Mark Carney talked about of a possible fiscal cliff with stranded assets as we're more and more worried about carbon and we've got things like the Totten Glacier, the largest source of ice in the world, now slated to collapse. The last thing, what about putting into this dynamic mix players like *Jally(?) with virtual power plants where you're integrating value right across from network retail and behind the metre spaces? I'm just wondering, if you try and toss all that together where do you get with your numbers over the so-called 40 year life of these clean coal plants?

MICHAEL BREAR: That's a very good point. I was saying before, I've got no idea what the future's going to look like and there's all sorts of opportunity for extraordinary innovation in many parts of this system, a virtual power plant in a local community right through to making wind turbines more dispatchable and having more synthetic inertia and all these good things. So your point is a very good one. Things get cheaper all the time, that's true of a Commodore versus a Kingswood, it's going to be true of a wind turbine in 20 years' time compared to a wind turbine today. It'll be better and cheaper than it is today, I guarantee that.

MAXINE MCKEW: Tania, do you want to respond to this one?

TANIA CONSTABLE: I would agree. I would say every technology is going to cost more until we get the learnings right across a whole range of technologies. Relating to the point that Michael made in the cost of wind coming down, I would also say that the cost of HELEs and the cost of CCS, and specifically CCS, will also come down over that period of time. That point is around it's not just one versus the other. We've got carbon in the system and we need to take it out of all of the power stations including renewables, because the componentry of renewables is involving a whole range of industries, not least of all the petroleum and the coal industry, to make those component parts. To get all of that carbon out of the system we need a whole range of solutions and the costs are coming down. The 22 projects and the projects in train are decreasing the costs of CCS overall.

MAXINE MCKEW: Can I just throw something in here? It is a truism to say that we are living through a period of indifferent if not really crook public policymaking in Australia, yet everything I'm hearing suggests that we need people of immense wisdom to bring all of this together and in the right timeframe. Let me bring this back to exactly what you were talking about Michael. My worry would be that if Victoria gets extreme weather next summer and has some kind of South Australian problem you'll be in an even worse situation because the natural, instinctive response from the political class will be to go for the set of quick fixes that are inimical to everything we're talking about.

TIM BUCKLEY: Black Rock has given us the answer. Irrespective of what Australia does, as you said, we've had a decade of policy failure and we've got a problem as a result. So, as you say, if we have a heatwave next summer caused by climate change our grid's not going to cope with it. I'll agree 100% with that. We're not going to get system security, whether we fund CCS or wind or solar, in the next 12 months because we can't fix a decade of policy failure in a year. But the biggest investor in the

world is Black Rock - \$5 trillion of investments - and they will determine where money flows on a 40 year view. Finance will determine where the money goes globally. It won't be our government, our government will respond to pressures and failure to invest and the money will just be invested offshore. So what does Black Rock call for? They say the solution is really obvious: put a global price on carbon, do it today and do it really high, and let the market determine the lowest cost solution. Get rid of the RET and put a price on carbon. It doesn't need to be \$100, put it in at \$40 or \$50.

MAXINE McKEW: Well, as I say, we're a long way from that.

TIM BUCKLEY: We are, but that's what the biggest investor in the world is saying and what did Korea do this month? They put a \$29 a tonne price on coal imports. So Korea's acted and they're our third-biggest buyer of coal. They've acted.

MAXINE McKEW: Michael?

MICHAEL BREAR: I agree, but I look forward to a Prime Minister who whacks that \$40 or \$50 a tonne carbon price on there and see how they go getting re-elected, or elected at all.

TIM BUCKLEY: Well then do what the American Republicans are calling for, let's hand every Australian citizen a \$2,000 cheque and we'll put up the price on carbon on the flipside. So we price on carbon, we give a dividend back. I don't care how we do it, whether it's a carbon tax, whether we reduce the deficit, we do have a major budget deficit. We actually need to encourage energy efficiency, we need to reduce carbon emissions, so let's do it in the most cost effective way. Black Rock says the most cost effective way is a price on carbon. I'm with the biggest investor in the world.

TANIA CONSTABLE: We saw a price on carbon, we saw a carbon tax and we saw money returned to low income earners around Australia.

TIM BUCKLEY: Did we or we saw it returned to the power companies?

TANIA CONSTABLE: No, that's actually not correct. We did see it returned in a form of subsidy to low paid workers and the most disadvantaged in Australia, but we didn't see a lot of change during that time. We had a quasi-price on carbon through the RET. That was what drove the change in what was happening in the renewables sector, but we didn't see any sort of movement on coal and gas. So I would agree, we need to see a carbon price in Australia but we're not going to see that in the short term. That is an absolute given. We're not going to see a carbon price. What is most effective and why we have seen Gorgon up and running in Australia is because it's being regulated. The Western Australian Government said to the Gorgon Joint Venture, "If you want this gas processing plant up and running then you need to decarbonise, you need to put CCS on your plant". So they have done that in Australia. We have seen movement in the US and in Canada because of regulation. We have seen no movement in Europe because Europe works on a very, very low carbon price, there's not much happening at all in Europe around coal and around gas.

So if we want the most effective approach then I would argue, as do some others, that regulation is the way to go, not a carbon price which is set very low because of political sensitivities around votes anywhere in the world.

AUDIENCE: This question of system security is a bit of a furphy. The problems of low inertia systems were known at least five years ago, this is not something that's not been known by the engineering community and even over three years ago AEMO did a study and the problems of security and the particular problem of South Australia was known by AEMO, but they did nothing about it. No incentives were provided to ensure that the higher level of inertia was maintained and without those financial incentives nothing happens. So the problem is that the regulatory bodies have actually been asleep. The other thing of course is that there needs to be a paradigm shift in terms of how you manage power system security. You need high inertia on a network when your security is dependent on synchronous machines because you need to keep them synchronous. You're also dependant on very prudent advice, the rate of change of frequency relay to manage the security and do load shedding, and these things are not even being set properly. The other thing of course is that with renewables the output of the renewable is a controllable solid state device.

In other words, you can control its output so that you can manage how the system behaves under fault conditions in a different way and you need to look at the proper management of system security in terms of the old way of doing it, but taking advantage of the way the outputs of renewables can be controlled and managed for system security. I don't know if you've got any comments?

MICHAEL BREAR: I agree with everything you're saying. I'm not a power system engineer and I'm guessing you are. I'm a mechanical engineer, I know enough about this stuff to be dangerous. You opened with saying it's a furphy, AEMO knew about this years ago. They indeed did, that doesn't mean that therefore it's a furphy. Just because the system didn't behave as we would've liked it to behave doesn't mean it was a non-issue. Related to Tim's point, can we design agnostic markets, incentives and regulations and let the best solutions provide the services we want, be that clean electricity or stability, that might be a battery, it might be a spinning pumped hydro pump that's operating in synchronous condenser mode? We would hope all of those things could compete on a level playing field. I don't want to speak on the market operators' behalf, but I don't think anybody's suggesting that the system and its design need urgent updating.

TIM BUCKLEY: I would agree 100% with what you said. We need bipartisan long term planning for a long term system overhaul. As to engineering requirements, I would just look at what the biggest grid operator in the world says. China State Grid, their chairman has made it clear there is absolutely no engineering problem whatsoever that can't be solved; the only problem is mindset. That's the biggest operator in the world. He's also incorporating more renewables than any other grid in the world and he's doing it very, very clearly. That's his answer: have a long term policy and get on with it. That's how the Chinese do it and they're doing it.

MICHAEL BREAR: I agree.

TANIA CONSTABLE: I actually don't think it's mindset. This comes down to cost and who pays, and even the solution that was put forward by the Australian Government, a 2,000MW power plant which is in feasibility right now, there's no agreement who is going to pay for this upgrade in terms of 24/7 reliable power generation in Australia. So until we actually get to the stage where it's a cost that is shared between public and private - it's not a mindset, it always comes down to cost and who is going to pay at the end of the day - then we're not going to get agreement on the pathway forward in Australia. So that's our starting point. The other thing that Australia needs to do is not just bipartisan,

it's Commonwealth and state relations coming together to come up with an energy policy that is well-planned for the long term, and it's going to include all of those solutions that we talked about.

TIM BUCKLEY: Everyone in this room is actually paying the price. Our electricity prices have doubled in the last decade, our gas prices have trebled in the last decade, and we are all paying the price every day of policy failure. We're paying double what we were paying a decade ago.

TANIA CONSTABLE: Yes, exactly right, and what has changed? It's new technology coming onto the system and it's because we didn't plan well enough for renewable technology and say to the consumers, "It is going to cost more". It's all going to cost more and that should be something that is realised by the Australian public right now.

AUDIENCE: Can I ask a question coming back to coal and whether or not it's clean and how much it costs? The shareholders of Origin took a bath when that company doubled down on LNG and had to do a disastrous equity-raising at \$4. When they announced the project their share price was close to \$16. Their market cap has at least halved and by my reckoning on Tania's numbers or if I take the numbers for the Petra Nova in the US, the cost of CCS on 200MW at Lang Lang or the Eraring plant for Origin, two of the biggest in Australia, would be around somewhere between \$8 and \$10 billion. So my question is, given the experience that Origin shareholders have been through in a time when AGL shareholders have seen their share price double, why on earth would any shareholder stump up the equity or allow their directors to put the company's equity into funding a retrofit of either one of those plants to CCS, assuming they got paid \$100 a tonne for the CO₂ as well, which is about what it needs to do to make it work? Why would any shareholder of either of those companies stump up or allow their directors to stump up that amount of equity?

TANIA CONSTABLE: I wouldn't suggest that any company with shareholders would stump up \$10 billion right now. I wouldn't advocate that. The report that I showed you that we worked on is about retrofitting part of a power station to get an industry up and running that decarbonises a large proportion of that carbon emitted from a power station. That will get the industry up and running. What we've done is directly compared it to the costs in Australia of solar PV on a single axis and they are absolutely comparable. And that's factual, it's not just pie in the sky, and we include transport and storage in those costs. So when somebody asks the question about what's included on levelised costs of electricity, comparing apples and apples, I can say to you that CCS on a single boiler on a power station, so that's 250MW, that's 440,000 households, you get an absolute comparable outcome with solar PV in Australia. I think I made the point before that it's not going to be private sector that invests on their own. That's what we've seen elsewhere with renewables. It will be public and private sector investment that will get these industries up and running.

TIM BUCKLEY: The coal industry has been around for 50 years, they've had their hand in our pockets for 50 years and the answer is the only person who's going to fund it is our Prime Minister, a taxpayer subsidy yet again for a coal industry that's been around for 50 years and who refuses to fund it themselves. I think I rest my case, let's go no subsidies, put a price on carbon and let the best technology win, and it'll be a diverse technology set, it won't be one technology.

MAXINE McKEW: Thank you, you've been a most engaged audience. Could you please show your appreciation for our guests? Thanks to the Grattan Institute and the Energy Institute. Stay tuned to the



website announcements because this is the first of four this year. We look forward to seeing you at future energy forums. Thank you very much.

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