MELBOURNE ENERGY INSTITUTE

GRATTAN Institute

Sustainable Energy – At What Cost?

Chair:
Robyn Williams

Speakers:
Patrick Hearps
Andrew Stock
Terry Teoh

Panel:
Ric Brazzale
Dr Jenny Hayward
Tristan Edis

Endnote Speaker:
Professor Mary O'Kane

25 May 2011

Transcript

The debate on how to make the transition from the current carbon intensive energy system to one that is sustainable and low-carbon largely centers on cost. This seminar explored various zero or low-carbon technologies, the cost of bringing them online and what people will end up paying for their electricity under the different scenarios.

Experts from industry and academia explained what carbon pricing signal will promote the best long term strategy, other complementary mechanisms we might need, and what impact these might have on the economy.

The Melbourne Energy Institute's Renewable Energy Technology Cost Review, prepared for the Garnaut Review Update, was launched at this seminar. This report looked at how innovation in wind and solar energy production will shape the future cost of zero-carbon technologies.

Speakers: **Mr Patrick Hearps, Melbourne Energy Institute**
Mr Andrew Stock, Origin Energy
Mr Terry Teoh, Pacific Hydro

Panel: **Mr Ric Brazzale, Green Energy Markets**
Dr Jenny Hayward, CSIRO
Mr Tristan Edis, Grattan Institute

Moderator: **Ms Susannah Powell, Melbourne Energy Institute**

Chair: **Mr Robyn Williams, The Science Show, ABC**

Endnote Speaker: Professor Mary O'Kane, NSW Government and ACRE

AUDIO: This is a podcast from Grattan Institute, www.grattan.edu.au.

SUSANNAH: This series is a partnership between the Grattan Institute and Melbourne Energy Institute. There's another four in this series: The Future of the Electricity Network in Australia; The Future of Wind, Solar; and last, but not least, The Future of Transport. The full program is available on the MEI and Grattan Institute website. Tonight we are also launching the first in our Technical Paper Series: The Renewable Energy Technology Cost Review, which is available on our website. We are also live-streaming for the first time this evening and if it works we will be doing this for future seminars. It's now with great pleasure that I introduce the host for the evening, Robyn Williams, ABC Science Show host and excellent journalist. Thank you, Robyn.

ROBYN: Thank you, Susannah, and welcome, everybody. I live in a parallel universe in which I get lots of messages, many of them conflicting. Let me give you a message that I just got from The Spectator, conservative magazine. We all read conservative magazines where I work. We're required to, you know that. This is a diary in The Spectator written by Matt Ridley. He says, a day in London for the launch of my new report, The Shale Gas Shock, published by the Global Warming Policy Foundation. I argue that shale gas calls the bluff of the renewable energy movement in the same way that genetically modified crops call the bluff of the organic farming movement. Just as GM allows the organic dream of drastic cuts in pesticide use to come true without high cost, so shale gas promises gradually to replace both coal in electricity generation and oil in transport, drastically cutting carbon emissions without needing subsidy.

Since subsidy is the lifeblood of most of the busybodies in the energy business, and since good news is no news, few people turned up for my report's launch. Matt's a friend of mine. He went to Eton and Oxford. His father is Lord Ridley and they owned a bank called Northern Rock, which was one of the first to go bung, and when I interviewed him to give the alternative side to energy questions, he did point out helpfully that his family's riches in the north were based on coal mines and it was sad for me to find out that Matt was, in fact, working with the Global Warming Policy Foundation, which a certain Lord Lawson heads. And the thing about that is that here was yet another lobby group telling us something about which one felt uneasy, so imagine the delight when you come to an outfit like this, where you have a line-up of speakers and a report, which is only mentioned just now, with the costing, which is going to be the first feature and to be launched later tonight, the Technical Paper Series, Renewable Energy Technology Cost Review, and to give you an outline of some of that report, Patrick Hearps, who is a chemical engineer with several years' experience working for ExxonMobil Australia.

He is now a research fellow in Energy and Transport Systems at the University of Melbourne's Energy Research Institute. So would you please welcome Patrick to tell us about the report. Thank you.

PATRICK: Cool. Thank you, Robyn. Can everyone hear me? Yeah. Okay. So I'll be talking about the report that we've just released. The purpose of this, it was commissioned partly through the Garnaut Review on Climate Change Update which was just done, so Ross Garnaut was looking at all the factors to do with climate change, mitigation economics that he looked at the original 2008 review, and looking at where things had changed in the last few years. So he looked at … commissioned quite a few reports from various different agencies. There's quite a few from CSIRO, and we've got Jenny Hayward here tonight, who was part of that, but to look at what has changed in this space. So the three main points that I want to give you, sort of, some take-home messages for are: how are the expectations changing of the cost of renewable energy now and in the future? It's looking like good news at the moment. And then what implications does this have for climate and energy policy? Which is obviously a pretty big topic at the moment and continuing. And then some ideas that we can have a discussion with amongst the panel of how we can accelerate that shift to renewable energy.

So to get into the guts of it I'm going to show you some pictures here and then I'm going to show a whole lot of graphs later and then some more pictures to balance it all out. We didn't look at everything. We chose to look at three renewable energy technologies: solar PV, wind power, and concentrating solar thermal power, and part of the rationale behind this was because they're technologies that are now commercial enough and mature that we have a good idea of where the costs are and where the costs are going, because the things we know, especially I'll show you some examples from PV that the costs of these technologies have been rapidly declining over the past 10 to 20 years or so, and we wanted to see how that was looking to change in the future.

Now, we compared a range of cost projections to the datasets that are currently used by the Australian government and industry, so specifically a dataset of all energy technology costs currently used by the Department of Resources, Energy and Tourism, and similar data that's used by the Australian Energy Market Operator, which is the industry body which oversees the whole electricity and gas market for the Eastern Seaboard and they've got plans, which they run each year, looking at different scenarios of how they expect the energy sector to play out, and that has big implications in terms of how they plan transmission lines and plan for the future. So that dataset had everything from fossil to CCS to renewables, nuclear, everything there. We chose to look at these three specifically. I guess our policy was we know that most of what's going on in renewable energy around the world is happening elsewhere in the world and there's much faster booming markets in other countries, so we thought we'd see what a range of international studies were saying, so get some international perspectives, and compare that to the Australian dataset.

So, to get into it, for solar PV, this is what we found. So our methodology was to look at the levelised costs of electricity, which takes into account all the differences between capital and operating costs and fuel costs because, you know, they are the different structures. Renewables will cost more to install but you don't have fuel costs, so over the long-term you have to look at how these things balance out financially. So there's financial calculations done on the same set of parameters, of weighed average costs of capital and resource quality and that sort of thing. So what you're seeing here up the top, the pink and the reddy lines are the two Australian datasets from AEMO and EPRI is the Department of Resources and Energy dataset. EPRI is the organisation who was commissioned to do that study. So that's their projections of the costs of PV now, in 2010 out to 2030. And so in the green we have a couple of scenarios from the International Energy Agency, which is the peak body overseeing energy matters for the OECD countries, and also from the European PV Association, Photovoltaic Industry Association, who are building on their knowledge of the larger markets over there, and there's a range of different scenarios depending on, you know, their outlook in terms of strong policy, weak policy.

So what it seems to be indicating is that, internationally, the costs of PV, even today, is considerably less than the data that is currently being used in our planning, and it is expected to continue to drop quite a lot over the next decade. And I will just point out the black dot there is confirming the costs of PV systems installed in Australia recently, so that's another piece of data we've got from actual PV installations that have gone on the ground and they're more in line with the international numbers. So, with wind, we're not seeing as much of a projection for a continued dramatic decline. The same way as solar, wind is more mature, it's been around for longer and is already at quite a scale. However, again, we've got the pink and red for the Australian datasets and the green is the IEA's numbers and blue is the Global Wind Energy Council, and so there's quite a difference there, you'll notice, not as much expectation of continued reduction in costs, and the black is the … an average of a number of wind projects in Australia.

So again the take-home from this is that while there's some potential for wind to continue to reduce in costs, Terry might talk about this, it's maybe not expected to be as dramatic as the other technologies, but, again, the actual costs of projects on the ground appears to be different from what's being used elsewhere, and this is again the pink and blue here … the pink and red here are the 2015, 2030 ranges from AEMO, and the blue is data from actual wind projects, so most of them are slightly below. For concentrating solar thermal power we looked at, now that is a more nascent industry than wind and PV, however it's now commercial enough that we have a pretty good idea of where the costs are and where they're expected to go. So we reviewed information from, again, the International Energy Agency, the US Department of Energy's Concentrating Solar Power program, and the ATK numbers there are from a European study, so put together by the European Solar Thermal Electricity Association from a consultancy called A.T. Kearney.

Now, the light blue and dark blue there show the range of costs expectations for solar thermal from A.T. Kearney. From discussion with the actual authors, they expect that, you know, given what they're seeing on the ground right now, they expect the costs to be more down towards the dark blue lower end. So with solar thermal it seems that the costs expected in Australia today are relatively in line with what we're seeing overseas and we've confirmed this with a few of the latest projects as well. However, internationally, and this is based on what's actually happening with our large-scale deployments in Europe and in the US, the costs are expected to decline quite rapidly over the next decade, compared to the AEMO dataset which would not see much happening until around 2030.

Now, why is this happening? There's a range of factors which are contributing to this, but it's important to understand that these are existing technologies. Reducing costs is not so much about research and development breakthroughs. There are incremental technology improvements, you know, improvements in the efficiencies of the solar PV technology using, you know, high temperatures or high quality gearboxes and motors. There are those incremental gains, but a lot of the cost reductions as well are just coming from things like economies of scale, so, you know, getting much more efficient at building and delivering large projects from experience. The entrance of Chinese manufacturing for things like wind turbines and solar panels has been one of the single biggest drivers in reducing the costs in recent years. It's, you know, pretty well understood. Henry Ford figured it out about 100 years ago. You build lots of the same thing at the same time, you can produce them for a much lower unit cost, and that's what we're continuing to see to happen. And a lot of it is through just the learnings that you get, as I said, from deploying the technology and the companies getting more familiar and finding more efficient ways to do it.

So that's actually key to understand what does it mean? And I'll interject this with a photo, a pretty good looking photo from a solar thermal power plant recently installed in Spain. It has implications in terms of how we plan out the future because basically if we're thinking that the costs of zero emissions energy is going to remain expensive for the next 20 years, then we don't want to be going and building a lot of it at once. It is going to do large things to power prices and we're going to be looking at what's the next best alternative, and a lot of the current debate is talking about things like abatement costs of different measures. How much … what's the efficiency of abatement on this particular technology? However, with technology that's coming down a costs curve rapidly, looking at something like, say, the dollars per ton of CO2 abated can be a bit simplistic.

This is the actual costs curve over the past few decades from solar photovoltaic. That's a logarithmic graph, so it's decrease in costs by orders of magnitude. Now, right now solar PV, the costs of putting solar panels on the roof, compared to abating your retail electricity is about $200 a ton. If you looked at it about 10 years ago, it would have been more in the order of $1,000 a ton. It's dropped by quite a bit since then, and the expectation is that's going to continue to decrease to the point where it's likely to actually hit grid parity, to the point where the costs of installing solar panels is going to be, you know, roughly equal or even cheaper than the costs of getting fossil electricity, at which point you don't need any kind of extra subsidy or feed-in tariff. So, while at the moment you're paying extra, you have to understand that the benefits of installing that solar panel is not just the CO2 you abated with that, but it's the fact that you're continuing to reduce costs so in the future there will be the lower costs abatements.

So, in terms of policy, we should actually be trying to do two things. We're talking about a carbon price at the moment. A carbon price could be a useful thing to have, the idea there being that you, you know, make the pollution or the release of greenhouse gas emissions at a cost that will increase the costs of burning fossil fuels relative to the costs of renewable energy, and so if you've got something, especially, say, for example, wind, which is already quite a way down the costs curve, you may not need that much of a carbon price to make it competitive with fossil power. But for something which is coming down the costs curve and is still relatively quite higher, then a carbon price is not necessarily what's going to drive change there. For example, to get, you know, concentrating solar thermal power at the moment, at cost competitive, you'd be looking at maybe $200 a ton. Possible, but probably not going to happen. What's actually likely to happen with carbon pricing going forward is a switch to gas. This is something that's been started to be discussed a bit more recently, but the kind of carbon pricing we're talking about, 20, 30, $40 a ton, the main effect there will be to make it more economical to produce power from gas power plants than coal-fired power plants.

Now, again, this comes back to the rationale of if you're looking at … if your other zero emission alternatives are not going to come online, they don't exist yet, or they're going to remain expensive for another 15 to 20 years, then gas, which has less emissions than coal and is a bit cheaper, is going to be your next best option. However, unfortunately, gas is a fossil fuel. Like anything else, it will produce emissions, and the way we account for it at the moment possibly isn't taking into account everything that's going on. Methane, the actual gas itself, is accounted for being about 20, 25 times worse than CO2. If you look over the 20 year timescale it's about 70 times worse than CO2, which means that any methane leaked in the process has quite a big impact. But this is the outcome of the kind of modelling using the Australian datasets I was showing you before. There's a range of different scenarios. I could show you about 10 but that would be death by PowerPoints. Most of the expectations are that, you know, there would be some switching to gas and you might start switching to zero emissions alternatives in 15 to 20 years' time.

Now, is this really the outcome I want? I'm going to inject a little bit of climate science here because it's very topical, with a report released at the moment, Will Steffen's, the Critical Decade, released a couple of days ago, where he talked about, really, the way we should be thinking about climate policy is not, you know, how much we're going to reduce emissions by what time, like 5% or 15% by 2020, but understanding there actually is a budget. There is a limit to how much carbon we can afford to emit and, you know, the focus should not so much be on, you know, what is the cheapest way of getting to an arbitrary, you know, 5% target, but how do we get to the long-term goal of essentially decarbonising the economy? And so investing in short-term measures, like gas, which has less emissions, may not be as effective as understanding that we need to be aiming for zero emissions. Now, he was talking about the budget approach being zero emissions by about 2050, and that's based off work that's come out of the Potsdam Institute of Climate Change. However, that's talking about the whole globe, and I can understand why, in his position, he didn't really point this out, but if you look at the same reports that he was using for this budget approach recommendations, once you allocate that budget on a per capita basis, then countries like the US and Australia with high per capita emissions would start running over our budget in more like 10 years' time. So we need to be decarbonising on a much faster timeframe to allow the whole globe to decarbonise by 2050.

So the last little bit I'll touch on is how can we do this? Now, what's built the world's renewable energy today? Is it actually, you know … Emission Australia sitting, like, in the EU has had a bit of an effect, but most of it has been due to directive incentives like feed-in tariffs, Renewable Energy Portfolio Standards, or Renewable Energy Targets, that's what we have in Australia, or just direct government grants or procurements, such as in China, often called complimentary measures but they are actually the ones that have worked in getting renewable energy built. Now, I'm going to show you a bit of a scenario. What's a feed-in tariff? It's where the producer of a renewable energy is paid an extra premium which reflects their costs of production and that cost is spread out by … over all consumers, so everyone pays a little bit more. That's the way the renewable energy target currently works. So the extra costs of wind power is borne by a small levy over all consumers. The difference between a feed-in tariff is that you can give different rates to different technologies and build wind turbines and solar panels at the same time. We haven't been able to do that in Australia. It's a different system.

Now, okay, that is going to raise electricity prices, however, it is important to understand that whatever we're going to do is going to raise electricity prices. Now, that may not be a mature discussion we can have with everyone, but that's the case. I'm not going to mention any politicians' names. What we're seeing here is the expectation from AEMO is what will happen to wholesale electricity under business as usual with no carbon price. And this is only wholesale. This is only from the power plant. This isn't taking into account your transmission costs, your retail margins, which push up the end consumer retail price to about over 200. That's going to be a result of higher gas prices, more expensive power plants. Having a carbon price is going to raise that. That's with a low $20 a ton carbon price up to a really high $50 a ton carbon price.

However, the outcome of this kind of policy, even if you had this carbon price, would be mainly a gas switch. What if you had a feed-in tariff instead which did the same thing to electricity prices, $120 a megawatt I have at the end there, but what have I just done? The modelling behind this is the model of the feed-in tariff that gets you up to 54% renewable energy in this scenario. So the yellow band there I've modelled building a whole lot of solar thermal and I've just chosen to use that because that's what we have costs for. You could apply it for any other renewable energy technologies on top of the green renewable energy targets. So here we have a scenario where, yes, you're raising electricity prices, but you're directly building a renewable energy as opposed to having a carbon price, which is going to be useful but may not give us the end result.

So that's the end of my presentation. A little bit over time. The main point is that based on the international expectations, the cost of renewable energies are dropping. The implications of that, we should be thinking about how to deploy them now, within the next five to 10 years, as opposed to waiting 20 years. Thank you.

ROBYN: Thank you. Well done. Thank you, Patrick. Questions will be at the end, and next we've got Andrew Stock, who's the Director of Executive Projects of Origin Energy Limited. Now, the very interesting thing in my notes is that it says, given Andrew's real world experience. Does that imply that academics have unreal world experience? If you read Peter Shergold's analysis, a famous essay published just a matter of a couple of weeks ago, he did point out there seems to be a gap between what academics do and the influence outside in the world. So to test that, Andrew Stock, your reaction, please?

ANDREW: So thanks, Robyn, and I'll talk a little bit about some real world experience as I talk to you about not just the sort of things that Patrick has talked about, but also some of the other dynamics that are going on in the current debate in Australia, because the debate we're having is one of society's most important debates actually today. It's going to have a major bearing, not just on this country, but globally, on the future of mankind and planet Earth, and that debate is about how we decarbonise our economy, our modern economy. It's about our future energy mix and that energy is the thing that powers our economy. It's why we can stand here and talk with microphones and under lights and stay warm.

As Patrick indicated, and I reinforce that point, many of the policy decisions that are made today by politicians draw on conclusions from the very studies that use this complex input data, gets used in complex models and the outturn of that is graphs that politicians can then understand and then they make decisions on that basis. It's why it's so important that we critique the cost assumptions, because the cost assumptions for technology is not just renewable, but all technologies indeed used in these studies have a huge impact on policy decisions that are made. One of the things that Patrick's report concluded, and you saw it in the graphs, was that the studies that are used in Australia are using higher costs than international studies would suggest, and I'd argue that that's a cause for some concern because it will have an influence in terms of the conclusions people reach and it might mean that the choices that we cost for future pathways to the future, when it comes to energy, may be skewed or flawed. We might not make the best decisions.

Let's just touch on how big of a challenge that task of emission reduction is, the one that lies ahead, at least for Australia. We all know we build our economy in Australia on low-cost coal. That's no surprise. We have a lot of it. But it does mean we've got one of the most carbon-intensive economies in the world and it means that electricity generation is the biggest contributor to that. In 2009, the electricity sector's emissions had increased some 60% above the Kyoto 1990 levels, and in the absence of new policy initiatives they're projected, on a business as usual basis, to increase a further 15% by 2020. That's only nine years away. So to reduce the sector's emissions by 5% by 2020, which is a bipartisan abatement target, we need to cut emissions from the sector, the electricity sector, by 60 million tonnes a year. It's easy to say it and as I'll come on to show you it's probably going to be fairly challenging to do.

The current renewable energy target will deliver around a third of that, about 20 million tonnes a year. Assuming around 70% of that were to come from wind, going forward that means that as an Australian community we have got to build around 6,000 megawatts of wind in the next nine years. That's about six times as much as exists in Australia today, and that's not going to be any small challenge in itself but when you consider we're in the midst of a mining boom and an LNG boom, both on the east and the west coasts, those developments are going to be competing for the same sorts of people that you need to build wind farms: engineers, project managers, electricians and so forth. And then when you build the wind, you've also got to build more gas turbine capacity because we all know that wind is intermittent, and without wanting to have a debate about that today, to build gas turbine plant also will require the same sort of skilled people. But that will only give us a third of the gap, so the sector has got to chase another two-thirds, so where will that come from? It could come from wind, but that's an enormous amount of wind to be built, for example, by 2020. Origin believes that the way to help close that gap is through an emissions trading market and we believe that would be a preferred way to achieve that additional abatement because what it will encourage is switching of fuels and power generation.

There has been a lot of commentary on the potential for gas, and we've already heard some more of that from Patrick, as a transition fuel. There is no doubt today that in terms of fossil fuel technologies, gas is the most efficient in terms of its carbon intensity. About .3 tonnes per megawatt hour generated comes out of a modern combined cycle plant like the one Origin built recently in Queensland, the Darling Downs plant, at 630 megawatts. Point 35 tonnes a megawatt hour is about … it's less than half that you get out of a coal-fired power station per megawatt hour and it's about a quarter of what you get out of the power stations in the Latrobe Valley, on average. So every megawatt hour that you can generate by using gas displaces a megawatt of brown coal, say, saves you a tonne of CO_2. There's been some talk in this state about Hazelwood and its future. If you were to displace Hazelwood by gas generation, you would save around 12 million tonnes a year of CO_2. To do that, though, you would need to build 1,600 megawatts of gas combined cycle, and you need to supply that with about 100 petajoules a year of gas and new developments are needed, whether they be in Bass Strait or elsewhere. You need a new reserve base to be able to do that, and together all that means that you've got to spend about $5 billion, $5,000 million, to save that 12 million tonnes a year.

Closing Hazelwood with more gas power with those renewable savings I talked about earlier would bring us to about halfway of the abatement challenge that we've got. So we've got to find more. We've seen a lot of announcements about LNG export projects up in Queensland and in those discussions often people talk about a thing called an LNG train. A train could supply about 3,300 megawatts of gas-fired combined cycle for about 20 years and that would be enough to shut down Hazelwood, Yallourn and a power station in South Australia called Northern, and those three combined are our most emissions-intensive power stations. And if we did all that we'd probably go pretty close to achieving the 2020 abatement target for the electricity sector, but you can see just from the outline that I've given you that that transformation is huge, huge, and gas has to be appropriately priced and more particularly carbon has to be appropriately priced to provide the commercial incentives for the industrial sector to go out and make those investments.

In the near-term, the talk is about lower carbon prices, potentially through a carbon tax initially, and they could see other fuel-switching take place from brown coal to black coal. Black coal is less emissions-intensive than brown, so switching will reduce emissions on an Australia-wide basis, but it only saves about half the emissions that you save using gas. So that would see us leaving our abatement target for 2020 fairly short, and the other challenge will be the mix of economics, I guess, in all that and I won't go into that today. Unfortunately, we've still got our population growing and we still seem to be using more electricity, we have more appliances, and even though some of them are more efficient than others, we seem to have more to choose from to buy, so the chances are we'll need more power generation as we continue to go forward. So I guess at low carbon prices and in the absence of some continuing and expanded renewable target, economics would suggest that if you go forward, and as I said, at low carbon prices, more likely that more generation might come forward from black coal, but no-one, I don't think, in the commercial sector is going to build a black coal plant today, a new power generation plant. It's just too risky, whether or not you could fund it. The risks are too great and so that's of concern.

The other thing I talk about from some experience, about new build generation, and it does relate to this state, is that it's a challenge. The last two power stations in Victoria that have been built are at Laverton and at Mortlake. They're both peaking power plants and I'd have to say, based on the experience there, particularly around Mortlake, that if we don't get better productivity in building power stations out of the labour that builds them, and in particular electricians, it's going to be a challenge to build the generation that we will need for the future. So unless something is done to improve that in this state, we're going to see power stations that take 30-50% longer to build than it would take to build one in Queensland, for example, or South Australia, and it would cost, because it takes longer and the productivity is lower, 15-20% more. So that's an issue, I think, that hasn't been talked about a lot in this whole debate but it needs to be because it's front and centre, because ultimately these are very capital-intensive assets and if we can't build them, in the first place, effectively and cost-effectively, we're going to be challenged because we're burdened with that cost for the operating life of the asset.

Let me turn back to renewables, which is what Patrick's talk was about. There is no doubt that they are the least emissions-intensive technologies available today and solar and wind are being more rapidly deployed under state and federal policies, but it's interesting also, as the debate intensifies, that the degree of media outcry against both is rising, particularly we see it around wind in Victoria and more recently around solar PV in New South Wales. So rather than talk to wind, I'd like to touch on solar in New South Wales and some of the real world debate that's been going on. IPART, which is the regulatory agency that sets the maximum retail price for electricity in New South Wales, issued a draft report in April of this year on the maximum retail prices and in that report they took aim pretty squarely at the state's solar feed law, which Patrick also talked about in more general terms, and the report recommended that the New South Wales government close the New South Wales Solar Bonus Scheme and that the federal government eliminate its solar credits multiplier as well as a number of other recommendations, and it was interesting to observe that in the Minister's announcement about this change recently to shut the scheme down, which has generated a lot of press, certainly interstate, he commented that around 160,000 New South Wales households decided to invest in solar under the scheme. The scheme had added about 360 megawatts of power generation in that state, and doing the numbers on the back of the envelope you can pretty quickly work out that that means that private households had invested something like three-quarters of a billion dollars in putting solar on their rooftops and adding generation to the state grid.

What's really noteworthy, though, and didn't get much press is that in IPART's analysis two other factors impacted on electricity price increases in that state far more than the renewables of solar. Firstly, their maximum retail price is based on energy costs set at what's called the long run marginal cost of generation. It's a sort of complicated term, but it's effectively a hypothetical number about what it would cost you to build a new power plant, and that cost is $20 a megawatt hour, assessed by them, relative to the cost of buying power in the market, which is what companies like Origin do today. $20 a megawatt hour just happens to be about three times the impact of the solar scheme in New South Wales on power prices. The bigger increase, though, was around network charges and we've heard a little bit about that but not a lot. A 40% increase in the last two years, $36 a megawatt hour, something like seven times the cost of the solar scheme. So where was the media coverage and the shock-jock hype? It wasn't around network costs and it wasn't around wholesale power prices that were theoretical. No, it was around the costs of solar. And what we saw follow was effectively state and federal governments, not just state government in New South Wales but the federal government and also governments in other states, Western Australia, now South Australia yesterday, announcing capping or stopping PV support, and in one case, arguably, retrospective cuts. And as Patrick pointed out in his talk today, PV is actually closer to being competitive for consumers than most in the community, certainly most that would read the Australian would think, and I think most in the media generally, and I think that's for a number of reasons. Firstly, the demand growth, and we heard about that. It's just intensely powerful in driving costs out of business. Origin has a joint-venture with a company in America called Micron where we're commercialising the PV technology. I mean, the cost reduction that goes on in the business is brutal, let me just say it like that. The power of those learning curves and competition driving costs out is brutal in that business. 18,000 megawatts of solar was installed last year, globally, in 2010. It won't be long before module costs are less than $1 a watt, given the cost reductions that we would expect to see in the next five years, maybe at 30% or possibly 50%.

The second thing is that as PV costs are coming down, fossil alternatives are going up and they are going up fast. I talked about New South Wales and network costs, but when you factor in carbon pricing as well and the need for deep emissions cuts, whether it's through gas combined cycle or carbon capture and sequestration, that technology deployment has to flow through to pricing and to retail pricing. So prices are going up, and the third thing that's going on is that consumers of necessity and always have been arguably price-conscious, but what they're seeing now with electricity prices are increased prices, firstly, but secondly volatility and uncertainty. So as they look to the future, what do they do: bank what they know today or take a risk on the future? Increasingly, consumers are banking what they know today.

The final thing I wanted to comment on in relation to PV, and we saw it in Patrick's curves, is that typically when these curves are presented, they're presented as if for the costs of generating power into the grid, as if it's a big power station. When you add lots of little ones up, it is big, but the consumers that are making that decision are making it as if it's a power-avoidance decision. Consumers see power prices that are five or more times the wholesale market price level for electricity and then they pay GST on top of that as well. So when a consumer makes a decision to invest in solar, what they're making is a decision to avoid the costs of buying power not at $40 a megawatt hour, which is typically what you see in the wholesale market, but at two to three hundred dollars a megawatt hour going forward into the future. And it's very tangible. You see it on your bill, whether your bill is every month or every quarter. So it's very positive feedback. It feels good as well. But in Australia we believe that solar PV does need a consistent national framework. We see variability within states. We need surety for the installation sector, consumers and we need a regulatory framework that ensures that installers are licensed and accredited. So the tipping point we'll see for solar will occur when it approaches grid parity because then it is truly a sensible economic decision, and that isn't very far away. It's already close to that situation in markets like California, Italy, Japan, Korea, already today all within the next two to three years, and if you think about the size of those markets, just how many millions and millions of people there are, once that tipping point starts to be approached you get a virtuous circle created because the volume goes up dramatically and that creates a virtuous circle into an almost infinite market.

So we're very lucky in Australia. We've got a lot of coal and we've got cheap electricity prices, but what we're really lucky about is that it's other countries that have got and taken a more strategic approach to developing low-carbon and renewable technologies. Those learning curve technologies aren't related to any particular country. They're global curves. It's a global business, whether it's wind or whether it's solar, and it's the laws, the feed laws in countries like Germany, Japan, Spain, among others, that have driven that 18,000 megawatts of new build last year, and it's policies, manufacturing policies of countries like China, who now dominate the manufacture of photovoltaic PV, that will see it soon be the world leader not just in manufacturing, which it is today, but the leader in installations as well, a plan to have 50,000 megawatts installed by 2020. 50,000 megawatts is the size of the total Australian generation market.

But I guess we won't expect the debate here to abate around renewables. We'll hear that they're too expensive. We'll hear that a carbon price is needed, but that's too expensive, and we'll keep using more electricity, which means that if we don't do something about it our emissions will continue to grow and that will make our future challenges even more difficult. Origin believes we need a market price on carbon to lay a foundation for long-term change in behaviour and in our energy mix, and we believe that the Red scheme will help deliver that abatement as we transition to that market-driven economy in the future where basically renewables and fossil fuels compete on their merits to meet our and the world's electricity sector abatement targets. Thank you.

ROBYN: Thank you, Andrew, for reminding us of the real world perspective. Terry Teoh is also involved in the real world. He joined the Pacific Hydro in 2002. He's responsible for the company's Australian development activities in wind, solar and geothermal, and he has actually first-hand experience of how government policy influences the development of this industry and its economic cost for end consumers. Would you please welcome Terry Teoh.

TERRY: Thank you, John. Good evening. It's a pleasure to be here tonight. For those of you who have been fortunate enough to visit Spain or the great city of Toledo, which is just a few hours' south of Madrid, you might find there a 12th Century walled city which lies at the knowledge crossroads of the Arabic, the Judaic and the Christian tradition, and if you were to go there then you might also have the opportunity to visit the Magascona PV power station, which is shown in that photograph there, courtesy of Photo RTO, which is a European IPP in solar power. Tonight's theme, sustainable energy at what cost, may bring to your mind the implied thought of, well, financial costs for the consumer. So I'd like to broaden that out and pick up on, I guess, two dimensions to consumer cost. The first is, well, what are the other cost components that drive what you pay for your electricity, and Andrew Stock touched on that, but also what are the unsaid costs that are not priced in the economic system, so the externalities, the fact that a Latrobe Valley worker might have a lifespan that's 15 years less than the rest of us, so how is that priced into the system? And then I'll offer you a perspective on policy and what we need in industry to be able to invest in this sector.

So, Pac Hydro, we're an Australian-owned company. Our vision is, I guess, the energy transition and in Australia that means developing, building and owning renewable generating assets. For the first 10 years of Australia's energy transition, it has been wind, but we see that we are fortunate here in having, you know, a resource endowment in solar and other renewable resources that will play a really important role in the coming decades. This photo is courtesy of a company called AREVA Ausra, which is home-grown Aussie technology, which it would appear is travelling the path that many Aussie technologies travel, which is they have to go overseas for five or 10 years to deeper markets, become commercialised and then they come back to Australia, and this is one of the technologies. It's called Compact Linear Fresnel Reflector and it is in there in the mix of technologies that may play a role in Australia's energy future.

Before we drop into the theme, I just want you to step back from electricity, sort of, and sustainable energy and I'd like to pull up, I guess, three big issues that I think are potential game-changers in the electricity sector. The first, of course, is carbon price and I guess our take on that is it will have a mild effect in the coming five years, but it's very important, and the lack of carbon price right now, of course, is hampering investment and it's causing lock-in risk, which

I'll talk about, but carbon price is essentially a contract between consumers and government, where consumers and industry are essentially compensated for a soft landing, and that is the price the government pays to put in place the institutional framework that allows the controls to be tightened up at a later date. So in the coming five years probably you won't see much difference, but in the long run, of course, it will mean profound changes.

The other two big issues, I guess, LNG export and electric vehicle uptake. The possibility to export Australia's vast reserves of gas has been in existence for two decades now in Western Australia and in the Eastern Seaboard that is soon to become a reality. In the long run, gas, for which we currently pay 2 to $3 a gigajoule for power generation in the Eastern Seaboard, will be exposed to the global demand and price for that gas, sitting around 8 to $10 a gigajoule, shall we say. And that comes from countries like India and China who are hungry for our gas, for petrochemical feedstock to make your clothes, make the equipment around you, and for power generation. And so Australia faces a policy conundrum in that on one hand there's this huge trade-driven driver to realise the value that the exports of gas may bring us, and wealth for everyone, and on the other hand what that might mean for power generation which exercises a disproportionate effect on the minds of our hip pockets. So that will be one of the key issues that I think will drive the energy policy debate in the future.

Gas is also a very important transition fuel and if we have access to it now, then one could say that it may be a good thing to be able to build gas generation as new generation is required. On the other hand … and a carbon price will start to narrow the gap between coal and gas, but if gas is exposed to export pricing then it starts to put gas further out of reach, despite a carbon price, and then you're faced with, well, maybe you have to build new coal, but on the other hand the investors are now saying, well, we're not going to touch any more new coal, so where does that leave us? And what you see in WA right now is the heightening of lock-in risk where instead of moving to new gas generation, they're looking at dusting off the old coal-fired power station down at Muja. So they're big issues that we have to deal with.

On the electric vehicle side, that has the potential to completely transform the electricity sector. Previously, transport fuels and station generation were quite separate, and this would bring about a convergence of the two sectors, and it is driven by what we call, I guess, at its heart it's consumer-driven. So a rise in petrol prices, falling prices of electric cars, the consumer desire for new products and the manufacturers who help that along could potentially broaden out the electricity sector into transport as well. I think it was Henry Ford's chief design engineer who famously said our job … this is 100 years ago. Our job is to ensure the customer is dissatisfied. So you see that that holds true today, and if we are encouraged to take up this path, providing the costs come in on parity, then, yeah, it will change our use of electricity in a radical way.

Okay. A few graphs, so if you'll bear with me. This is courtesy of Climate Works and a good piece of analysis done based on the McKinsey abatement curves, where on the X axis you see a number of technologies lines up according to cost. The Y axis shows the cost and the X axis shows the width, shows the amount of abatement that we might get from particular technologies. Now, I just want to pull out the ones that are topical tonight, so obviously Australia is building wind power and we now have around one and a half gigawatts of installed wind capacity. In South Australia that represents 18% energy penetration on an annual basis, and in the last eight years that means that South Australia has gone from importing 16% of its electricity from the Latrobe Valley to exporting green electrons last year. That's the size of the effect that's happening now.

As we move along, we mustn't forget that the shift from coal to gas has a very important role to play, that onshore wind in slightly weaker locations will have a role too. Solar thermal, from all three technologies, from central receiver, from linear Fresnel and from parabolic trough, are very promising, and solar PV on a centralised scale we think will be also significant. This work was done a year or two ago and we think now that the position between PV and thermal has actually swapped over, so we're seeing that large scale PV is more likely to achieve market deployment in Australia ahead of solar thermal. Just touching on the lock-in risk, this is also by Climate Works. On the Y axis you have what we call the risk of lock-in, and a high lock-in risk actually means that you should do what's in the box because if you don't then you have to follow a more carbon-intensive option which is long-lived, and therefore you have to wait longer to undo it.

And then reading from left to right, that shows the relative ease or difficulty of implementation in terms of where the technology is, but also the cost and the investment barriers, and you can see, looking across those nine boxes, that there are quite a few things we need to do. In the top left, obviously, it's easy and that we should do it now because if we don't then we're locking in more carbon risk and that's dealing with energy efficiency and building standards, and then pointing out the ones that are relative to this discussion, you can see that solar thermal, onshore wind and solar PV sit in the high lock-in risk category and that there are some challenges to deal with, and then as we move across to the right you can see that geothermal and offshore wind are somewhat more difficult. Certainly from HotRock, geothermal is a big challenge, but in terms of conventional geothermal, which I have added to this Climate Works diagram, we see that as somewhere in the sort of middle area of being challenging.

Okay. A bit on policy. It's been a rollercoaster for the last 10 years under the Renewable Energy Target and what we need in the industry is certainty. Capital-intensive investments, if you haven't got the certainty over the 20, 30 year timeframe, you can't make the decision to invest. It's that simple. That's been a real rollercoaster for us. The experience in Australia with quota mechanisms, and I guess in the US with what we call portfolio standards is that the price per unit of energy is determined by the market, but the government sets the total amount of procurement and so that the total cost of the scheme is somewhat bounded, but the disadvantage is that it tends to focus on one technology, and as we've seen in Australia that has been wind, to date, but the economic efficiency is good because there's competition between parties to originate projects and therefore they have to bring forward the economics ones first.

The theory goes that the quota market mechanism is generally insulated from political interference, but as you saw on the previous graph, if you try really, really hard you can muck it up as well. On to the feed-in tariff, this has been the, I guess, instrument of choice in Europe and I guess in the Aussie residential PV market and it's sort of the other way around, so the price is politically determined but the market finds the volume. So, really, from the government perspective, this is quite nervous, or it's risky because the costs of the scheme can be somewhat unbounded, but the great thing about it is that you can pick different tiers for different technologies, you can do it under geography and so on, but there isn't really an economic test. It's a blunt test. So as long as your project clears the particular threshold then you get to go ahead with it, and so if you don't set that threshold carefully you end up overheating or undercooking the scheme and then you're faced with then having to pull it back and then when the technology costs decrease you're meant to digress the tariffs along with that but then it's always hard to do that and then, you know, it's inherently difficult to manage. So energy politics are difficult to cut, whether you choose option A or option B.

There is a third option and it's called a reverse auction. It has been used successfully in some markets and the way this works is, if you recall in the 15th Century, the Dutch tulip market, where you had one buyer and multiple sellers. It's like going to a house auction, but it's the other way around. And then all the sellers basically bid their price down, and the one left standing with the lowest price wins the contract. So that mechanism has been used in Brazil. It's still in prototype. There aren't any tulips involved, and we think that that can have some merit to run alongside the existing Australian Renewable Target because it would be too big a leap for Australia to move from a quote to feed-in for large-scale, but it may be a plausible jump to augment what's already there with a reverse auction mechanism and allow our prospective solar and geothermal technologies to come forward when their learnings have brought them down to a point where they're within cooee, nearly there.

So our, I guess, report card on the renewable energy target, the current design is fine, please don't touch it. We think there will be, as Andrew said, around 6,000 megawatts of projects coming forward. In fact, there's a stock of permitted projects in the market that are ready to be built. We think there needs to be policy for market deployment of utility-scale solar PV and we think that further thinking is needed from the Australian Solar Institute and from ACRE on pre-deployment support for conventional geothermal and for solar thermal. On gas, we think that market actors are already behaving as if there is a proxy carbon price, despite the lack of policy, but that is not a reason to move towards an explicit price. We think investors will find it hard to justify building new coal. The shift to gas has already occurred, but that this investment is distorted because there's a lack of explicit pricing. So, for example, companies like Origin are investing in open cycle gas turbines which are very good for peak load, but they also have the least, I guess, capital risk and if, for example, the carbon price never materialises then, you know, you stand to lose least by walking away from that investment, but if you go to combined cycle then you've got more at stake, so that … and it may be that combined cycle has the sweet spot now to drive our energy transition, but Origin can't make that decision because there's no carbon price.

I just want to touch on the affordability. In Australia, electricity is affordable. If you look across this, from the Garnaut Report, in Australia, electricity is 2.8% of our per capita income, and if you look across Europe it sits around the sort of 5 to 6%. We're comparable to the US. If you look at the costs makeup of the Residential Electricity Tariff, and this is the graph that Andrew was referring to, and this is published by IPART, which is the New South Wales economic regulator. Then they're your network charges, which are the big part of it. The generating costs takes you up to that amount and then, if there was a carbon price at $26 a ton, that's what it would represent, and you can convert the Y axis to what you pay at home. So $200 is, if you like, 20 cents per unit on your electricity bill. That's what the retailers get for delivering you the electricity to your door, and that thin wafer up the top there is the contribution due to the renewable target. Okay? I'll skip this part.

So, concluding slide, technology pathway we think will be driven by gas and renewables. Gas will have a big role in terms of its share of the energy mix and in terms of driving long-term energy costs. The export of LNG will be a vexing policy question to balance domestic needs with trade income. LNG export will also perversely increase our emissions signature because of fugitive emissions, and that's just the way greenhouse gasses are accounted for globally that it's what's emitted on your own soil, so we will have to deal with that as well. We think investment occurs when there's good long-term policy put in place, and economy, right, we think that the abatement costs from renewables is effective at around $30 a ton. And finally to you as the consumer what I would say is that, you know, the financial costs to consumers is minor, and I'll leave you with a parting thought that would be the global perspective on who we are as a nation in Australia, and that is that the global view is really that we need to do the most, that we have the capacity to do the most, that at present, for whatever reason, we are doing the least. Thank you.

ROBYN: Thank you, Terry. That was fun. You talked about tulips from Brazil. My partner, Jonna Cannubi, as one of the stars of catalyst, had a birthday the other day and I bought her some yellow roses. It turned out they came from Colombia. I was astounded. Right across the Pacific. Anyway, this is the second part where we have prompt questions, which we probably don't need but I'll give you a couple of anyway. Ric Brazalle, is that pronounced right?

RIC: That's close enough to it.

ROBYN: Brazalle. Director of Green Energy Markets. You've been closely involved with the Australian solar PV sector for about a decade as head of an industry association representing the sector and now with a company that trades in solar PV renewable energy certificates. Over that time, what kind of changes have you seen that indicate that this sector is getting better at supplying electricity with reduced cost? Also, are you optimistic that the sector can achieve further improvements such that it might bridge the costs gap with other larger scale technologies? Double-barrel for you.

RIC: Thank you, Robyn. Let me deal with the first part of that question. When we look at what the Australian PV industry has achieved, we've seen quite a dramatic growth over the last three years, and just let me throw some numbers at you. Back in 2009, there was 80 megawatts of PV installations. That grew four-fold to 380 megawatts in 2010 and this year we're expecting around 500 megawatts. Now you might be wondering what the hell is a megawatt? Let me put that into some sort of context. Our electricity grid managers are currently projecting that to meet our growing power needs, a demand for electricity is actually growing at about 1,000 megawatts per annum in the National Electricity Market states, so that's around the eastern states.

So PV is actually contributing half of our growth in electricity demand, and that's significant and it's actually material, and you might say, why has PV grown dramatically? It's been amazing to watch the sector over the last couple of years. It has responded, what I'd say, in an unprecedented manner to government policy support. In fact, I'd say government policy has failed to keep up with changes in the market, changes in technology costs, and in fact PV has consistently embarrassed government policy efforts, and we only have to look at the debacle that was the New South Wales Gross Feed-in Tariff. We've also had … there was the $8,000 rebate that was massively oversubscribed a couple of years back, and just earlier this month we had the Environment Minister, Greg Combet, reduce the solar credits multiply.

So then what's driving that? Now, Andrew has really touched on it significantly and we've seen significant reduction in international panel prices because of Chinese manufacture, of course, but let's not underestimate we're actually achieving scale here in Australia. We've got significant volumes now that lead in to reduce costs through the supply chain, and it's staggering to think that we actually now have 4,000 accredited PV installers. When I was with the VCSE a short sort of three or four years ago we only had 300. So that's a significant increase in the number of people employed installing systems. There's also been significant changes to business models and we're actually seeing volume … we're now seeing a number of different solar retailers actually going to market in a number of different ways, and I've been astounded. You know, who would have thought that there's actually … you know, there's three AFL teams that are actually sponsored by solar PV companies. It's unprecedented and I think that just gives you an indication of just where the industry has got to.

The other point that … and that Terry certainly pointed out is we're also seeing significant growth in electricity prices, and that's been driven predominantly by network investment. Both Andrew and Terry have clearly articulated it's not the costs of renewable schemes. What that means is that we're really very close to what's called, you know, grid parity and we can see just in a couple of years' time we'll be achieving system paybacks, or paybacks for a typical PV system, around 10 years. So that's a discount rate of seven and a half per cent and that's without any government support. So what the industry has achieved has been remarkable in the last couple of years. The challenge, though, is to ensure that we actually maintain some sort of scale. Now, let me just give you an indication of what that scale is. We're now installing more than 200,000 systems a year pretty well all at the residential level, and so when you look at sort of the amount of PV that's actually installed on, sort of, owner-occupied detached or semi-detached dwellings, so this is the key market, we're nearly at 10% of available buildings, so we're actually really getting there.

That brings me to answering the second part of the question, and probably the key thing we need to remember, and certainly Andrew made this point, is that PV is a distributed technology, so it's not meant to compete with coal-fired power stations. It's meant to compete with retail electricity that we can put a power station, effectively, on our roof. We're also seeing continued development efforts that will lead to continued reduction in costs. I mean, Andrew talked about less than a dollar a watt. That's phenomenal compared to, you know, it would have been $6 a watt not so many years ago, but also bear in mind that PV is a modular technology and you can roll it out many, many places and there's a lot of markets that we really have barely touched, including the off-grid market. There's a lot of electricity that's produced and consumed in remote regions that aren't on grids. There you're competing with diesel-fire generation and we're only going to see oil prices continue to rise. You've also got end of grid support and you've got the potential for PV to, you know, reduce or defer network investment. So we see that PV has got enormous potential still to reduce costs, but let's not just focus on costs. There's a lot more applications that we can drive PV into, and I might just leave it at that.

ROBYN: Thank you. One quick follow-up question. Ray Kurzweil, who told me he was a genius, did say a couple of years ago at the AAAS Conference that because solar can be digital it could obey Moore's Law. In other words, double the power, halve the costs every year. Do you agree?

RIC: I think you'd actually need to create a new law for PV, because I think you could certainly … you could certainly say that of the cost. I don't know about the performance yet. I think we still need to see some breakthrough technologies and that's not to say it won't happen, we just haven't seen it yet. But bear in mind, PV has responded in a very short time. In other words, it's just a couple of years. A lot of other energy technologies that it's competing with will take a hell of a lot longer to respond.

ROBYN: Thank you. Well, Doctor Jenny Hayward is from Newcastle, a research scientist. I know what you want to say. Go ahead and say it.

JENNY:Okay. Well, I'm going to talk about the electricity model that we've developed at CSIRO. So this is a …sorry?

AUDIENCE: I can't hear you.

ROBYN: Just keep going.

JENNY:Is it on?

ROBYN: They'll do the volume up there.

JENNY:So this is a global model of electricity generation we call GALLM, which stands for Global and Local Learning Model, and this model contains learning curves which Patrick nicely presented for me earlier on. So we've got about 20 different technologies in that model with these learning curves, and the reason why we have a global model is because most of the technology learning and most of the development happens on a global scale, and most of the technologies are sold on a global market. However, we have included some local learning in this model, which is why it's called Global and Local Learning Model, which is a unique aspect of this model. So what it does is it looks at different regions around the world. So, for instance, we've got Australia in the model and we have local learning curves for the Australia, and the reason why it's important to have local learning rather than just global is because you do also have aspects of local learning.

So, for instance, with wind, the wind turbines are sold on a global market, they're developed globally, but the installation happens locally, and there are different costs associated with local installations. So you've got different installers, you've got different network infrastructure costs, you've got different labour rates, that kind of thing. So we tried to build that in our model. So we've done it for wind and we've done it for photovoltaic, but we haven't actually done it for other technologies yet just because it's so hard to get the data, but we're working on it. So that's one thing that we've dealt with in our model and, sorry, I should say, the reason why we developed this model in the first place is because we use it to generate capital cost projections which feed into our other electricity models. So we've got an Australian electricity model and other models. Another aspect that we've dealt with in our model are market forces.

So in recent years the price of many different technologies has been on the increase, especially electricity generation technologies, and the learning curves, as Patrick showed, say that as you build more of a technology it gets cheaper, which is true, but in recent years the costs have been increasing and it doesn't mean that the people haven't been learning how to build these technologies. The costs have just been increasing for various factors. So, for one of … as an example, wind, which is a technology I've looked at quite extensively, part of it is to do with very high demand for wind, increases in labour costs, material prices, and basically profit-making, because the demand is so high they could charge more for their turbines. So we've found a way to build that into our model where if someone … so, in the model, if they tried to build more of a technology in any single year, they have to pay more for it. So we've got a balancing act between the costs going down from the learning curves and costs increasing if there's too much of a build of one technology, so … and we project out to 2050 so we get a nice balance of our 20 different technologies that we look at. Okay. That's it.

ROBYN: Thank you. Tristan Edis is I hope you're ... correct pronunciation. A recent Grattan Institute Report which you co-authored was highly critical of a number of schemes aimed at supporting renewable energy and carbon capture and storage, and strongly emphasised the importance of Australia putting in place a price on carbon pollution instead. So should the Australian government just simply put in place a carbon tax or emissions trading scheme so you get direct control of greenhouse gas emissions, rather than supporting clean coal and renewable energy which are often high-cost methods of reducing emissions?

TRISTAN: Thanks, Robyn. Can you hear me up the back there? Am I on?

ROBYN: Yeah.

TRISTAN: Yeah. Good.

ROBYN: I can hear you.

TRISTAN: Good. Yes. Unfortunately you're not all the way back there. I suppose the short answer to your question, Robyn, and I think you'd be keen to get some questions from everyone here so I'll try not to bore you, but the shorter answer is no, we shouldn't be just putting a price on carbon. The problem we've had here in this country is we do everything except the most obvious and most important thing to do, which is to actually put a cost on pollution, and so yes, it is important that we're progressing those leading edge technologies that are going to really bring our emissions very low down. The problem is we're not doing all the easy and obvious things as well. And the other thing is that often those policies that look like they're really good, they're doing something tangible, like, for example, supporting solar PV, have often been little more than tinkering at the edges.

So, for example, I worked with Ric for many years, toiling away, during the Howard government period, and one of the things that we worked on was the Solar PV Rebate, and that was in place for something like seven years and it basically drove maybe about, what was it, 5 megawatts, 10 megawatts' worth of capacity each year. It was doing nothing, yet these are the sorts of policies the politicians have been getting away with for some time, and are still continuing to do, and even once they start to take off, they pull back from them, immediately, the moment that we start seeing a surge, partly because of high costs. And the other point that I want to make is that, so, until we put a cost on pollution, we're not really putting in place a wide-scale incentive for businesses to change their practises, and the other thing is that we're not just dealing with electricity here. We're actually dealing with a number of other sources of pollution.

So, for example, between now and 2020, the major growth in greenhouse gas emissions in Australia is not actually going to be from the electricity sector, and a feed-in tariff is not going to do anything to change incentives in those other sectors that are going to be a huge source of growth of greenhouse gas emissions. So there are a number of opportunities that are less obvious for us than, say, installing solar panels or putting in place wind turbines or even switching from coal to gas that many people think is, you know, a dead end in the long-term but certainly is going to give us a lot of reductions in the immediate-term which I think are worthwhile. So that's why I think we put a lot of emphasis on the need to put a broad-based cost on pollution to provide an incentive across the economy.

ROBYN: Do you want to comment on that, Jenny?

JENNY:Well, in our models we do put a price on carbon and we do see different technologies coming into the models certainly when we do put that price on, yes. So by about 2030, we start to see changes. So we see retirements of existing plants, so coal-fired plant, and we start to see more wind coming in, solar and also carbon capture and storage, and wave energy, that's something else we model too.

ROBYN: By 2030 I'll be about 80. So slow, isn't it? Right. Time for questions.

AUDIENCE: We have another panel member.

AUDIENCE: Yeah, Robyn knows.

ROBYN: Yes, yes, yes. I'm going to introduce her at 8:15. Yes. Mary O'Kane, Chief Scientist from New South Wales. We have a question over there. Yes, please. Wait for the mic to come to you and if you could say your name, please, and a brief question, and if there's any particular person you'd like to talk to.

AUDIENCE: Yes, it's a question for Patrick. My name's Anthony Baird. I'm from a company called Heuris Partners. This year I did a project for one of the governments in Australia addressing the question … helping them in the design of a reverse auction process for a solar feed-in tariff at a large scale. I worked the numbers aggressively in terms of, you know, getting … taking market risk out through the feed-in tariff, a very high debt level in the project. I pushed aggressively as far as I could in capital cost assumptions. We got to three and a half thousand dollars a kilowatt of installed capacity, after collaborating that with interviews with all of the major PV players in Australia and one of the major engineering companies, and when I run it through a debt finance model I get to … on a 20 year feed-in tariff, depending on where the plant was built and the insulation, we get to 290 to $340 a megawatt hour. So it's about where some of your other countries are today, but I think it's important to note that, you know, it's about 10 times the 12 month average for the Victorian wholesale price. So that's a comment. Now, the question is a bit of a challenge to you on your experience curves because …

ROBYN: We need a quick one.

AUDIENCE: Yeah. The experience curve for solar PV, as you correctly showed, over much of the past 15 years was going upwards. It was going in the wrong direction, and similarly for wind power and much of that I think is related to the impact of feed-in tariffs. The sudden drop in the last four or five years is really a China factor. It's not an experience curve effect at all. It's, in a sense, a one-off shock to the thing as you get to a completely different cost structure, and the challenge question to you is that if you factor in your thinking around the Chinese economy going forward, the likelihood that the cost of capital to Chinese investors is likely go to from a fundamental low at the moment, the cost of labour in China rising at 20% per annum, and the likelihood that their exchange rate is going to shift substantially over the five to 10 year period, what do you think the risks are, given those assertions, my comment on them, what do you think the risks are to that experience curve, if you like, nirvana you're pointing out from the overseas analysts showing these miraculous cost reductions for solar PV over the next 10 years?

ROBYN: Patrick, what are the risks?

PATRICK: Cool. Can you hear me? Is this on?

ROBYN: You keep talking.

PATRICK: Okay. So the first one I think has actually been addressed by a few people about the cost differential between PV, so, yeah, if at about $300 per megawatt hour sounds about right. Now, if you're trying to go large scale and if you're trying to, you know, build maybe a system such as Terry showed and trying to plug in directly in the transmission grid, then, yes, it is quite a bit more expensive than the black fossil price. Though I would add that my understanding is that the cost of power from a new fossil power station is going to be about twice that of the existing markets, but that's where the benefit of distributed PV comes in. If retail prices are already in the order of 200 to $250 per megawatt hour and are going to increase, that's going to be the big contribution to grid parity. So, you know, grid parity for retail is … you know, could quite easily happen very soon. For wholesale, yes, it's a long way away.

In terms of the China question, it's a good point and Jenny might want to comment on this as well about, you know, one of the largest factors has definitely been the impact of Chinese manufacturing, but you can't, I guess, ignore the scale of the industry now. I mean, if you were to compare it to 15 years ago in what Tristan was talking about, you know, 10 megawatts or something a year. It's true that, you know, through both the wind and PV curves there have been the bottlenecks, as Jenny discussed, and that's due to, you know, supply chain management, you know, the costs of resources, and particular components taking a while, I guess the supplier taking a while to catch up with demand, but the beauty is when you're getting into the very large scale industries we're at at the moment then that can be, you know, spread out over the whole globe, I guess.

ROBYN: Jenny, China?

JENNY:Yeah. Well, I just want to say, too, that I think what's happening is it's actually going back to the learning curve. So there was a departure from the learning curve. If you look at the graph it's actually going back to where it should be. So there was a sort of hump in the learning curve and that was just due to really high demands. There was high demand in Europe. There were high demand in other countries. The industry couldn't keep up. They were also competing with the computer industry for the silicon. So there was, like, a shortage of the stock of polysilicone in the world. So these factors led to an increase in the cost of PV and it's just returning. So the increase in, you know, manufacturing in China, other countries. There's Taiwan as well. Korea. It's just returning it to the normal level where it should be.

ROBYN: A question on this side. Yes, please. Just one there and then we'll go over there. And a question, not a soliloquy, if you wouldn't mind. Yes, Sir.

AUDIENCE: Guy Abraham from Climart. We're talking about comparisons of costs and I'm just wondering to what extent are the costs we pay at the moment for fossil fuels and for the energy that's produced by them artificially lowered by government subsidies? My understanding is there's about $12 billion of government subsidies per annum to the fossil fuel industries. If we took that away, would that level out the playing field, so to speak?

ROBYN: Is that one for Andrew? Or Terry?

ANDREW: I can have a go. I'm probably not in a position really to comment a lot of numbers around subsidies for the fossil fuels sector. You know, there are any number of observations one could make. I mean, when you drill and exploration well, you can deduct the cost of that well against income in the first year. It's not depreciated like a lot of other investments are. You know, income generated at the wholesale level by generators is taxable income and they get a deduction for making investments. When people put PV on their rooves they don't get taxed on the income they make or their effectively offset costs, but on the other hand they don't get a tax deduction for the investment they're making either. So I guess I can't comment on the numbers like 12 billion.

ROBYN: Patrick?

PATRICK: I think what … so there have been a few reports recently that have been outlining, yeah, about $12 billion in fossil fuel subsidies. My understanding from looking at them is it's actually mostly relating to non-electricity sector fossil fuels. There's a hell of a lot of, you know, tax breaks for the fringe benefits tax for company cars, that sort of thing. A lot of them more relate to oil and gas than to electricity. So, I mean, you know, if I was … you know, the biggest, you know, thing we're not taking into account with fossil fuels for electricity is mainly the fact that we're not placing any value on the fact that they're causing climate change.

ROBYN: There's one over there. Yes, please.

AUDIENCE: Hi. It's directed to Andrew, but perhaps the other panellists as well. In your opinion, why are electricians in Victoria less productive and efficient than in other states?

ANDREW: Yes. I thought I was leading with my chin so I'm not surprised I got a question. Let me say my experience. Up until recently I was in charge of all of Origin's major capital projects. In that time I built … or the team that I led, we built over 3,000 megawatts of power generation in every Eastern Seaboard State in Australia as well as a major … over $1 billion gas project in New Zealand. Just to give you a contrast and it's with New Zealand. In New Zealand we had to stop people working in the rain, because they wanted to work. They wanted to get the job done. To contrast that, in Victoria we were working down at Mortlake, finishing a power station there, which is about 550 megawatts. A very big open-cycle gas turbine plant. It gets quite wet down at Mortlake in the wintertime and it's been a very wet period this year and while we've been building the power station, but it's misty some days and the rain's there and it's not. We've had to build, during the construction of the power station, effectively, tunnels that people can walk from the crib huts out to the site because it might rain while they're working, or walking. We've had situations when you build a power station that you often are doing terminations in buildings sort of smaller than this, but they're in buildings. You might have three or four guys working outside and it starts to rain. What happens is that they call up their mates and they all come back through the tunnels to the crib hut for three or four hours and if it rains for more than four hours they go home for the day. That's just how it works.

So what that ultimately means is that the power station that was going to cost you X, cost you X plus 30% and instead of taking two years to build, takes three, and it's not just our experience. It's been the experience of the people that bought Snowy Hydro and Seimens, building the power station at Laverton just on the outskirts of Melbourne as well, which was also open-cycle. I think it's just … and it's not replicated in places like Queensland, at least, not currently. It's not replicated in South Australia, it's not replicated in New South Wales and it's not replicated in New Zealand. So it's not for me to sit here and tell you how to solve the problem in Victoria, but I think it's a genuine issue, because if it's not dealt with, ultimately, as I said in my talk, those costs are capital costs that get built into the long-term cost of electricity in this state, and while we operate with a national market, we still have inter-regional flows that get limited and, you know, you really have to ask why is that occurring and perhaps question some of the things.

ROBYN: So there's your answer. Mind you, it's always raining in New Zealand. Yes, please.

AUDIENCE: Sandy [unclear 1:09:02].

ROBYN: Just keep talking.

AUDIENCE: Right. Yeah. No-one's mentioned the word baseload power today. I've heard it said that if you have more than 20% of renewables, or shall I call them variable power sources, it destabilises the electricity grid, so, given that, and I'd also like to note that solar thermal is still variable, it just has a longer period of variation at a slower rate, how are we going to decarbonise the grid under those conditions? What are we going to use for baseload power?

ROBYN: Thank you, and I think you're going to get a slide in answer.

PATRICK: So this power station that I'm showing you up here is a concentrating solar thermal plant that's just opened up in Spain. It's just finished commissioning as well in the past few weeks. It has molten salt storage which allows it to go for 15 hours without sunlight. So it's surrounded by large mirror fields, some of them which you see there. They're about the size of a tennis court. They'll collect enough energy at the top of that tower in the day so it can both operate during the day and continue operating overnight as well. Now, you're right in the sense that if that particular power station is covered by cloud for a few days, then it's going to run out of energy. However, the solution to that is to have a fleet of these power stations. So there's a term that, you know, Andrew will be familiar with in power generation which is capacity factor, how long they'll operate.

So there's no power station in the world which operates 100% of the time. The average production for, say, a brown coal-fired power station might be 85 to 90%, so it will produce electricity over a year equivalent to running 85 to 90% of the time. However, the black coal fleet, the entire black coal fleet of New South Wales, only operates at about 65% capacity factor. PV is maybe 20, wind 30. This power station operates at 75% capacity factor, so comparable with that are the coal-fired power station, so just like right now, you can have them ramping up and down and with gas plants and everything else coming in to meet the differences. We've actually done some pretty detailed modelling on the whole system for Australia, taking into account solar data, wind data and these solar thermal storage plants and show that a large fleet of them could supply reliable power with the same effective low carrying capacity as our current fleet.

ROBYN: Thank you, Patrick.

AUDIENCE: [Unclear 1:11:35] over a wide continental scale.

PATRICK: Yes. So our modelling to date has taken into account that actual real solar data from across the whole lot, and that does … and most of the time it's going to solve it. The few times where you will get a bit of an issue, and that's like over the last couple per cent of the year, is when you do have other plants that could burn either gas or biomass for backup system, or even integrate the backup into the solar plant. Now, just like today's grid, if AEMO only had to meet 90% of the electricity demand and, you know, on the really hot days and, you know [unclear 1:12:10] we have blackouts, then electricity would be much cheaper because it's the meeting of the last little bits which is more expensive, when you have to have peak implants and grid upgrades. That's going to be the same system in a renewable system, so if you can have renewables doing the vast majority 98, 99% of the job, only need backup a couple of times, that's comparable to what we do today.

ROBYN: We'll have two quick comments from Terry and then Ric and then we'll go over there, question over there, please.

TERRY: Yeah, look, on the question of baseload, it's worth understanding that the energy system is constructed around following load. So the way we've achieved that historically is you've got three members of the orchestra and they've each got a different job, so the coal-fired power stations are there to do sort of a constant load, but we don't ask them to move around, and then you've got the sort of intermediate sort of shoulder stations like combined cycle gas which do a bit of both, and then you've got the peaking power stations that can move quickly but we don't ask them to do baseload. In the new energy mix where you might have substantially more renewables, there are a lot of studies that show that we can achieve load following, because baseload's a generating concept, a historic one. We can achieve load following using a mix of solar, wind and gas. So it's eminently achievable and, you know, companies like BrightSource have done studies in California to show how that might work in a similar power system.

ROBYN: Ric?

RIC: I was going to make the point that this concept of baseload is a bit of a misnomer. There's very, very, very, very few people or businesses that actually use electricity constantly at 24 hours a day, seven days a week. They just don't. And the other point is why would you want to produce electricity in the middle of the night when no-one wants it? And that's what this concept of baseload is. And in the end, you want to produce electricity when you have the resources available, whether it's the sun or the wind and then, as Terry said, you can then pack other bits of the generation mix around it, so ...

ROBYN: What about putting in your electric car?

RIC: Well, that could be an opportunity to actually … well, that could provide electricity during the day and you could actually charge it in the middle of the night.

ROBYN: And storage, that's right. Please, over there.

AUDIENCE: Dennis O'Neil. Just probably a question to Patrick, but others may wish to comment. Has all the costing data that you've churned through dealt only with the cost of the generation side, no matter what technology is involved, or have you also factored in that with a more distributed form of generation we're going to have to move from the fairly centralised transmission links that we have at the moment, looking at the Eastern Seaboard, largely into the Latrobe Valley here and the Hunter Valley in New South Wales and equivalent centralisation in Queensland, to a far more distributed replication of those transmission links presumably to take care of where these solar thermal plants may go, where the wind farms may go and so on? What cost addition is a function of that renewed or that fully replicated transmission system? And the second part of the question is related to your comment about the load factors being far lower than say your average 85% for coal, therefore does that not lead to the need to have backup systems or replicated systems to ensure that you've got full coverage across the entire system and is that also costed into the numbers that you've crunched?

PATRICK: So, yeah, that's …

ROBYN: It will have to be brief, I'm afraid.

PATRICK: Yeah. So what you're talking about there is more of a, you know, design a portfolio, design a new energy system for Australia. The particular piece of work that we were talking about here tonight, we haven't done that. We've only looked at the actual costs and what's likely to happen with those generation technologies. In a separate piece of work that we released through the Melbourne Energy Institute last year called the Stationary Energy Plan, Zero Carbon Australia Stationary Energy Plan, we did do that. We [unclear 1:16:20] and we actually did a design of, well, if you were going to do the whole job, where would you put all the solar plants, where would you put all the wind farms and how would you link up the transmission, and in that case we actually were … you do end up with a semi-centralised system. So, like, we're going to do more scenarios where you have a lot more distributor PV, for example, or a lot more wave power and other things, but you still need some centralisation to, you know, get better efficiencies.

The capital costs for that transmission was about a quarter of the total costs of the rollout and we included it in that and that is something that will be taken into account, but that's why actually there are benefits from doing proper planning as opposed to ad hoc, so, you know, right now, as I understand it, you know, wind farms, you build a new wind farm, you've got to pay for the transmission, it's got to be connected and, you know, everyone has to have their own transmission line, where we looked at situations where, if you go to an area where you're going to build a lot of wind farms, you build one large transmission line and only have little links connecting to that, which is a much more efficient way of doing it. Now, that's something which has been looked at a bit by the industry, but, as I understand, it hasn't quite reached the level of reaching … you know, being put into place in policy.

ROBYN: Thank you. That will have to be the last question, I'm afraid. Please?

AUDIENCE: The discussion tonight has focussed mainly on supply, but I'm just interested in what research is out there on demand, I guess, in two regards. Just in terms of the price elasticity of demand, so as prices go up I assume people consume less electricity, just on how consumers might respond to higher prices. But, secondly, I note, just noting that Victorians reduced their water consumption dramatically in response to a government advertising campaign to encourage us all to reduce our water consumption, so you can see fairly dramatic shifts in consumer demand based on government advertising and other means. So just interested in what research or what, you know … what has there been out there in relation to demand?

ROBYN: Terry, do you want to answer?

TERRY: I'm happy to cover it to some extent.

ROBYN: Please, yes.

TERRY: So in the last report that we published, one of the things that we looked at was the efficiency of the household appliance stock, and there have been some quite significant gains in the efficiency of the household appliance stock over time, driven to a large extent by Energy Efficiency Regulations' minimum standards, and there's a next round that are coming through that will feed through the stock over the next decade and they are bringing household, or at least household electricity consumption was … is still continuing to grow and sort of … but it's starting to level off and it's expected to level off over the next decade as we sort of ban electric storage water heaters, we put in place minimum standards for televisions and some other factors, but, unfortunately, at the same time, we've got major growth in the industrial sector driven by things such as LNG and also mining, and unfortunately they outstrip that saving or that gain that we're getting in energy efficiency that the household sector are expected to reap as a result of new energy efficiency standards, and they really won't be susceptible to major electricity price rises.

It will still be worthwhile pursuing your LNG project because it is so financially worthwhile in spite of a higher electricity cost. But at the same time one of the things that we don't generally model, in fact, the government has explicitly not modelled this, is the aluminium's melting sector, if it faced the true cost of electricity, it would probably be more efficient to do it somewhere other than Australia, and if you took that out of your demand mix, it would be one of the lowest cost forms of abatement in this country, and it would be a very large amount of abatement that you would get at a very low cost, and that is often not analysed or taken into account in a number of the economic models.

ROBYN: Thank you. I wish we had time for more questions, but still, I'd like to introduce Professor Mary O'Kane, who, of course, was the Vice Chancellor of the University of Adelaide, mathematician, who has looked in the last few years at innovation and was involved in a major report on innovation, as you probably know, and please would you sum up … she's now of course the Chief Scientist in New South Wales.

MARY: Well, and again, thank you, and I hope you can hear me. Just wave from the back. There's a bit of a frog in the throat so it might go a bit weird. Robyn, thank you for that, and Robyn didn't mention I'm his near neighbour in Balmain so we often get the cha … well, we don't actually get to see each other a lot, but we do, you know. We share the odd taxi home from functions like this when it's in Sydney. But I actually think I'm here, Robyn, for another reason. I also chair the Australian Centre for Renewable Energy for the Commonwealth Government, and that is part of the Federal Government's Clean Energy initiative, which of course is a $5 billion initiative. Large amounts are devoted over $1 billion in each case to the big flagships, carbon capture and storage flagships and the solar flagships. Then the little cousin is the Australian Solar Institute at $150 million, and the remaining piece is ACRE, the Australian Centre for Renewable Energy, which is not a centre, it's a policy and funding outfit, a very unusual structure, and it looks after the rest of funding, getting technologies down the curve, renewable energy and enabling technologies down the curve, and we have a budget … well, when I arrived and I was appointed I was told I had a budget of about $700 million that the board would be advising Minister Ferguson on.

Quite a bit of that actually has been allocated. $100 million is being put to a venture capital fund, which we're just looking to advise the minister on who to appoint to fund manage and we're expecting an announcement about a new program that the minister signalled in the budget, an emerging renewables program. Anyway, and there's about 500 million out there. The biggest amount from ACRE is in geothermal, which we haven't talked about much tonight, but it also funds quite a bit of solar, and various mixes, hybrids and so on, and sort of storage-style other technologies. But that's … I think that's why I'm here. But what I wanted to say, just a few comments between you and your dinner or going to sleep, first of all I wanted to say congratulations to the organisers and to the speakers.

We need more of events like this. We need more people here at the institutes as a response of this doing the modelling. Congratulations, Patrick, a great report. Congratulations, Jenny, on the work she's been doing. And we need people like the fantastic speakers tonight and the very good questions about these issues. We need to be debating this. And we need to be modelling the options, because if we're going to make informed choices we need to sort of tease things apart and be able to look at some of the hidden things that only cone out when you do quite detailed models. We're not going to get it totally right. We're going to miss the effects of humans in this system driving things, but it will allow us to probably make better choices. I loved that point about the aluminium issue. I was dying to make … I was wondering if someone was going to ask a question like that, whereas several of you did anticipate some of the things I was going to raise.

You really do have to look at it in detail, and often before, you know, ACRE might spend the money or get the government to spend money and others invest in things, it really helps investment if you have that modelling done. At the moment investment is a real problem in Australia. There's very little capital out there in the energy area in the renewables and low emissions area because of the uncertainty of the carbon price and so on, things that our speakers have covered very well, but it would make things easier if some of that … if more of that modelling is done. So my first comment is please do more of the modelling, and I want to raise a few more things that I think we need to model. The speakers, starting with Patrick, but Andrew and the others, touched on, I think, a very important aspect of things, and that's the innovation bit, and Robyn mentions I've been involved in the National Innovation System Review, and I think the issue of learning by doing is one of the best reasons for Australia to be getting going in the renewable energy area.

As we know, you know, people pluck this figure out of the air. It hasn't been adequately modelled, I suppose. About 90% of innovation is said to be non-technical in a sense, in the sense that it's not new inventions, new patents. It's about process issues. It's about learning by doing. And Australians are great learners by doing, and I think we do need to think about that and about incremental learning. And the solar PV story told so well from many angles tonight is a great example of that, in various ways. I have to say, I'm up for danger money in my New South Wales Chief Scientist role. I chair the solar summits up there. I've done one, and despite escaping to the United States next week, I understand the day I come back I do solar summit two. Don't throw things at me if you come to it. Well, depending on when it's actually held. It's certainly fascinating. But I think there are many other things we need to be touching on and they were touched on in the questions, as well as all the great things the speakers raised, and I think we need to think about modelling them. So we do need to think about trying to model the innovation effect. It's quite hard to model but we need to give it a go.

I think Andrew touched on some very important labour points. You know, whether it's competition for labour, for in the mines and so on, whether it's efficiency of labour, again we need to try and model that and impact on the energy system. After all, it is energy that powers our economy, but an awful lot of other aspects of the economy turn around at the labour aspects. I was very pleased in the questions to hear people raising questions about the grid and about peak load issues. We saw several graphs tonight about the transmission matters and the cost on the transmission system, and we need to understand a lot more about renewables and towards the end of the discussion we got into some of the points about some of the other work that Patrick and his team have done on what happens if you locate various power plants, be they renewable or whatever, at different places, what does that do to the transmission system? What might it actually even do to the country?

I mean, what if you build big solar power plants right in where the insulation is best, right in towards the desert? Are we going to see a sort of flowering of the desert, the sort of thing that's been raised a lot in Israel for sort of other reasons. What can we do there? What happens about if … what do we do if we can try and reduce the peak load? A lot of our energy systems are built to the peak load. What happens if we have a more distributed load arrangements, a lot more residential arrangements and we, particularly with the great air conditioning problem of the summer in Australia, what happens if we can deal with that at a more local gridded level?

The AEMC on our … we've got a wonderful board at the Australian Centre for Renewable Energy. It includes Brian Spalding who ran the precursor to AEMO and is now a Commissioner at the AEMC, and one of the things that Brian and John Pierce, the Chair of AEMC, have pointed out is they've got a new reference to look at the grid, which is classically, like many grids in systems in countries like ours, hierarchical downwards, how might we make it more suited to putting on distributed renewables of variable sorts, be they distributed to a power or mini-power plant scale, maxi or more residential, and what can we get out of that? And early studies do show we can save a lot in the abatement area there.

The other thing I'd like to point out here is something about our expertise, and I think it was Terry who touched on the point that Australia has the capability of doing a lot of this, just like, you know, we did the Snowy all those years ago when, well, some of us were born anyway, but, you know, we do have some amazing capability in this country we forget about. For example, we're extremely good in control theory and of course here at the University of Melbourne is one of the great world centres in control theory, and we have great modelling power in things like NICTA, National ICT Australia, which again has a big lab just up the road over there, on the campus here, and we have great capacity in e-research, and it's not just here. It's right round the country we can do a lot of this modelling. So we ought to be joining up a lot of that big ICT scientific capacity, our control theory capacity and doing that.

Just now jumping around a few topics, one of the things I enjoyed on the plane flying down, and I got here a bit late from racing in for meetings, but I did read the Financial Times flying in and there's a good article in there about Germany, as you know, is closing down a lot of its nuclear power stations and looking at how it's going to use renewable energy more, and of course the interesting things is with their … the relevant minister giving an interview, it's talking all about the exports from Germany, and again it's something we tend not to talk about here, and maybe for good reason, but it is something to think about and to put into the modelling system. The other thing that I wanted to mention is hybrids. Just like looking at the grid and looking at efficiencies around the grid, ACRE, and if you want to read ACRE's sort of approach to things, the strategic directions, if you just Google strategic directions Australian Centre for Renewable Energy online, you can get a copy of it, is a publication that came out not so long ago, just about eight weeks ago, which lays out a lot of the things ACRE's going to look at in its upcoming funding, but one of the things we're very keen on is hybrids. Things where you can get going with renewables but you don't have to face the full capital cost of a full power station installation, and one we've already funded through one of our component programs that's now closed, the Renewable Energy Demonstrator Program, is Kogan Creek in Queensland which is a sort of solar booster to a coal-fired power station. Similarly, we've got a project, again through the Renewable Energy Demonstrator Program, on King Island in Tassie, looking at how we bring together a set of renewables into a smart grid, and again the smart grid issues and how we do that along with hybrids. We're also looking, in New South Wales, at mixed solar and geothermal preheating on the Liddell Power Station where we do solar boost it now and we're exploring geothermal boosting as well.

Another couple of things, I want to just go a little bit more way off … or, no, before I go way off, let me pick up the comment about off-grid issue. That's a big thing, and again something that ACRE is looking at a lot. We've got a lot of off-grid modelling studies. We have, too, joined the modellers and so we should. And again I think that's worth thinking about. It's also worth looking at the enormous mining activities that Australia is looking at, like Olympic Dam 2, and BHP Billiton, of course, is looking at the power options and what we need are really big organisations, like our big companies, who might be able to afford to lose two or three billion dollars and put that at risk in looking at the power in options like this and actually to experiment a bit. Part of it is understanding part of the capital scale questions in this area. I liked Tristan's point about less obvious opportunities. I mean, I've been making that point myself through here about grids and other things we could look at, but I think we need to be looking at them, while, at the same time, absolutely modelling the mainline ones as well.

I just want to throw a couple of mad ones into the mix, but mad ones that I've enjoyed hearing about. The Academy for Technological Sciences and Engineering has been very interested in energy for quite some time and had some wonderful seminars, and we had one last year on sort of … an international one on energy. Not just renewables but it had a fairly new energy focus. One of the proposals I liked best came from the Japanese presenters who showed this truly wonderful slide that I wish I'd brought with me, how, what they were looking at out in the 50-year timescale, and it had these wonderful cables coming down from Japan to Australia and they were going to import direct energy from Australia up to Japan, and so that sort of thing is not so silly. Just like PNG was talking not so long ago about exporting to us. Should we be importing or exporting energy up through Indonesia? And I think things like that … energy is not just … we've got a very exciting country with lots of energy resources in it, but we need … energy is a global thing and I think we need to think about that sort of thing.

I was very pleased the electric vehicle issue came up. I think the transport matter we didn't talk about a lot tonight but that's a very big energy matter too, and the whole issue of where we bring transport, electricity and the storage matters together in the electric vehicle matter is very good, just as it all fits in back to the grid matter in the smart grid area. So there's just a few extra things to think about. Again, congratulations to the organisers. Please let us all keep this sort of debate and discussion going. Let's keep it going in the press. Let's keep it going in detailed technical mathematical models that are going on, and I think if we keep an eye on that sort of thing it will help us move the whole of the energy debate in Australia forward. Thank you.

ROBYN: Thank you.

AUDIO: This has been a podcast from Grattan Institute. Want to hear more? Check out our website, www.grattan.edu.au.

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