Energy Futures – Energy Storage: What Scale? What Cost? What Impact? - Melbourne 27 Feb

Is energy storage the 'next big thing' that will enable greater deployment of renewable energy and reduction of greenhouse gas emissions? If so, will energy storage be found at centralised grid locations, at substations throughout the network, or in the garages and utility rooms of homes and businesses? By what mechanisms will it be implemented? And how will the benefits of energy storage be shared among those who generate, distribute, sell, and buy energy? These questions and more were explored by our selected speakers and panel of experts from industry and academia.

Chair: Mr Giles Parkinson, Founder and Editor, RenewEconomy

Speakers: Mr Tim Forcey, Energy Advisor, Melbourne Energy Institute
Mr John Wood, Chief Executive Officer, Ecoult – developer and marketer of the CSIRO UltraBattery
Mr Tosh Szatow, Director and Co-Founder, Energy for the People

Panel:
Mr Rob Clinch, Associate, Arup
Mr Craig Chambers, Market Sector Director, Power Generation, AECOM
Mr Terry Jones, Manager, Distributed Energy and Innovation, SP AusNet

GILES PARKINSON: Good evening everybody. I'd like to welcome you all to the University of Melbourne and the seminar on *Energy Storage* hosted by the Melbourne Energy Institute and the Grattan Institute. First, I'd like to acknowledge the traditional owners of the land on which we're holding this event, the Wurundjeri people, and to offer our respects to their Elders and the families past and present.

My name is Giles Parkinson. I'm the editor of www.RenewEconomy.com.au. It's a newsletter and a website, and I hope many of you already read it and, if you don't already read it, that you do sign on and read it. I'm not selling you anything, it's actually free and some of you might find it informative. If you're interested enough to come to this meeting then you might find it interesting. I've been a business journalist for 30 years and I've been writing about renewable energy and climate issues for about six or seven years, and I really did not expect to be involved in a session looking at the intricacies of storage and battery storage, and I wouldn't have expected 500 people to turn up to listen either, but such is the interested in battery storage now. It's something which people say is threatening to transform the electricity systems which we've been using for the last 100 years. We're only now at a stage where we're just starting to absorb the implications of solar and some of the other technologies, and battery storage seems destined to make a quantum leap and take those trends even deeper and even more quickly.

What makes battery storage so exciting is its potential to transform systems, as I mentioned before. And this is not something that's really just put out by the battery storage people itself or green activists and boosters, if you like; it's actually something which is noted by the industry itself. And I'd just like to start off with a few quotes from some interesting people overseas and in Australia. The first quote is from Jon Wellinghoff and he was the Chairman of the Federal Energy Regulatory Commission, which is probably the equivalent of our AMC, and he just recently retired but he said this when he was still in his office. He said, “Solar is growing so fast it is going to overtake everything. Once it is more cost effective to build solar with storage than to build a combustion turbine for power at night, then it is game over. At that point, it will be all about consumer-driven markets”. Another quote from David Crane, he’s the CEO of NRG Energy – they’re the biggest generator in the United States, they have 52 gigawatts of generation which is about the equivalent of our entire grid. He said, “Consumers are realising that they don’t need the power industry at all. That is ultimately where big parts of the country will go”. And he actually was at a speech last night I saw and he was talking about the craziness of trying to operate a 21st century electricity system with 120million wooden power poles and maybe we had to find different ways to look at it.

In Australia we’re getting similar observations, and so we should because there’s probably no other country which has such excellent solar and wind resources as we do, access to the best technology, and such high electricity prices. We often talk about or hear about cheap coal in Australia and it’s true, for a lot of the time we have had cheap coal, but right now we’ve got wholesale electricity prices which are at records lows at 4c per kilowatt hour, yet the retail price is up to nearly ten times that much. It’s the cost of delivery which is making electricity expensive and which is creating a huge opportunity for distributor generation, such as solar and battery storage.

Here are some quotes. Ergon Energy, which runs the grid in regional Queensland, said last year, “We may see a time in the next decade where renewable and battery storage will be cheaper than grid power for the domestic consumer”. Energex, which manages the grid in south-east Queensland, says, “As energy management options such as smart appliances, energy management software, in-home generation and battery storage become more available and affordable, we expect to see a significant change in the way consumers use energy and our network and this will have wide-ranging implications for the way the distribution network is planned, built and operated as well as for our ongoing business sustainability”.

You could probably come up with some more quotes. UBS talked about solar being a no-brainer. City Group did a big report on energy Darwinism. They predicted that 50% of electricity could actually be sourced from distributor generation, a lot of it on the rooftops of households and commercial businesses. And the CSIRO came up with a report just a couple of weeks ago called *The Future Grid* which talked about up to 45% of electricity coming from households being generated and being stored by consumers. The big question though, and one we hope to answer here tonight, is how will this emerge? Will the case for energy storage be found at the centralised grid locations; at substations to the network; or in the garages and utility rooms of homes and businesses? And through what mechanisms will these be implemented? How will the benefits of energy storage be shared amongst those who generate it, distribute it, sell and buy energy? And the latter point is interesting, because we’ve talked about a lot of technologies – wind and solar – and a lot of that focus is on cost and that’s going to be true for battery storage as well, but there’s going to be just as much emphasis on the value of the storage and how that fits into the system because a lot of it will really depend on how the utilities respond and also how the regulators respond and how some of those incentives are framed.

We’ve got a range of fantastic speakers tonight to help us answer those questions. I shall probably just introduce them very briefly just so you know who you’re staring at and I’m going to have a few slides and then I’m going to invite them to speak. We have Tim Forcey from the Melbourne Energy Institute; we have John Wood from Ecoult; we have Tosh Szatow from Energy for the People; we have Rob Clinch from Arup; we have Craig Chambers from AECOM; and we have Terry Jones from SP AusNet.

I'm just going to indulge in a couple of slides just to get the juices flowing about a few interesting things that have just popped up recently actually. One of them is a report which came out two days ago and these next two graphs are testament to the fact that you can do a good report, but you can't necessarily do a very good graph. It comes from the Rocky Mountain Institute and it tells us this, and this is about solar battery costs and grid. This is in America and they took five jurisdictions and they were just trying to say "How close is it to parity to the grid?" And what they found was pretty amazing. That dotted blue line going across the top is the retail price in Hawaii and where it's going up to 2050 and this is for commercial installations, so people who want to put solar on retail and shopping centres and factories and what have you. They're already at commercial parity. The other places you can see, in New York and California, Kentucky and Texas, those solid blue lines are the estimated levelised cost of electricity of solar plus battery. That is their base case with no improvements, but you can see that even there New York and California get to within about a decade, however, if you add a few demand management incentives and also technology cost falls then it's going to be within the next couple of years.

This next one was really interesting, and that's another terrible graph but I'm going to try and explain it to you. It basically suggests that within ten years, homes in New York and Los Angeles could actually find it cheaper to leave the grid, rather than stay connected to the grid, within ten years. And if you look at the top right-hand corner, that's basically if nothing much happens – well, it looks to me like Kentucky's never going to get off the grid, but in Hawaii it's already pretty much grid parity and with the combined improvement of accelerated technology and demand-side improvement they're suggesting that Los Angeles and New York could be there by 2020 and Texas could be there probably ten years later. I find that quite an extraordinary thing and Tosh might be telling us later on that it might actually be happening even sooner in Victoria.

This is the CSIRO *Future Grid* scenarios. It's an interesting one. The red and green ones are the really interesting scenarios. In the red, 45% by 2050 stored and generated in the home and the green one is 30%. As I said before, a lot of what happens over the next ten, twenty years is going to depend on how the networks react and also how the regulators react. The leaving the grid, which is the green one, is where basically the networks don't evolve, don't respond and people get really jacked off with what they're being offered and decide "Well, we're just going to get off the grid". I guess not everyone is going to want to do that so some people will stay, but there will be a lot of people who do want to do that. Red which has more people producing and storing at home is where the networks respond and they're providing a lot of incentives to do so. The yellow is the "set and forget" which is actually quite interesting. There's still 25% home generation or local generation by 2050 and that presumes that nothing much changes, and the "renewables thrive" is an interesting scenario suggesting that if we have an awful lot of renewable generation – say, 60%, 70%, 80% - in the main part of the grid, then people won't feel so motivated to have solar on their rooftop or storage or what have you. In the current administration I'm not too sure whether that's going to happen, but it's an interesting idea.

This is what the South Australia Power Network people reported a couple of days ago. What happened during the recent heatwave? The blue line is what happened five years ago when there was very little solar PV; the yellow line is what's happened now. They've got 550 megawatts of rooftop PV in South Australia, which is quite a lot, and that's just showing the demand. It's brought down the demand all through the day you can see by 400 megawatts basically and they're probably operating at 70%, 80% capacity. It has shifted the peak by two or three hours. The peak is now at seven o'clock, or it was on that day. It doesn't take much imagination to imagine what an hour or two of storage would do to that peak as well and that's one of the interesting questions we're going to be dealing with tonight is what do you do with storage? Do you put it on houses? Do you deploy it so you can actually remove the peaks? Are you going to play an arbitrage game or what have you? And I found that really quite compelling. During the day between nine o'clock and three o'clock rooftop solar is providing 15% to 20% of their electricity demand and it's going to be interesting to see how storage implicates that.

I apologise for this graph too. Ignore the one on the right for the moment. The one on the left is basically a forecast by City Group as to what's going to happen to the generation profile in Germany when they get a bit more solar, say, in about ten years' time. During the day, that big black lump in the middle is solar, the pink is wind, and the orange is fossil fuel generation, so coal and gas, and you can see how they're being squeezed out. The graph below is the interesting one, that shows why it might be of interest to the generators and the network operators to have a lot of storage because basically you capture a lot of that output at the peak times and you spread it through the day, and that's the grey line, and therefore you make the fossil fuel generators a much happier bunch down the bottom because they've got much more even output, rather than being squeezed out in the midday profile up above.

Just a couple of very quick other things. We're going to talk a lot about battery storage and hydro storage; there are other forms of storage. This is the solar thermal plant being built in Nevada, it's almost complete. It's called Crescent Dunes. It's 110 megawatts and it is the largest solar tower with storage in the world today and I reckon it's going to have the ability to transform the way we think about some of the large-scale generation. On the left-hand side is what you normally see from an output from PV, it's sort of up and down all over the place and just comes in within certain hours. On the right-hand side is basically the output plan from Crescent Dunes which is a nice big block which grid operators like. They've got a contract to supply Las Vegas between midday and midnight and that's what they're going to be doing, so they can guarantee to do that each and every day and that makes actually a very powerful proposition, and they could actually configure that any way they want. They could turn it into a peaking plant to be switched on or off whenever you want it or to provide base load at a lower capacity throughout the day or whatever.

This one, I've visited them in California. This is an Australian one because under the new government we like to be supportive of Australians – go Aussie! This is a steam engine, outside is a parabolic trough which attracts electricity and boils the water, creates steam, and it goes to an old steam engine. They dug out an old steam engine, using 300 year-old technology – and this is their pilot plant – they've put it into a crate, they've got a tank next to it and they're just using the difference between the high and the low cycles of the steam engine to be able to regulate the output as they like. And this is an interesting one because it's going to be on distributed level about 500 kilowatts and up to one megawatt, really interesting for people like irrigators and people like that, and also small townships. So good luck to them because it's a bunch of Australian entrepreneurs in California and they're just rolling out the first of the commercial ones now, so that's pretty interesting.

And my last slide is in Germany, I went to visit these guys, these are battery developers in Germany. I love their thing at the start there: you are leaving the CO2-producing sector of the world. And if what they say about their technology is right then it could be true. They've set up a 10 megawatt module and they said that if you put around 200 of these around Germany for a cost of about $2billion you will actually be able to provide the frequency and the regulation of the network, which was previously provided by the fossil fuels. And that is really quite important because a lot of coal generation runs at the moment in Germany not because the energy is needed, but because it's needed to provide support to the grid. If these guys are right and you could provide regulation and frequency with battery storage at a much cheaper price then all of a sudden you have no reason for coal to exist, apart from at the moment their energy output. And that means that you can actually go forward to have an awful lot more solar, an awful lot more wind, and it's a key plank to getting up to 100% renewables.

There you go, that's it from me. I hope that's thought-provoking. I'm going to start asking the speakers up now. The first speaker is Tim Forcey. He currently holds the position of Energy Advisor at the Melbourne Energy Institute. He is a chemical engineer employed in the past by the Australian energy market operator Jemena, BHP Billiton and Exon Mobil, and he's going to talk to us about hydro. Thank you very much Tim.

TIM FORCEY: Batteries, batteries, batteries. That's small-scale stuff. If you'd like to work in big-scale, maybe you already do and you're a bit nervous about these batteries, what can you do? Pumped hydro.

Thanks for coming along tonight. It's a fantastic crowd and it's good to see you. As Giles described, energy storage is a very broad topic and there are plenty of questions to ponder. Every day there are new developments in energy storage, but it's not new. It dates back to the first plants and other Earth processes that fossilised all that solar energy for us so many years ago. Certain humans, such as your speakers and panel members tonight, we've only become really enthusiastic about energy storage in more recent times. So how to unravel these questions and figure out what might be best for Australians and for people the world over as we strive to stabilise our climate, reduce other health risks, and improve the efficiency of our economy.

Well, what the University of Melbourne Energy Institute (MEI) did over the past year is to take a fresh look at one of the largest and most-used forms of energy storage, which is pumped hydro. We wanted to see if this technology might have a new life in Australia, especially to complement solar PV and wind. Tonight we launch this research paper entitled *Opportunities for Pumped Hydro Energy Storage in Australia* now available on the MEI website. I would like to recognise my colleagues who conceived, led and contributed to this paper, Patrick Hearps, Roger Dargaville, Dylan McConnell, Mike Sandiford and Peter Seligman. I would also like to recognise the engineering and consulting firm Arup who supported this research.

Though pumped hydro exists on a small scale, tonight when I say "pumped hydro" I mean multi-megawatt, large-scale energy storage. There are three large-scale pumped hydro facilities in Australia already: Tumut in the Snowy Mountains, Shoalhaven also in New South Wales, and Wivenhoe in Queensland. However, no large-scale pumped hydro has been built in Australia in the last 30 years, which raises two questions: why did we build them then and then why did we stop? But before I address those questions, let me describe what pumped hydro is and how it differs from conventional hydro electricity generation.

Many of you will have driven past conventional hydro in Tasmania on the way up to the Falls Creek ski resort or around the massive Snowy Mountains hydro scheme in New South Wales. The principle of conventional hydro is that water at a height is a source of potential energy and if you let that water flow downhill through a turbine you can generate electricity. I have a mate who lives on the Nicholson River in Gippsland and he generates some watts of electricity with an old washing machine pump and motor and basically running them backwards. However, if your aim is to generate electricity on a large-scale, this may involve building a big dam. Dam building comes with its societal and environmental consequences well-known to people like me who've rafted the Franklin River in Tasmania. And that is one reason why when you say the words "pumped hydro" some people think it has no future on the dry continent of Australia.

But before I go into those issues, how does pumped hydro differ from conventional hydroelectricity? Like conventional hydro, a pumped hydro plant generates electricity but before it does it that it stores energy by buying electricity from the grid when it is cheap and demand is low and using that electricity to pump water up into a dam up the top of a hill. The water can sit there for hours or weeks until electricity market price signals indicate there's money to be made by letting that water back down the hill through a turbine, just the same as conventional hydro. But unlike conventional hydro, pumped hydro doesn't need a large or continuous supply of water. Of course, you must find enough water to fill up one of those dams the first time and you also must replace evaporation and leakage losses, but you don't need any more water than that. So if you look at pumped hydro from afar, you won't see much difference between it and conventional hydro. In fact, pumped hydro is often integrated with conventional hydro, such as was done at all three of those Australian facilities I mentioned before.

So I've described pumped hydro and shown that it already exists in Australia, but here's a question: after all these years, are those plants still actually used? To check, we downloaded electricity production data for the Shoalhaven facility and we saw this behaviour, for example, during June 2011. The red spikes show the day-to-day fluctuations of wholesale electricity prices in New South Wales and the data shows that at night electricity is generally cheaper than it is during the day, on this chart by as much as a factor of four. The blue spikes show electricity production from Shoalhaven that matches those price spikes. The Shoalhaven facility pumps up water overnight and then lets it down during the day and generates electricity in order to make money from what is called market arbitrage: buying low and selling high. So yes, the pumped hydro facilities in Australia are used.

Now, if we look at how pumped hydro is used around the world we have this pie chart where pumped hydro basically takes up the whole pie. Pumped hydro compared to all other man-made on-purpose energy storage technologies such as batteries, compressed air, flywheels, molten salt thermal energy storage or synthetic chemicals created for energy storage; pumped hydro dwarfs all of these combined by a ratio of more than 20:1. Why? Because it's always been the cheapest. The first pumped hydro facilities were built in the 1890s in Europe but pumped hydro became big in the 1960s and 1970s. Why? Well, back then a new energy source had arrived on the scene but it needed a partner, and that new energy source was nuclear. The first nuclear plants were truly base-load devices. You got them running and then you didn't fill it or ramp their electricity production up and down, but electricity demand goes up and down. So, to balance those nuclear plants a form of energy storage was needed, even back in the 1960s and the answer to the energy storage question back then was pumped hydro.

Some of the pumped hydro facilities around the world are just enormous. This one on the shores of Lake Michigan can generate electricity at a rate of nearly two gigawatts for 13 hours, and if you know your gigawatts from your kilowatts, that's a lot of stored energy. Decades ago in Australia and elsewhere it was found that pumped hydro could complement coal plants and was also a way to maximise the utility of a conventional hydro plant. These two pictures here show that pumped hydro does not necessarily mean you must dam a pristine valley. It is possible to create what we call in rural Australia "turkey nest dams" where a pond is built by simply moving earth out of the centre and piling it up all around to make the dam walls. Even the Shoalhaven facility we saw before in New South Wales has characteristics of a turkey nest dam.

So, that is a short history of pumped hydro, however building nuclear plants is not so common anymore so why is pumped hydro and the whole topic of energy storage in the news? Well, as the world moves to greater amounts of renewable electricity generation, wind and solar whose output can vary throughout the day and night, it is again handy to have a way to complement those new technologies. So, pumped hydro is resurging globally in places like China and Europe and is being considered again in Japan, Canada, California and Hawaii and today I have to add Arizona to the list with the new news that just came in.

But what about water supply? Australia is prone to droughts, so should we build things that create any additional water demand? The supply of water is something that proponents of pumped hydro need to think about and I don't doubt that there are sites in Australia where fresh water pumped hydro can be built, but if you want to avoid using fresh water altogether there is the Okinawa option which uses seawater. This photo shows the 30 megawatt Yanbaru pumped hydro facility that has been operating on the coast of the Japanese island of Okinawa since 1999. It remains the only seawater pumped hydro plant in the world. The upper pond is at an elevation of 136m above sea level, covers five hectares, and is 23m deep. The lower pond is very large because it is the Pacific Ocean. If this photo looks familiar it may be because it features on page 124 of Dr Seligman's book that you might have picked up on the way in here published in 2010, but more recently, in May last year, Dr Seligman visited Yanbaru as a guest of the operator J Power.

So, are there coastal areas in Australia where seawater pumped hydro could be built? To test this, we built a high level cost model, as I shall quickly illustrate just with these charts from our report. Now, you're not meant to be able to interpret these charts at quick notice, but we combined these cost equations with space shuttle radar topography data to map out possible pumped hydro sties in western Victoria and in South Australia, as shown here. With this tool, MEI quickly scanned huge land areas and found where there might be suitable sites. Ideally you were looking for a site with a high elevation yet near the coast. High elevations mean that you can get more energy out of a cubic metre of water, but you don't want to invest too much in the pipes and tunnels that will have to connect up the two water reservoirs and get that water back to the sea.

Our model ranks these sites based solely on cost. In future we'd like to take into account factors such as competing land use constraints, seawater quality, geotechnical integrity, and also proximity to electricity generators, users and transmission lines. If you're not familiar with the land along the coast of western Victoria and South Australia, here is a view produced from Google Earth. At this location on the Fleurieu Peninsula in South Australia the land rises to a suitable elevation not far from the coast. Here, potential pumped hydro sites just happen to be located near an existing wind farm. I mentioned we used a costing model and this next slide shows some of the example costs. So was MEI able to say if seawater pumped hydro can be built in Australia at reasonable cost? Our view is that it would be worth going to the next stage of investigation - a pre-feasibility study - where we would narrow down sites and gather more real-world construction cost data. But we don't expect the cost to build pumped hydro in Australia would be vastly different to what is being pursued overseas.

However, costs are only one side of the equation; what about the economic benefits? We saw before the Shoalhaven facility was at times being used nearly every day, but does Shoalhaven make any money? Can an investor make enough money to justify the expenditure of hundreds of millions of dollars? Similar to what others had done in the literature for America; MEI downloaded historical Australian electricity price data and built a spreadsheet model to represent a pumped hydro plant. The top red line shows the wholesale prices over the course of 24 hours. The prices start off low at $50 a megawatt hour and then climb to a high of over $150 per megawatt hour – more than a factor of three difference – before falling again. In response to that, MEI's pumped hydro model buys electricity to pump water and fill the upper reservoir overnight. The water is held for a few hours and then, once the electricity price has risen, water is discharged to generate electricity. The black line down the bottom shows the cumulative cash flow. For a while we are cash negative as we buy electricity to pump water, but then we recover those costs and make some profit by the end of the day.

In this modelling we made a lot of assumptions, as modellers always do. One of these is called the small device assumption. The size of the pumped hydro system is assumed to be so small that it has no impact on market prices, however you can imagine that if large energy storage devices were installed in a small market it could have a tremendous dampening impact on prices and in that case, the small device assumption would be invalid. In fact, during last month's heatwave wholesale electricity prices in Victoria and South Australia spiked to over $10,000 per megawatt hour – a factor of 300 times greater than the normal price. If there existed an additional large-scale energy storage device in Victoria or South Australia today, would we have seen such high wholesale prices?

The next chart shows our modelling of nine financial years in South Australia. We call this chart the pumped hydro arbitrage value index because it provides insight into how much money an energy storage device might have made in South Australia during those years buying low and selling high on the wholesale market. One thing this chart shows is that the economic optimum amount of storage is around six or seven hours. Having eight or nine or ten hours of storage earns no extra revenue. This makes sense because six or seven hours is longer than the duration of most electricity price spikes. But the more interesting thing is the great difference we see between the financial years. 2007/08 and 2009/10 look like good years where a storage device could have earned more than $300 for every kilowatt of generation capacity installed, whereas in other years the income would have been a third or a sixth of that.

What caused such a difference between these years? Falling electricity demand? PV panels? The Carbon Tax? Actually, the answer might be simpler than that. This slide reproduces the previous chart and below that is a chart from a report for South Australia by the Australian Energy Market Operator known by their acronym AEMO. This chart simply shows the number of days in Adelaide where the temperature went above 38 degrees and, sure enough, the financial years 2007/08 and 2009/10 stand above the rest. What happens with those hot days, as we experienced earlier this year, is that electricity prices spike and a pumped hydro facility could have earned a large fraction of its annual revenue over a very small number of days. This analysis gives investors an idea of the economic opportunities for wholesale energy storage.

But one can seldom make investments on the basis of models that only look at history. The trick is being able to judge what the future will bring and looking to the future is what AEMO did in this study published in September last year entitled *Integrated Renewable Energy*. It looked out to a time when the national electricity market has more than 20% renewable energy which mostly comes from wind and most of that wind is expected to be built in South Australian and western Victoria. In this future 20% renewable energy scenario, AEMO described potential grid operation problems relating to system inertia, frequently control and interconnector transfer limits that could in future result in the curtailment of wind energy if no other complementing action is taken before then. The possible solution? Pumped hydro. It is interesting to reflect that South Australia is the place on the grid with the greatest amount of renewable energy installed today and also the place where great constraints are projected to be of greatest concern in the future, and South Australia is also the place today that has the least amount of stored energy available in the forms of conventional hydro or pumped hydro. The dots do seem to connect.

So pumped hydro has economic benefits, but one last question: who will invest in developing these concepts? Who are the friends of large-scale energy storage? If one purpose of energy storage is to rein in wholesale electricity price spikes, those business profiting from price spikes, namely other electricity generators, won't automatically be the best friends of energy storage. Rather, perhaps amongst the friends of energy storage are the consumers of electricity: people and businesses who want to shield themselves from future price spikes that may occur more frequently as our summers become hotter and hotter.

To conclude, the University of Melbourne Energy Institute and Arup are pleased to launch this paper and to engage with stakeholders that would like to further examine the potential of pumped hydro energy storage. Thank you.

GILES PARKINSON: So the challenge to the battery industry has been laid down by the hydro people. So our next guest is John Wood. He is the Chief Executive Officer at Ecoult, which is one of the world's top 100 private companies in Clean Tech Group's 2013 Global Clean Tech 100. John joined the energy storage community in 2008 having previously launched technologies globally in security, identity, payment technology and telecommunications. Here's a man who's picked the right trends. So could you please welcome John to the stage? Thank you.

JOHN WOOD: So I'm going to talk about batteries, batteries and batteries. But before I talk about batteries, batteries and batteries, I absolutely believe in what Tim's doing. I think that pumped hydro is the answer to our long term storage and has a big impact. I'm going to disagree with you on a graph later on when I do the presentation! I'm going to talk about mid-scale storage and, in particular, I'm going to talk about the use of energy storage for variability management.

So follow me on this for a moment. The grid used to be a pretty stable environment because we had loads that were variable but we had generators that we could control. And so what we did was we took the generators and the loads and we connected them up with the grid, and there was a little bit of mismatch between supply and demand but not a whole lot. And it's very important that electricity supply is always [undefinable 36:11] because if there's more load than supply then the grid will slow down, the frequency will change and that's bad: motors can burn out and inefficiencies and all sorts of bad things happen. And if it goes the other way, that's bad. So what we want to do is always balance supply and demand on the grid.

So we came along and we added some renewables to the grid and what happens is when we add renewables to the grid we create more variability. And so one of the things that we can do with energy storage that has a big impact that helps us to go from renewable penetrations of, say, 5% up to renewable penetrations of 30%, which is where we're really moving through now, one area that energy storage can make a very big contribution is in taking away that variability that comes from adding renewables to the mix on the grid. Energy storage and batteries, batteries, batteries are really expensive. So putting energy into a battery and pulling it back out is actually more expensive than pumping water up a hill and storing it on the top of the hill and letting it come back down. And so what we tend to do when we apply batteries in energy storage on the grid is particularly to apply them to activities where you get a big bang for your buck, so power applications are good, where you're using lots of power to have lots of value.

So okay, if we take that variability and we add some energy storage we can move the variability off the grid and we can have much higher percentages of renewable generation on the grid, and that is called ancillary services. And so I'm Australian, I spent my life building Australian businesses and travelling all around the world with them. I moved to the US, found myself coming back to Australia all the time. Came back to Australia and now I find I'm spending all my time in the US again because what I'm doing is taking an Australian technology, invented right here in Melbourne, Clayton, CSIRO's laboratories, by Dr Lan Lam, an energy called UltraBattery and I'm taking that technology out to the world and commercialising it. And one of the markets that I'm spending a lot of time in is the US because the US is very focused on open markets and in those markets we earn a lot of dollars out of energy storage providing ancillary services. And we like to think that we're also making a fair impact contribution to greening the planet by increasing the amount of renewables.

So I'm going to tell you a little bit about that Australian story. Dr Lan Lam, David Rand at CSIRO, and a whole host of other people at CSIRO got behind a fantastic Australian invention called an UltraBattery. An UltraBattery combines battery chemistry with a double layer electrolytic ultra-capacitor in a single electrolyte and that creates a hybrid device that has a whole new set of capabilities. We all know and trust lead acid batteries, we use them every day. So we jump in our car and we turn the key and the engine starts, and it's because the starter battery that gives a little bit of a pulse power to start things going and keeps the ancillaries going. That today is a $15billion market around the world. We know the motive battery, which is the one in the forklift that is used once a shift and it sort of uses all the energy and then you charge it up at the end of the day, and then there's the standby battery.

Now, that's where I'm going to challenge Tim on the graph because there are 28 gigawatts of back-up energy storage in the US which is lead acid batteries basically keeping the internet and the smartphones going. The internet needs two materials: silicon and lead. Because without the lead acid batteries that keep the data centres up, if the grid fails we would not be having 99.999% reliability. And so we have already distributed throughout the network around the world massive energy storage assets, and I'm going to come back to that a little bit later as I go through this talk for you.

So now we have this new capability that came out of CSIRO right here in Melbourne courtesy of the work by the scientists there, and they've created this battery that can run continuously in a partial state of charge. So all of these other battery forms are good for giving a certain amount of energy and then they sit around for a while afterwards, I like to call it lazy let – I get in trouble for that one – but basically it sits around waiting for something to go wrong. What Dr Lam invented was something that can charge and discharge continuously and if you think about that and what's needed to always balance supply and demand you can see what's following in this story really quickly.

Well, CSIRO got together with Furukawa Battery in Japan first and then with East Penn from the US. And I think there was a management philosophy around at the time that if you can take a couple of pieces of technology and put them together in an Australian company you can make something out of it, and that's where Ecoult came from because CSIRO created a company called Ecoult to go out and take this energy storage and combine it with work that CSIRO have been doing on algorithms to make application of energy storage really good with renewables and created this company. And so collectively these companies worked together to take UltraBattery out around the world and Ecoult was fortunate enough to be selected amongst the top 100 private clean tech companies last year out of Washington DC, the Global Clean Tech 100.

This journey for me is five years young. I came in, it was an idea and where we are today, we have several megawatt-scale systems deployed around the world. And I think it's fair to say if you went to the Department of Energy in the US and asked them to name their top five initiatives, we'd be up there in that top five initiatives. We apply the energy storage to do lots of different things, so wind smoothing, solar smoothing and shifting, peak shifting, moving energy from seconds to hours, and little medium-sized ones up to big medium-sized ones in terms of system size. So it's been quite a journey and these systems are distributed around the world in Australia, in the US and in Japan.

This is one that is in the Blue Mountains and what we're doing in this case is we're on a wind farm and the output of the wind farm is the white line down at the bottom. You can see that after we process it through the battery we've reduced the variability out of that wind farm by a factor of ten. It makes it a lot easier to integrate into the grid. And we use a small amount of battery to make that contribution. If you think about a lot of wind farms or solar farms distributed around the grid and you can modify the behaviour of them a little bit, then they all tend to cancel each other out as well.

This is a solar smoothing and shifting project in the US. This was the first large-scale grid-integrated solar energy storage project in the US. It was awarded to the Australian technology UltraBattery and it was the first of the US large-scale energy storage programs sponsored by the DoE to be completed and in operation. Very successful. You can see that what we're doing here is – the output is the blue line here – we're just smoothing the five-minute or ten-minute output of the farm, we're not trying to bulk shift in that case. And that's what the utility needs, so I did start by saying energy storage is reasonably expensive. So if you can use a little bit of energy storage to have a big effect then that's really well-received. And in this case, we're taking the energy progressively through the day and then passing it across into the shoulder period in that middle diagram on the screen there to give the energy where it's needed. In particular, that's being done in that case because the load on that particular feeder is high and by putting the energy in at that time of the day we can allow things to work more effectively on that feeder.

Working with diesel generation is a challenge and a lot of fun. The challenge is that if you want to put solar onto reliable systems you've got to deal with the variability in solar. The output of a solar PV farm can go 70% to 80% in a minute and so if you're trying to run a mine site or you're trying to run a remote facility and all of a sudden you have that big jump, that's pretty bad. And storage is too expensive just to put on there to get rid of those events where the cumulonimbus goes over the farm, but you can pay for the storage by using the diesel generators more efficiently. And so when you combine making the diesel generators more efficient and getting rid of the variability on the solar, what happens is you can use more of the solar. And so this is one area that working with energy storage, we're making a big contribution at the moment.

So you see here the gas generators now have these nice square shoulders where the diesel or gas generators are either running full power or they're off, which means they're very efficient or they're off rather than running partially where they're not efficient. And then the battery gets that bit that's left over there, that's the green, to take care of the mess so that the generating assets can be used much more efficiently. And, of course, the asset can also do the mini-grid functions, like frequency regulation and VAR correction and spinning reserve and such. And there's a large project that we are part of which is a Hydro Tasmania project on King Island. This is all Hydro Tasmania's IP; we're just providing a battery into that project. And they're doing marvellous work down there where what they're doing is taking an island that used to be 100% diesel and progressively taking it through where they're increasing the amount of renewable used on the island and from time-to-time they run the island completely on renewable generation and battery as well.

This is a site in the US using UltraBattery used for frequency regulation on the grid. I put that one up there because it's a very profitable use of energy storage today. So the facility that you see behind me there, it actually earned $230,000 worth of service fees from the grid in the month of January, the month just gone. And it's using batteries to do this, so if you've seen a recurring theme in this presentation you're seeing that batteries are getting the mess to clean up and the variability to clean up. And so what we get paid to do with the batteries in this case is just to do this, which is we get a signal from the grid and it says "charge, discharge, charge, discharge" and then what we do is cancel out that leftover residual, and that means they can put more renewables on the grid. And they pay a lot of money to do that because batteries are more effective at doing the variability than generators are at chasing it. So now you can see that batteries are symbiotic with generators used the right way, so they form a natural part of the grid.

What I did say was that there's already a huge resource on the grid today, so there's 28 gigawatts of these things on the grid. That's the JP Morgan data centre in the US on the left and those batteries sit there against grid failure happening to make sure that all the computers keep running and the money keeps going around. But they look exactly like the batteries over here which are the ones that are doing the frequency regulation and it's no surprise because they're the same shape and size and everything and the only difference is the ones on the right are the ones that came out of CSIRO and are the UltraBatteries. So if you combine the DNA of the batteries that are doing the backup and the DNA of the batteries that can do the variability management then you can make a significant impact, because in theory we can go out and get that 28 gigawatts of existing resource. It's already grid-connected, it already has the power control systems, it already has batteries, and we can dual-purpose an existing resource to put more renewables into the grid.

One of the amazing things about CSIRO's invention was that if I take the batteries that are in the data centres and I discharge them in a reserve event it actually only uses a small amount of the battery. If I use UltraBatteries to do partial server charge the state of charge of the batteries move around, but if I have a reserve event and there's a grid failure and I need to have the batteries available to support the data centre or the telecommunications centre, they're still there and they still have that energy available. So now what happens is that, well, you can make about 16% via just doing ancillary services on the grid, but if you combined it with backup the return on marginal investment is about 43%, which is a pretty good return; payback for putting a battery in in about 3.3 years. And so we're actively engaged in that now in the US with this Australian invention called UltraBattery.

So have a read on www.UltraBattery.com or www.Ecoult.com, they're talking about this story and they tell it much better than I can in a 15-minute window. In particular, there's a really cool white paper there called *The UltraBattery White Paper* that you can download and it'll tell you about the technology and, more importantly, it will tell you about how we're implementing energy storage to make a contribution to a whole bunch of different applications on the grid. Thank you.

GILES PARKINSON: Thank you very much John. We're now moving down to the smaller scale. Tosh Szatow is the Director and Co-Founder at Energy for the People, a social enterprise with a mission to enable a citizen-powered clean energy market. Tosh previously worked at the CSIRO and did research into the value proposition of distributed energy combining economics, social science and engineering disciplines. Please give a warm welcome to Tosh.

TOSH SZATOW: Thank you Giles. The last time I spoke to an audience that looked a little bit like this, I'm confessing now, I was actually doing a skit in a comedy stage show and my role was to be the naked French chef and I had a French baguette as a prop. I'm telling you this obviously to get a cheap laugh, but I'm telling you this because I think it's relevant to what I'm going to talk about tonight.

Energy technology is presenting us with a clear choice: we can cling to the past and what we know or we can embrace a new future; a new future where power is cheaper, cleaner, more reliable; a future that we can own physically and metaphorically; and a future we create if we embrace the change. Tonight I'll suggest the energy market, a bit like me and a bit like the metaphorical emperor, has no clothes. Technology choice is threatening to expose the energy market for what it is.

I'm here tonight to present some research that we, Energy for the People, conducted in partnership with the Alternative Technology Association with funding from the Consumer Advocacy Panel. And the research was designed to test what might happen to the energy market if battery storage technology does what solar power technology has done over the past decade. For those not familiar, the solar story is a little bit like this. Over a period of ten years there's a slow ramp up in global manufacturing, competition between the fuel industrial power houses, and in Australia between 2009 and 2011 solar power costs dropped by 80%, caught everyone by surprise. All of a sudden solar is the cheapest, easiest way for households to get energy.

We sacked our graphics department recently because they were doing horrible work and, to save some of our clients' money, we produced an incredibly simple graph which explains the research. And that is, by 2020 the combination of essentially solar panel batteries with a back-up generator is more cost effective than being on the grid if you're a residential energy customer, quite clear-cut. Our work was very conservative and, it might surprise some, but leaving the grid can even be cost effective today we found in some scenarios. So if you're a regional community relying on bottled gas, you might be considering or your network company might be considering upgrading the local network in your area, it costs about $2,000 a home. It's actually more cost effective today to retrofit your home, convert to standalone power as a community. So we contemplated scenarios of 500 households retrofitting their grid together.

To highlight the significant of this for Australia's energy market, we looked at some of the toughest climate zones in the energy market where there were solar resources. We looked at Bendigo, Melbourne and Werribee. So the results would suggest that for much of Australia's energy market, particularly the mild coastal climates of New South Wales and Queensland, standalone power would be cost effective well before 2020. We don't have much time between now and 2020 clearly. And, as Giles knows better than anyone and as you'll read on RenewEconomy every week, the production and storage of clean locally-generated power is becoming financially compelling.

So, to make the research a little bit more, let's contemplate some scenarios.

If you're a typical energy user and you don't want to adapt your behaviour it will be cost effective by 2020 for you to be part of a standalone power infrastructure system in regional Victoria. You'll organise yourself through a local community group or a council; you'll set up a business structure, probably a partnership with a financier, an energy services company or a technology system integrator; you'll negotiate a fair price with your network company; and by 2020 for around $20,000 a home the grid will be yours and profits made on assets will be retained locally. If you invested your own cash you'll make around 8% per annum before tax, and so your energy bills and your investment dividends become two sides of the same coin. Not a bad thing.

In a green field development being planned today for sale by 2020 the developer or builder will come up with an off-grid development package. When you buy into the development you may even get shares in your local energy services company. At only $13,000 per home, the additional cost is barely noticeable on your mortgage. In fact, if you bought the compact 180m^2 home instead of your neighbour's standard 250m^2 home, you're coming out well ahead. If you have enough space for eight kilowatts of solar power on your roof, you're living in a harsh climate with extreme summers and winters, you won't have to adapt your behaviour to be energy self-sufficient as an individual house by 2020. If you don't use much energy and you're willing to adapt your behaviour, you can go it alone today. By 2020 you probably won't even bother with a back-up generator. Even on dark winter days, your six kilowatt solar system will put out six kilowatt hours of electricity, enough to get by in your thermally efficient home with barely any storage. If you're living in the country, ten or twenty days of cosy wood fires are something to look forward to.

The technology of the standalone power is not new; people are living like this now. The ATA have members that are going off the grid within Melbourne, but today the technology has been limited to small portions of the energy market, remote and fringe-of-grid locations or where people are willing to pay a large premium or willing to forgo creature comforts. For regional Australia the transition to standalone power will have the added advantage of reducing power outages or power outage risk due to high winds and fire and reduce fire risk itself. Importantly, the transition to standalone power is likely to make power prices cheaper for city customers who will no longer need to cross-subsidise the long skeme lines that connect places like Mallacoota to Melbourne.

So for city dwellers here today, if you're looking for a way to reduce your energy costs, it's time to get your campaign hat on; it's time we buy back the grid, and we'll need you to add your inner city intellectual weight to this complex debate. For city customers, space constraints will mean the transition to standalone power may take longer or may not be for everyone. It may stay limited to market niches in the cities and suburbs. Technologies like building integrated with solar PV or newer, better landscapes where solar PV-covered walkways become the norm will probably be necessary to make standalone power available to the mass market in inner city areas.

Of course, this isn't just a technology choice. Our research considered a whole new energy service model, a place-based energy service model where the energy provider has a real incentive to help you manage your energy use, reduce your costs, and provide services such as retrofitting your home so that you use energy more efficiently. One of the big advantages of standalone power systems and this type of model is that the energy provider has a much more powerful incentive to help customers use energy more efficiently instead of the current market where we need rules and regulations to drive that type of behaviour by energy companies.

So the choice before us is we can stay connected to the big bad grid with door-knockers, billing mistakes and power prices that only know one direction; or we can buy back the grid and create place-based energy services that have customer interests at heart. Buying back the grid will seem a bridge too far for some, but it hasn't been for communities in Germany that have been doing it for years or Boulder, Colorado who recently voted to buy back their grid. The common response to this suggestion we hear in Australia is that "We've built the grid, it's there. We should use it. What a waste to get rid of it" and there are three things that we need to note when we hear that.

First of all, the research that we did was "Oh, it's a hypothetical". In practice, a community may not want to unplug from the grid in the entirety. They may want to retain a connection to the energy market for exporting energy in summer where solar power is producing excess, but just have a contract which means they don't need to buy power in from the energy market. Secondly, we built the grid at a time before solar power, a time before sophisticated battery technology and before energy management systems. We had no choice but to build the grid and taxpayers, migrant workers and customers have paid heavily to establish it. It was a solution for its time and our research is conclusive: the time for big grid energy solutions is coming to an end. Thirdly and finally, if we constrain our thinking to incremental change of the current energy system we risk creating a technology Frankenstein with bits and pieces of technology bolted on to an infrastructure monster. As communication technology evolved we didn't strap the new onto the old and call it innovation. You won't see any hipsters walking the streets of Melbourne with this contraption strapped around their neck; you'll see iPhones, smartphones, tablets and more. Love or hate communication technology, the innovation came from reinventing the customer experience so the customers got the most out of technology.

Customers will leave the grid, regardless of the economics. We know they're doing that today. They already are because they're tired of energy companies, they're tired of dealing with call centres and they're craving autonomy. These customers know the energy market has no clothes and they're starting to expose it. We can let this transition be chaotic by pretending it's not happening; customers or citizens will be forced to pick up the tab on a disorderly exit from the grid, that's something that we need to be aware of and it's not in anyone's interest if we let it happen. The alternative is to seize the opportunity presented to us by cheap solar power, battery storage and smart energy management to proactively buy back the grid before it becomes redundant and to create a win-win outcome for customers and energy companies.

Will we create an energy market Frankenstein or will we reinvent the customer experience and design an energy market that works for the people? The choice is ours. Thank you.

GILES PARKINSON: Thank you very much Tosh. We're now moving from formal presentations to more of a sort of fireside chat and then questions and answers. I'm going to introduce our last three speakers who are going to give a quick five-minute talk and then we're going to have a discussion, and we would like your questions.

Our next speaker is Rob Clinch. Rob is a Mechanical Engineer who formerly built power stations for what was then known as the State Electricity Commission of Victoria. Today, Rob advises energy consumers on how to minimise their energy use and costs to also minimise their associated carbon emissions. Rob is an Associate at Arup, the global engineering consulting firm that employs 11,000 staff globally and around 1,000 staff in Australia. Rob.

ROB CLINCH: All I want to share with you today is why is Arup here? The first paper that was presented by Tim on the large-scale energy storage pumped hydro, Arup funded that. Why did we do that? Well, Arup, through its offices for Foresight & Innovation out of London, we wanted to generate a relationship with the universities and the research institutes. So we created a competition or a challenge called the Collaborative Global Research Challenge where Arup approached a number of universities around the world and said, "We've got some money we want to invest in some research, give us your best ideas and we'll fund it". So out of that competition, the application that we received from the Melbourne Energy Institute on large-scale energy storage – I think it was gravity storage we were talking about originally – pleased the panel in London.

The original concept not only looked at pumped hydro but I think, as I recall, there was even a concept of gravity trains using trains laden with ore from our mines in central Australia and going to the coast to be shipped off, we will use that gravity and energy and convert that into electricity. But at the time, when we were considering all the applications, we thought perhaps that was too broad a horizon, so we just focused the research on pumped hydro. In Australia, with the current circumstances where we've had a large influx of renewable energy, particularly in the form of wind energy impacting on the grid, but we haven't really got the best value out of that and we wanted to see through the research being undertaken by Melbourne Energy Institute how that could be improved and how we could get better value out of our renewable resources by providing potentially a different source of energy storage that could be applied to the Australian environment.

Arup has been involved in other similar types of studies overseas in Europe, but we wanted to see what we could apply to that technology in Australia, so hence the funding was awarded to Melbourne Energy Institute to carry out that research. Based on the information that was shared with you today by Tim, we're really pleased that at least the findings that have been generated from this research will encourage further conversations and further political will, if you like, in Australia to institute the change from the way we've always done it before to thinking about doing things differently and maybe embracing a storage facility that will interface with the grid and will maximise the return we can get from either pumped hydro or from solar energy or any other wave or tidal energy that we can use for storing energy.

We've been so happy with the work that we've done with Melbourne University that we've actually started to do another related research with MEI through the Carlton Connect Initiative looking at liquid air as an energy storage medium. Something different, but it's something that is really just the same in it's another mechanism for storing energy so you can release it and use it when you need it and not have to have extra generation capacity to be created or be available when you want to meet your peak demand.

So in closing, I'd just like to say that we're really happy with the results from the research that Tim has presented in the paper today and we look forward to continuing our ongoing relationship with the Melbourne Energy Institute. Thanks.

GILES PARKINSON: Thanks Rob. During my visit to California last year I went to one of the major wind areas and there was a man in a boilersuit who came up and talked to me about gravity trains and I thought he was joking. So it's interesting that it's actually on the cards, maybe we can hear about that later on.

Our next speaker is Craig Chambers. Craig has responsibility for AECOM's power generation and renewable business across Australia. Craig has more than 17 years' experience in the electricity and gas industry in Australia, Asia and the US, and in the areas of finance, design and commercial evaluation of energy projects. Craig, you've got the floor.

CRAIG CHAMBERS: Thanks Giles. Our involvement in the energy storage space has been in a number of fronts. It's probably been less so at the residential level and probably more at the grid level or, I suppose, the differentiator that I might bring to the panel here is we're doing quite a lot of work in the off-grid market or remote energy market. But just to summarise my thinking around energy storage, I think there's probably five or so drivers in Australia for energy storage. The first one is the more traditional use which is the UPS, the back-up energy support.

Then you've got the grid level requirements, and I think we're just now seeing that with SP AusNet and other utilities across Australia now looking to adopt energy storage for a number of reasons, one being an alternative to augmenting as against the more traditional sense of delivering energy as would be poles and wires; and the other things at a grid level, and just challenging a little bit what Tim's thinking was, that arbitrage benefit that storage brings. Despite the few very hot days, we as AECOM aren't seeing a really strong business case today for buying low/selling high for bulk energy storage like pump storage. I think as you see a higher penetration of renewables in markets like Germany and California, they are mandating and driving a need for energy storage for that arbitrage effect and I think that's probably when Australia will start to rethink. The problem for pump storage, it is a long development period, you could be sitting for ten-plus years from a concept for a pump storage project to a commissioned project, maybe longer. So do we think in ten years from now we're going to see very high penetrations of renewables in our market? Then yes, we need to start thinking about those things now.

The concept which Tosh talked about, the local grid level, even though we don't do a lot in that, where we think – and I don't want to steal what Terry's going to say at a grid level - I think the defection from the grid concept is one that needs to be really thought through. We're already seeing the impact of the AMC commenting on this; we've seen SA power networks say to some people with rooftop PV "We're going to pull back on your feed-in tariffs" or their incentives to put rooftop PV in because of the impact that PV is having on networks. So you're seeing – and I'm sure Terry will talk to this – this death spiral impact of people still wanting the grid when it's a very hot day and they want to put their air conditioners on but, on average, they're using the grid less. So they have to charge more to be able to recover the investment that's there and we still want to have the lights on and the air conditioning going on those hot days. So, I think that's something that needs to be thought through and a cut-off and forget the grid where we've all paid for that grid for many years is something that needs to be really thought through. And the grid can provide a benefit back to energy storage, so yes, you can go off the grid and stop paying those network tariffs and wholesale tariffs, but you can, when you have excess power, generate back to the grid. And so I think that needs to be thought through from a holistic perspective.

As I said, what I'm hopefully bringing to the panel is about that off-grid market. We're doing quite a lot of work with remote communities and remote mining companies that are being incentivised by government funds and by their operating costs or to stabilise their operating costs hedge their cost of energy in these remote environments, not only in Australia but we're also working with some remote communities in the Pacific, Papua New Guinea, where they are paying a lot more than what Giles was quoting for our wholesale energy today. So, they may be paying $300, $400, $500 a megawatt hour for their energy. So renewables and as you get to higher penetrations of renewables you need energy storage to balance the intermittency of those renewables is something that we're doing a lot of exploration in and the different technologies, you've got John's Ecoult technology and there's others out there, all have different benefits and the business case in trying to evaluate those is quite complex.

I'm happy to talk more about that off-grid market, but we see that's probably the lowest lying fruit for energy storage. As you get to higher penetrations beyond the, say, 30% energy in renewables you need to start thinking about energy storage. Now, we've done some work in that market and there's five gigawatts worth of installed capacity in the remote energy market in Australia. One gigawatt of it is diesel generation running at that $300+ a megawatt hour. It makes a lot of sense in that market where today you have about 1% of energy being produced by renewables in comparison to the NEM about 13% and the Swiss about 6%, there's a real opportunity in that market for higher penetration renewables to offset diesel, fuel security – some of these places in wet seasons are very hard to access so they have to have very large storage tanks for their diesel – energy storage with renewables makes a lot of sense. Thanks Giles.

GILES PARKINSON: Terrific, thanks very much Craig. Our next speaker is Terry Jones and he's from a network. He has a background in electrical and electronic engineering, he's Manager of Distributed

Energy & Innovation at SP AusNet, which is a 7billion electricity and gas network that is predominant in Victoria, and prior to that at SP AusNet he was at the CSIRO where he was theme leader of the distributed energy theme inside the energy flagship.

TERRY JONES: I guess what I'd like to share with you all is what SP AusNet is doing in energy storage today and some of the activities we've been involved in, and then to issue a challenge with due respect to my panel of colleagues and yourselves. All the enthusiasts on storage, all the suppliers of storage tell you what the real challenge is from our point of view in network businesses.

So SP AusNet has been actively involved in storage investigations and trials for some three to four years now, starting with some converted Prius electric vehicles where we were looking to examine the charging behaviour and later on in the product the discharge behaviour back into the home. Could we set up an electric vehicle with a bigger battery to charge and discharge that would help us manage peak demand because, of course, to our business uncontrolled charging is a real threat. It could double the evening peak demand from residential homes, so that's a really threat to our business. The opportunity is if we can charge it at the right time and discharge it when we need it then we can actually manage our network peak demand in a better way.

So, electric vehicles were the start of that some three to four years ago. More recently, last year we had a project with solar PV and storage in ten homes where we're getting five-second data throughout the whole of this summer and we're hoping to try and understand whether we can actually manage peak demand in the home with a battery solar PV set-up. We're getting very detailed data and this is the first summer where we'll have a full summer. Thankfully, it's been a great summer. It's been really hot, consecutive hot days, so it's really tested the systems out.

The last area of work is with the grid energy storage system which is a one megawatt battery with a one megawatt Genset to provide ampere hour extension to the battery, and that's going to be installed in August. It's going to be installed in a location where we're able to play around with the network a little bit, it's an industrial site. We can island the network to see whether the battery can support an islanded functionality; we can use it for voltage control, VAR support and various other functions that are technical functions of the network, but have value to us in terms of providing customers with a steady reliable power supply; and, of course, peak demand. The question for us on this very big system is can we get all this functionality out of it reliably in a ten-year period in the Australian environment of -10 degrees to 50 degrees? Question: can batteries perform in that sort of an environment?

So they're the three areas and really the overarching question, which I think was referred to a little bit earlier, is do we solve the peak demand problem at source where we have residential peak demand as the thing that is driving our network augmentation and our network build? Or do we solve it further up in the network at 22KV in aggregation where we miss out on some of the deferral benefits further down the network at 450 and three-phase, single phase, but we can actually manage it with a larger system centrally? So there's a demand-side solution in the residential side and a network supply-side solution with the large battery, and I hope that at the end of next summer we'll have facts and figures on both of those cases. So that'll be a very interesting slide pack that I'm sure we'll present to everyone around the country.

So moving onto the challenge with due respect to all the enthusiasts for storage. My question is how is this very high-priced technology going to be introduced into a non-subsidised market, i.e. Australia, which is a small market, at the end of the day? Our purchasing experience last year with the residential and the grid energy storage is that compared with augmentation work, it's about 50% too expensive. Now, that's not just the batteries; it's also the balance of plant; it's the inverters, the smart inverters you need; it's the enclosures; it's all the temperature regulation equipment to keep it in a nice operating environment. So that's the challenge for not just batteries, that's the challenge for systems supplies of this type of equipment. Can we get the price down and do we expect the pricing to come down? Thank you.

GILES PARKINSON: Thank you very much. Look, we want to open up to questions in a moment so start thinking about those questions. I'm going to invite the questions, so if the people with the microphones can possibly be poised, however I think Terry's actually asked the first question. John, would you like to respond to his question?

JOHN WOOD: Well, I'll have a go at it. We've got a project we're doing in Pennsylvania, with Penn State. It's DC. So what Penn State – it's one of their courses, they've set up a whole laboratory, their whole environment is DC. The washing machines are DC. The fridge is DC. There's no balance of plant, I mean, there's batteries, there's solar. We charge the batteries, we run the DC equipment. So it's a whole different perspective. If you can do that for – sorry, I brushed over the fact that what Terry said is if you actually put energy storage on the grid you buy a battery that's about 40% of the price; you buy a PCS that's probably about 30% or 40% of the price; you've got a transformer, now you've got to make it into AC and you've got to get it in synch with the grid and you've got an energy island and you've got to do this and you've got to do that. So the balance of plant is probably 60% and it doesn't go away. So, with respect, there is an answer, which is get rid of AC.

GILES PARKINSON: Very good. Terry, I'm going to throw one more question back to you as well. Tosh said that he was urging people to buy back the grid. He might come up with an offer. Will you sell it to him?

TERRY JONES: Pass.

GILES PARKINSON: Or parts thereof?

TERRY JONES: I'll pass, thank you.

JOHN WOOD: I'll give Tosh a DC grid.

TOSH SZATOW: DC is unregulated in Australia, so I think that's two problems solved.

TONY WOOD: High efficiency.

TERRY JONES: Just to be serious, I think one of the issues around islanded grids is the safety and the operational responsibility for that islanded network. Who takes that on? At the moment we take it on, it's regulated, there are standards etc. We are finding this with embedded network applications where people want to run an embedded network, still connected to our network but they own and operate the embedded network. And there are quite serious obligations there to run that network, so if a community wants to cut the wires or semi-cut the wires, who is going to take on that responsibility?

GILES PARKINSON: I've just gone one quick other question for you because I've been dying to ask it. A CSIRO report suggested that in one scenario one-third of customers could leave the grid. When you see predictions like that, do you just think that's a lot of rubbish or do you think that could be true, we've got to react to this and we've got to think about things differently? How does a network operator respond?

TERRY JONES: Yes, I think we're trying to think differently. It might happen. I think the issue is people have paid for that connection already and continue to pay for it, so then you start to say, "Well, if they're not putting the energy down that connection, the cost of that connection goes up in terms of their tariffs" and that's the old spiral we don't want to go down.

GILES PARKINSON: Exactly, and Craig was talking about the death spiral. So what's the solution to that? Essentially what you're talking about is sunken assets, is it, as the Grattan Institute has actually suggested, a matter of actually writing off the value of something which was built over the last three or four decades and no longer has as much value as was once thought? Craig?

CRAIG CHAMBERS: Yes. From 2009 to 2014, $36billion has gone of all your energy bills into distribution assets. Are you just going to burn that up? I mean, that is a functional network that can help interconnect these systems. We need to have the interconnection factor. When you don't need your power you can sell it to your neighbour or the guy down the street or whatever. I mean, that's the benefit and I think we've got to think not about networks as the evil, kind of, "Let's cut away"; let's make them more functional so that they can enable the uptake of smart grids, enable the uptake of distributor generation. That's, I think, the frustration that many distributor generators have is that they can't back-feed into the grid, they can't connect easy. There are those challenges and if you can get over those it's a really functional network that can help enable more uptake of this.

GILES PARKINSON: Tosh, very briefly, the CSIRO prediction, one-third of the people leaving the grid by whenever, could it happen?

TOSH SZATOW: Yes, definitely. We had a bit of a tackle actually because the prediction came out of industry forums, so essentially industry opinion, and I think their timeline was by 2030 a third of the customers could leave. But they said "We might be out by a decade" and us and the ATL obviously came up with the 2020 figure where it's cost effective for people to leave the grid. So we think it's probably out by a decade, we think it might happen faster and in a bigger way.

GILES PARKINSON: One thing for it to be cost effective, another thing for people to actually do it. Okay, let's have some questions. We're going to take two questions at a time.

AUDIENCE: I've noticed that the variability data is all fairly local data. I wondered what would happen if we took a more regional or broader-scale view? So in that context, a question to Terry: what could we do with the transmission network in particular to address some of the variability issues?

GILES PARKINSON: Hold that thought Terry, let's have another question.

AUDIENCE: So there's a little bit of tension between the incumbent operators over here and Tosh over there about people leaving the grid, and what I'd like to ask is we have a regulatory model that is based around power coming from one end and going to the other end. Are there things that we can do to change the regulatory model that enables grid operators to stay there but also these people leaving the grid or semi-separating themselves off the grid for that to happen as well?

GILES PARKINSON: Excellent question. Let's go to Terry first with the transmission one.

TERRY JONES: I guess the issue is I don't work in transmission, but really where we see renewables connected at distribution level there are issues coming up as a result of the variability, the VAR flows in the network. Because most wind farms, for example, are customised connections, we take that into account in the design and it generally doesn't affect the network. But, of course, as we get more and more onto the network then we do have to pay a lot more attention to it and it could well be that storage for renewable smoothing is a viable option as part of a wind farm installation, such as Ecoult are doing. But I can't really answer the question at transmission level.

GILES PARKINSON: Craig, did you want to tackle the other one about the regulatory environment, because that seems to me to be quite critical?

CRAIG CHAMBERS: I think that number I quoted, $36billion going into distribution level, I think there's about $7billion over the same regulatory period went into the transmission level and most of it, if not all of it, is going into traditional poles and wires. I suppose if the regulator thought differently through that regulatory period about incentivising network companies to think a little bit differently, to incentivise alternative means of supporting that augmentation and those reliability requirements, you may have seen far more drivers by Terry's company and others to enable and, with open arms, accept more distributed generation.

GILES PARKINSON: Tosh, are they going to move fast enough?

TOSH SZATOW: I don't think so. I mean, network companies are required to invest efficiently in the network; the regulator is there to hold them accountable. And they've spent $36billion in networks, I guess the question is was that a sensible investment and who wears the risk if it's not?

GILES PARKINSON: But it sort of goes back to the question that Terry said and the gentleman suggested as well, is that you're talking about cost but there's also this question about value and the value is almost set by the regulator isn't it in the way that they ascribe the incentives and the way they create the market?

TOSH SZATOW: Correct and customers want energy, customers want comfortable homes. So the question is do customers want that to happen through poles and wires, through lots of spending on poles and wires, or do they want other things to supply them energy to make their homes comfortable? And so the question to the regulator, the question maybe to think about is could that $36billion have been better spent on other things that customers actually want?

GILES PARKINSON: I guess the question's got to be more about what happens in the future.

ROB CLINCH: There's a few things that have happened. I started my working life working for the State Electricity Commission and my first job was working on Loy Yang A Power Station. But over the journey of that 30 years, the tariff structure that we've got in Victoria hasn't changed a thing, it's the same. I think when we broke up from the State Electricity Commission into the five distribution companies, United Energy and SP AusNet, they bit the bullet and introduced the kVA tariff whereas the other networks have stuck with a kilowatt tariff. In the last couple of years we've had the mandatory rollout of our Smart Meters, but I don't think many of us have seen anything change in the way our tariffs are structured and what we're being offered a) by the retailers and b) by the network companies.

So the incentive to change hasn't happened. The infrastructure is gradually starting to change with the Smart Meters, so the opportunity is there to do things differently and innovatively, and I think there's also been other changes like all of the air conditioners that you might buy to put in your home now, they all have a smart chip in them now that can have them turned off by the network at some point in time when it suited the network to prevent a peak in demand. But those opportunities are not available to us, as customers, in the marketplace yet. It's promised, it will happen, but I think those sorts of changes need to happen and then the dynamics of those changes, whether it be shutting off air conditioning to prevent peak demand or having tariffs that change consumer behaviour, all of those need to have an effect before you can start investing billions of dollars in changing the way the networks are going to operate.

GILES PARKINSON: Terrific, thank you very much. Let's get onto the next question.

AUDIENCE: In the past molten salt storage seemed to be the rage. None of the panel have mentioned it tonight. What's happened to it?

AUDIENCE: I have a question regarding the use of industrial energy-intensive production as a flexibility mechanism in the energy system. You have quite some heavy energy-intensive industries still here in Australia - I'm visiting Geelong and of course I'm thinking of the smelter in Point Henry or similar sites. I know that in Germany smelters are actually very competitive compared to other European countries because of the low wholesale prices, because of wind and solar. So could one imaging that you'd actually run heavy energy-intensive industry on wind and solar and would you then use that arbitrage opportunity, which everybody here is competing on, in the heavy energy-intensive industry instead?

GILES PARKINSON: Thank you very much. Do we have any volunteers for molten storage? I actually made some mention of it right at the start with that slide there. And my understanding with molten salt storage is that it applies only to solar thermal power stations, particularly with parabolic trough and with solar power towers, neither of which we have at the moment in Australia because we've really stuffed up; our wholesale flagships program was a complete disaster and has achieved absolutely nothing and people are coming to Australia and are looking to do it.

We actually have two solar thermal plants. One has been operating at Liddell but I don't think it's actually been switched on for the last year or two because that part of Liddell has actually been closed down because it's been pushed out of the market by lower demand, so I don't think that's actually been operating. And another one which is being built is a solar booster for a coal-fired power station similar to the Liddell one, it's under construction but they've had all sorts of problems and delays and it's been put back a year. And there's also talk of having it in Port Augusta and there's a big push for that, but there's a lot of resistance for that to happen and it needs a whole bunch of things to happen. And it's really a frustration to a lot of people that that hasn't occurred in Australia because we actually invented a lot of these technologies and we should be putting them in. We've got the best resources.

The second question, who's going to put their hand up for that? John?

JOHN WOOD: I'll have a go at it. I'm going to answer three questions in one. So there was a question over here on transmission, there was a question on regulation, and there was a question on the industrials. I will use a case study which is PJM in the US which is the largest open market grid in the world, so that's a transmission grid. And what happened in particular there is that the regulator got together with the market operator. The market operator is emphatic about open markets and real markets. So the market regulator looked at what was happening, had a talk to the Department of

Energy. When it came to the variability on the transmission, the variability did get all back onto the transmission and so what they did was they looked at how they corrected that variability on the transmission. They were doing it with peaking gas turbines, but when they tried to correct it with peaking gas turbines they could only correct 30%, so they'd use a megawatt of peaking gas turbine capability and they'd contribute 30%.

So what the regulator did was they said, "Well, we will make you pay for performance" and so they found that with batteries they could correct it for 100%. So what happened then is the market changed. The regulator changed the market, the battery business case came in and all the energy storage is going in there. Same regulator in PJM has been working a lot on demand response in heavy industry as well. And so the reason I wanted to put those together is that yes, the regulator can make a huge impact against those goals, particularly if what they do is concentrate on inefficiency in active markets, so where markets have just become stagnant and are working on things that are not true market economics. So I think PJM is a great case study for people to have a look at where that work is going on.

GILES PARKINSON: Anybody else want to tackle the issue raised about the low wholesale costs and potential arbitrage?

CRAIG CHAMBERS: I'll give it a go. That was one thing I was talking about before, I think that increasing penetration renewables on the market depresses wholesale electricity markets, which is a good thing but you still need those thermal power generators to jump into the market when the sun's not shining, the wind's not blowing. So what you have is upward pressure on those peak wholesale market caps and I think that's what Germany's finding and what California's finding is that there's that arbitrage effect, which Tim was talking about, that as you get a higher penetration of renewables, the arbitrage effect plus the balancing effect that Ecoult offers, that balancing effect but also the pushing out of the thermal market but then still needing that peaking supply at short periods and those generators needing to get a higher return over a short period.

AUDIENCE: And I was talking about that heavy industry could balance its consumption?

CRAIG CHAMBERS: On demand management yes, it can do that as well.

GILES PARKINSON: Okay, let's move on. We've got a couple of Twitter questions, so Roger, what have we got?

ROGER: Thanks very much Giles. Okay, a couple of questions. First, how can commercial building owners retrofit energy storage systems to their assets and what benefits will they see?

GILES PARKINSON: Let's just stop there, anyone take that on?

TOSH SZATOW: I mean, I think it's fairly simple, you make space and install it. I'm not sure exactly what the question is implying there.

ROGER: Well, if you're a commercial entity and you want to install storage, what are the benefits of doing that if you're a commercial entity rather than a residential customer?

TOSH SZATOW: Usually tariff-dependent, if you can combine it with some renewable generation as well to attack things like peak demand prices. But it's dependent on the tariffs in the jurisdiction that you happen to be working in. So people in New York today are retrofitting energy storage and combining it with renewable generation and doing it specifically to reduce peak demand tariffs.

ROGER: The next one, would locational and capacity-based network charges help encourage battery storage?

TOSH SZATOW: I should say that in the research we did we actually did look at location-specific costs of supplying energy. So we looked at regional customers facing their flat tariff not necessarily the real cost of supplying those customers. So the conservative 2020 scenario comes forward very quickly if those customers in regional areas are paying the real cost of energy.

AUDIENCE: I'm an off-grid energy user, I use batteries. My question for John from Ecoult, you talked a lot about how your lead acid and capacitor-type cells are being used but no-one at all, including yourself, has mentioned how much they currently cost per kilowatt hour storage and how other battery types current costs are coming down in relation to what they've been in the past. So could you give us an idea of where costs are going with that? Because that's what's happened with PV over time, domestic users have driven down the price of PV. This is what's going to happen with the cost of batteries obviously when they're being used domestically in large numbers, their price will come down. So can you give me an idea on the cost of batteries, what's happening there?

JOHN WOOD: Yes. Are you grid connected at all?

AUDIENCE: No, I'm completely off the grid.

JOHN WOOD: And have you got a generator?

AUDIENCE: I don't need one. I've got solar with a bit of micro-hydro associated, Something that Tim mentioned earlier, he knew someone up on the Nicholson River; that was me.

JOHN WOOD: So solar, micro-hydro and battery?

AUDIENCE: Yes, 30 kilowatt.

JOHN WOOD: Outstanding. So the work that we're doing with CSIRO is all about a battery that in its lifetime will put through a substantial multiple of the amount of energy that a battery normally will in its lifetime. So the battery has a premium on an ordinary battery. On an ordinary lead acid chemistry battery, that will put through four or five times the amount of energy charge and discharge before the battery has to be replaced.

AUDIENCE: What's the premium?

JOHN WOOD: Appropriate!

GILES PARKINSON: The next question is do batteries have a solar PV-style slide down the cost scale?

JOHN WOOD: No, they haven't yet.

GILES PARKINSON: But will they?

JOHN WOOD: One thing I want to emphasise on it, you know, storage today is expensive, it is. If you put 4c energy into a battery and then add 12c to it before you pull it back out in terms of depreciation of the cost of the battery, then it's still 16c energy. It's really expensive energy if you're doing that. I know most of the chemical energy storage mechanisms out there today and they're expensive, they really are. That's one reason why we're really working hard on dual-purpose because if you've already got a battery asset that's sitting there today, it's already been paid for; it's got a grid connection; it's got a transformer; it's got a battery; it's got the balance of plant as well as the battery; and now you can repurpose that to make a contribution as well as what it's currently doing, then you've only got the marginal cost. So now you can take 4c energy, process it through this thing, add 2c to it. Really, as an industry what we have to aspire to is being able to take gigawatts of energy, shove them into storage, pull them back out, get 95% of it back and add no more than 2c per kilowatt hour every time that we do it, and then we've hit our mission and it's an important mission.

GILES PARKINSON: Excellent, we're just getting towards the end so let's have short questions and short answers.

AUDIENCE: As we figure out that climate change is actually serious we probably will figure out that using gas is not a good idea. Are batteries and PV going to cope with all the demands of hot water powered by heat pumps, air conditioners, heating our homes and, of course, cooking? Can battery systems cope with all of that?

JOHN WOOD: Energy storage systems can and the technology improvement is on a curve. A personal view is that ten years and you'll have that technology in place.

AUDIENCE: I was going to ask a very curly policy question of Terry and Craig, but I'll ask a different question instead and pick up on the battery theme. A question for John, so how do the ultra-capacitor batteries compare with lithium batteries in terms of, say, cost, performance and scalability? And maybe to put a curly end to it, is it possible that one of those is looking like a Beta and one like a VHS between those two technologies?

JOHN WOOD: Well, lithium's looking very, very Beta right now, I've got to tell you. Look, lithium batteries operate partial state of charge. Lead acid has not been a partial state of charge technology. So representing an Australian technology, I go around the world and the people sitting alongside me on the panel generally are Samsung and LG, and they're lithium suppliers. And UltraBattery can match those technologies in partial state of charge today. Now, we're, I think, earlier in our stage. So matching them today, we match them on economics; we can match them on performance. I know where we can go. They're going to have to work really hard if they want to match us.

AUDIENCE: There have been comments about the staggering amount of money invested in poles and wires over the last year and after your comment that we should use it because we already paid for it I would like to ask a question as a typical residential energy user, and I stress residential. I haven't paid for it yet. I'm expected to pay for it in the future in your network recovery costs. What motivates me to stay on the network if your comment about being able to export my energy is not valid because I don't get paid for it or I get paid less than my generation cost is? Where is my incentive to stay on the network if I can generate my own power, store it and satisfy my energy needs perfectly, 100%, at a lower cost?

CRAIG CHAMBERS: I'm happy to comment on that. At the moment it's not cost effective. So you can't get a payback period on putting PV and batteries in your home today.

TOSH SZATOW: We should clarify that. It actually is cost effective today where you're using natural gas for space heating and where the alternative is $2,000 per home in upgrading your network. We're happy to sit down and go through the numbers with you at some stage.

CRAIG CHAMBERS: But I think the issue is if you go off then the person next to you pays more.

TOSH SZATOW: Absolutely, and then they unplug as well.

CRAIG CHAMBERS: That's the issue, as more people go off, more people pay more and it's a death spiral.

TIM FORCEY: Someone threw an elephant in the room.

TOSH SZATOW: Someone better manage that. Wow.

GILES PARKINSON: Can I just ask for a show of hands, how many people would go off the grid if they had the opportunity to do so?

CRAIG CHAMBERS: Well, that's the decision you make. I guess yes, it's just whether people are interested.

CRAIG CHAMBERS: Could I ask anther question? How many people have PV on their roofs? Not as many. Why don't you? Because it costs money. It's probably 20%.

GILES PARKINSON: It's interesting. Let's have the next question please.

AUDIENCE: This is just a question to the panel about tariffs and someone mentioned before that nothing's changed in the last 30 years in terms of the way that's managed, both from I guess a behavioural change side, a market side, a demand side. What I've been wondering, and this is looking at organisations around Geelong, why you have some organisations paying only 2c a kilowatt hour and then you'll have a neighbour a couple of kilometres away paying 40c per kilowatt hour. Who's subsidising who and how long can that continue for and what's the role of the regulator in trying to free that up to reflect truer costs to enable these technologies to come to the fore?

GILES PARKINSON: Anyone?

ROB CLINCH: Well, I can make some observations for some clients that I've been working for recently and how that doesn't reflect what I'm paying for my electricity at home. For a large university, the price that they negotiated for their new retail contract to tender last year halved the retail price that they were paying and I think most large commercial businesses who are renegotiating their retail contracts since the middle of last year right through this year will see a price drop from roughly 8c a kilowatt hour down to about 4c a kilowatt hour in the retail price. I ask myself when I see that why am I still paying 25c a kilowatt hour on my tariff at home? And what we get offered as a residential customer is a standing tariff which might be 27c or whatever, and then you go round to the retailers and say "We'll give you 10% off" and "We'll give you 5% off" and it's not reflective of what the wholesale price is in the marketplace at all. And that is something that the industry needs to have a look at.

Now that we've rolled out the Smart Meters and you can have interval pricing available for consumers, we should be able to shake off the legacy of the old State Electricity Commission and have real cost-reflective pricing where the consumer has a choice to say, “Well, yes, I will have the air conditioning on on the hot day and I will pay the premium” or “It’s a hot day, I don’t want to pay that money for the air conditioning on, so I’ll leave it off and I’ll stay hot, I’ll save the money and go on a holiday somewhere else later on in the year”. So that opportunity for the residential consumer doesn’t exist at the moment. I believe that that will change over the next few years as the regulator relaxes control of what tariffs are allowed to be offered through the retailers and the networks have the opportunity to restructure their tariffs so that they can be confident they’ll earn the money that they need to run their networks.

END OF RECORDING