Australian Government
Chief Scientist

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Zunz Lecture

Electric Future: Wiring for Progress

6:40pm – 7:00pm

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Powerhouse Museum
SYDNEY

A triangle with consumers at the core

When I accepted the invitation to deliver the Zunz lecture, I didn't foresee just how interesting the topic of electricity was going to be. I certainly didn't expect to find myself in early November at the helm of the taskforce advising the nation on the future of the electricity grid.[i]

But though I am honoured to be Chair of that Review, I am here this evening in the capacity in which I was invited: Alan Finkel, Chief Scientist; engineer and scientist by training, entrepreneur by experience, optimist by instinct.

While the context of the Review is important, the time for conclusions is not this evening.

In the tradition of the great Jack Zunz, this lecture is a chance to reflect in all my capacities on electricity itself: how it entered our lives, how it serves us today and what possibilities it might open tomorrow.

The centrality of electricity in our society is demonstrated by the breadth of coverage of today's announcement of the closure next year of the Hazelwood Power Station in Victoria. This closure will impact the workers, the local community and our national electricity grid.

I am pleased to see a coordinated Commonwealth and State response to this shutdown.

This evening, before touching on the past and the future, I offer a few words about the aspirations that underpin the operation of the electricity grid. Experts in the sector have spoken for some time of the 'trilemma': the three objectives we bring to the grid. The same three objectives are the pillars of the current Review.

First and foremost, electricity supply needs to be secure and reliable. In addition, it needs to be affordable; and it needs to lower our emissions over time.

A triangle with three vital points; at the centre of that triangle is the consumer.

It is the consumer who sets the expectations; and the consumer who ultimately decides if they are met.

And the overriding imperative for the consumer is *choice*. Choice means the freedom to put the grid we share to work in the way that each of us wants, for our household, or our business or our town.
But choice can bring cost implications, so we have to be careful.

Whilst it is still early days for the Review, it is clear to me from all my conversations that this basic understanding is universal. The objectives are understood, as is the difficulty of balancing between them.

As you would expect, on a topic this important there is a phenomenal body of existing knowledge.

What's been lacking in recent years is a system-wide review of how all this work fits together, in the context of a market in the midst of rapid change.

As a result, one of our first tasks is to bring the existing knowledge together in the form of a "meta review". This will be part of the preliminary report we plan to deliver to the Prime Minister, and State and Territory leaders, in December.

Presently, accompanied by members of the Review Panel and the Taskforce, I am meeting with consumer groups, energy market bodies and peak energy organisations as part of a first round of consultations. We will also be engaging with the International Energy Agency to help us evaluate our performance against best global practice.

Following the preliminary report, we will conduct a further, wider round of consultations before the completion of the final report in the first half of next year.

I start from a platform of respect for the existing National Electricity Market, known as the NEM, and the many outstanding policy thinkers whose work it represents.

I also recognise the difficulty of projecting ahead in rapidly changing times.

Yes, we need to plan for the future – but no, we haven't got a crystal ball. And it would be worse than useless to pretend that we do.

To paraphrase John Pierce, Chair of the Australian Energy Market Commission, in a speech in September delivered in Oxford: if you hinge

your plans on a particular view of the future, such as forecasts of demand or the relative costs of different technologies, you are heading for a world of pain.[ii]

The right framework will be one that both secures supply and creates potential: for researchers to explore new possibilities; for investors to bring them to market; and for consumers to make informed decisions. Government defines the parameters, so the players can design their game plans.

The hard-wired world

But let's put the Review aside for a moment, and turn to the hero of my lecture: electricity.

In preparation for this evening, way back in August, I took my laptop off the charger and tossed around a few ideas for the all-important opening line.

"Let there be light". No.

"Welcome, bright sparks and luminaries, I hope we're switched on tonight". No.

"Friends, I'm wired – the atmosphere's electric!" No.

I could go on… but I hope my point is made.

Electricity is so central to who we are, so critical to the way we live, and so conveniently woven into the fabric of our lives that *we all speak electric*, every day. We *live* electric.

And so it is fitting that we gather this evening in the Turbine Hall of the Powerhouse – or the Ultimo Power Station, as it used to be known – to light up the path ahead.

Light from the past

Every brick is a reminder of a very different Sydney: a city teetering on the brink of the electric age.[iii]

Picture this town in 1899, the year this building was commissioned. The streets are lit with gas lamps. Households cook with wood or coal. The trams are powered by steam – or pulled by horses.

And many people back then were satisfied, these technologies worked perfectly well!

True, the streets were dim and dingy, thick with smoke and layered in grime. Yes, a moment of inattention could burn your house down.

Those with a competitive streak looked south. Down in Melbourne at the MCG they could see football played at night under electric arc lights – as early as 1879!

And the town of Tamworth had run electric street lights for more than a decade – and so had Young, Penrith, Moss Vale and Broken Hill. Forget Melbourne – even compared to its country cousins Sydney looked provincial!

But gas and coal were cheap. They were reliable! And the infrastructure was already in place.

Electricity was the disruptor, with all the risks and costs attached. Electric trams had been trialled, on a one-mile track – and they failed. Electric street lights were undoubtedly more expensive than gas. Electricity in homes – it was hard to imagine anything more dangerous, with deadly potential.

So, the Parliament could hold endless inquiries, and engineers could rail against this mood of ‘arm-folding apathy’, but the electric future was still on the blink.

Then came 1899.

It brought the commissioning of this Station, to power a fleet of modern, all-electric city trams. The appointment, at long last, of a panel of engineers to draw up the plans for electric lights.

And Sydney began to lead the nation, if not the world, into the Electric Age.

By 1904, the first street lights were switched on – and Sydney’s trams were up and running. They took Sydneysiders on 106 million journeys

that year – or 200 trips for every person – all of them made possible by the flywheels and boilers that hummed right here.

By 1905, Ultimo was the largest electric power station in the Southern Hemisphere. In the decade that followed, it would boost its output by over 680% – it was the racing heart of a growing city.[iv]

Now cinemas competed to provide the most brilliant light display! Luna Park gave an electric smile to the world! Sydney finally switched on to night-time cricket and football!

In the space of a generation, three-quarters of the State's factories converted to electric power. And people could crisscross the city with new freedom, returning home to their electric radios and lights.

It proved much harder, though, to persuade Sydneysiders to buy electrical appliances, or give up gas for heating and cooking. As late as 1946, only one in six Australian households had a refrigerator, and only one in fifty had an electric washing machine. These were novelties for the rich, not practical realities for the typical home.

But then came television – and we knew that our flirtation with electricity would be a lifelong affair.

And hungry for electricity today!

Today, nearly two-thirds of Australians live in a house with two or more digital TVs.[v] Electricity is ours at the flick of a switch.

And when the system somehow fails – as it did in South Australia, on a stormy Wednesday in late September – life as we know it shuts down. Commerce, industry, telecommunications, transport, security, the routine business of cooking, cleaning, warming and cooling – all of it relies on a secure and affordable electricity supply.

We didn't foresee the extent of our electric future in 1899 when we commissioned the Ultimo Power Station – but we were preparing for it, all the same.

We don't remember now just how dim the electric future once seemed. But we ought to remember it, because it is a powerful lesson for the industry professionals and the visionaries trying to pick up the legacy today.

Change is very rarely convenient. It's not linear and it's never unopposed. There will be mistakes and failed attempts along the way, as we branch off down all the paths where transformational technologies might go.

Ultimately, people will follow – and people will step forward to lead – not because we berate them, but because they choose a better future for themselves.

Perhaps the legendary American architect and designer Buckminster Fuller[vi] said it best:
"You never change things by fighting the existing reality. To change something, build a new model that makes the existing model obsolete."

The confronting question is, what do we want that change to be?

Facing complexity

We have in the National Electricity Market a system that has served us well since it went live in 1998, after years of patient planning.[vii]

I will not offer a blow-by-blow account of how it came to operate as we know it today. Suffice it to say that the NEM represents, in both policy and practical terms, an exemplary achievement.

It is a case study in the skilful management of the transition from a government to a market-led system, which both boosted productivity and delivered for consumers.

To understand that success, and the challenge ahead, we first need to know something of the complexity of managing the grid.

First, there's the technical complexity – the NEM is a massive organism requiring constant maintenance and upgrades.

Second, there's the economic complexity – the NEM supplies some nine million metered customers, across a span of 5,000 kilometres from Port Douglas in Queensland to Port Lincoln in South Australia.

It's a sophisticated network with an interplay of market forces and regulatory structures. Generators and retailers compete in highly

competitive markets. Transmission and distribution are controlled by monopoly providers, subject to strict regulation.

Both the market and the regulators need to work together to ensure security and reliability of the supply, a fair return for investors, all the while driving down costs for consumers.

Hard enough, before we add a third dimension – the complexity of evolving consumer behaviour.

Think of the endlessly expanding range of devices you might want as a consumer – amongst them electric vehicles and home battery packs. And think of the new ways in which you might want to engage with the grid – like selling the excess electricity from your solar panels directly to your neighbours, peer to peer.

And then a fourth consideration – the complexity of all the conceivable risks to the grid, from overhanging trees, to lightning strikes, to cyber hackers, to market swings.

So while the NEM has served us well, it is nevertheless under pressure from technologies and expectations that are a giant leap from what existed when it was designed.

Bear in mind, all the while, that we are dealing with a product that can kill you – which a toddler could access at any one of dozens of points in your home.

No wonder that when the Federal, State and Territory energy ministers asked me to lead the review of the NEM, security and reliability were at the top of their minds.

Security through change

But as we all appreciate, securing the supply doesn't mean "locking in the status quo" – on the contrary, it means being able to navigate change.

Looking to the future also brings awareness of the global challenge of climate change, and being mindful of the international commitments that our government has made to lower carbon dioxide emissions.

You know the challenge. For generations, progress has been powered by coal, oil and gas.
Fossil fuels have brought tremendous advantages to our lives. They were, and remain, a reliable source of energy to feed into the electricity grid.

And coal, contrary to the common assumption, continues to rise as a percentage of the global energy mix.[viii]

But human progress has come at a price, in the form of climate change.

Cities, in particular, are significant energy sinks and carbon emitters. They are home to about half the world's population but account for close to two-thirds of the global energy demand, and close to three quarters of carbon emissions from the energy sector.[ix]

Sydney is one of thousands of communities across the world committed to reducing their emissions, with a target of 30% of its electricity from renewable sources by 2030.[x] That means Sydney has to find a path on which its commitments to the planet can co-exist with the energy demands of the people.

And make no mistake – electrification is fundamental to achieving both aims.

Electricity has been made safe, it is versatile, and it is easy to distribute. The regulatory structures and the physical bones of the grid are already in place. We don't need to reinvent them to make use of them.

And, with good will and time on our side, electricity generation can be decarbonised. Whether it's hydroelectric dams, or solar and wind, there are many viable technology paths to cutting emissions.

There are challenges in bringing them online, but over time, the solutions will come – just as we have learned to harness new technologies before. Our electricity generation mix is changing, and will continue to change.

Ultimately, it is the market and the science that will decide – not the Chief Scientist.

Opening the discussion

In that context, there are any number of fascinating questions for our Panel to explore this evening. Let me set out just a few, starting with the perennial favourite: electric cars.

Today, they are the definition of a niche-market product. But every major car maker understands that it can't afford to ignore electric. Bloomberg predicts that one in three new cars sold in 2040 will be electric.[xi]

I've been an electric car owner-driver for the last three years. I can tell you that I enjoy the responsiveness and smooth ride so much that is difficult to imagine reverting to a conventional car. If others come to enjoy the driving experience as much as I do I would not be surprised if the percentage of electric cars sold in 2040 turns out to be considerably higher than Bloomberg predicts.

If so, the grid will have to adapt – although when, and how fast, remains to be seen. The National Electricity Market will have to be sufficiently flexible to cope reliably with a changing demand profile and an overall increase in demand, as well as new consumer expectations.

And if the buses used widely in Sydney for public transport become electric, some will see irony in this city, because in the 1950s Sydney shut down its electric tramway system and replaced it with buses, mostly running, rather malodourously, on diesel.

But from electric cars there's an obvious segue – to batteries, and more broadly, energy storage.

It's one of the big opportunities I see on the horizon for Australia; and one of the questions that the NEM review will have to consider. First, because it is one way we can deal with the problem of intermittency whilst harnessing renewable energy across the grid; and second, because it is a field in which we are starting to play particularly well.

Take the Queensland company Tritium, spun out from a global university solar car challenge. Today their business is making fast-charging stations for electric cars.

Charge your battery at home – and you'll wait up to 20 hours. At a Tritium fast charge station you're done in an hour. And you'll find them in Germany, Austria, Switzerland, New Zealand, and now coast to coast in the United States.

But we also have battery makers like Redflow. We have globally respected research leaders, like Professor Maria Forsyth.[xii]

We have millions of consumers who leapt at the potential of rooftop solar,[xiii] and are keenly interested in batteries as well.

So there is tremendous opportunity for Australian innovation at every point of the chain – from R&D, to manufacturing, to service delivery, to standards and regulation.

To gain insight into the scope of these opportunities, we will investigate energy storage of all types – batteries, pumped hydroelectricity or one day perhaps hydrogen storage – through the first in a series of new horizon-scanning reports commissioned by the Commonwealth Science Council.

And it says something that energy storage was the first topic that the Prime Minister and the other members of the Commonwealth Science Council opted to consider.

But let's not limit ourselves to storage solutions… let's think about other fields for Australian firms that could flow from our success in managing our grid. In particular, let's think about something that Sydney and Melbourne do particularly well – build platforms to grapple with complex systems.

The startup company BidEnergy is a good example. It gives clients who need lots of electricity at many sites a way to track and manage their consumption. But that's not all: it also harnesses that data to allow multiple energy retailers to bid to provide the most cost-effective service to that business. It's a platform that has a market beyond Australia.

We may not yet have any electric unicorns – the startup code for companies that hit the magic $1 billion mark. But they may well be waiting in the wings, if we cash in on the value of our substantial expertise.

Conclusion

I began this talk with the story of a city that switched on the lights. Let me conclude with an electric dream for the decades ahead.

Electricity is already the lifeblood of the nation. The grid from national scale down to the wiring in your houses provides the circulatory system of arteries, veins and capillaries that keep us energized.

Our future is likely to involve a growing role for electricity, wherever and however it is generated. It won't be easy – but it has never been easy. It will take invention, ingenuity and persistence, well-supported by a modern market and effective regulation.

But friends, if the road ahead is anything like the story of electricity to date – then it's surely a road worth following.

THANK YOU

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[i] For further information on the independent National Electricity Market Review, see http://www.environment.gov.au/energy/national-electricity-market-review.

[ii] John Pierce, "The (Energy) Restaurant at the (Other) End of the Universe", speech presented at the Regulatory Policy Institute 25th Anniversary Conference, Oxford University, September 2016. Available: http://www.aemc.gov.au/News-Center/What-s-New/Speech-Documents/Regulatory-Policy-Institute-Oxford-Speech-14-Sep-2.aspx.

[iii] See George WIlkenfeld and Peter Spearritt, *Electrifying Sydney: 100 Years of EnergyAustralia*, EnergyAustralia, Sydney, 2004. Available: https://www.ausgrid.com.au/Common/About-us/Corporate-information/~/media/Files/About%20Us/ElectrifyingSydney100Years.pdf.

[iv] See Institution of Engineers Australia ("Engineers Australia"), "Nomination of Ultimo Power House as a site for an historic engineering marker", November 1994. Available: https://www.engineersaustralia.org.au/portal/system/files/engineering-heritage-australia/nomination-title/Ultimo_Power_House_Nomination.pdf.

[v] ThinkTV, "How Australians watch television: a review of commercial TV viewing", January 2016. Available: http://www.thinktv.com.au/media/THINK_TV_Commercial_TV_Viewing_Report.pdf.

[vi] For further information on the life of Buckminster Fuller, visit the Buckminster Fuller Institute website: https://www.bfi.org/ideaindex/projects/2015/greenwave.

[vii] For further information on the National Electricity Market, see Australian Energy Market Operator (AEMO), https://www.aemo.com.au/Electricity/National-Electricity-Market-NEM; and Australian Energy Market Commission (AEMC), http://www.aemc.gov.au/Australias-Energy-Market/Markets-Overview/National-electricity-market.

[viii] The percentage of coal in the global energy mix has been calculated from the BP Global Energy Charting tool (2016). The tool is available at http://tools.bp.com/energy-charting-tool.aspx.

[ix] . International Energy Agency, "Cities are in the frontline for cutting carbon emissions, new IEA report finds", June 2016. Available: http://www.iea.org/newsroom/news/2016/june/etp2016-cities-are-in-the-frontline-for-cutting-carbon-emissions.html.

[x] City of Sydney, "Renewable energy", 2016. Available: http://www.cityofsydney.nsw.gov.au/vision/towards-2030/sustainability/carbon-reduction/renewable-energy.

[xi] Bloomberg New Energy Finance, "Electric Vehicles to be 35% of Global New Car Sales by 2040", February 2016. See https://about.bnef.com/press-releases/electric-vehicles-to-be-35-of-global-new-car-sales-by-2040/.

[xii] See https://www.science.org.au/fellowship/fellows/professor-maria-forsyth.

[xiii] Australian PV Institute, "Mapping Australian Photovoltaic installations", 2016. Available at: http://pv-map.apvi.org.au/historical.