A future of storable renewable energy

Brett Redman, CFO, AGL Energy Limited

Shaping a sustainable energy future for Australia

AGL's new brand campaign makes our position clear

Two strategic imperatives drive AGL's agenda

Supported by three key objectives

Strategic imperatives driving our agenda

Prosper in a carbon constrained future

Build customer advocacy

Key objectives for strategy and decision-making

From: mass retailing
To: personalised retailing

From: operator of large assets
To: orchestrator of large and small assets

From: high emissions technology
To: lower emissions technology

Strategic framework to enable delivery

Embrace transformation

Drive productivity

Unlock growth

Electricity is headed for a low carbon future

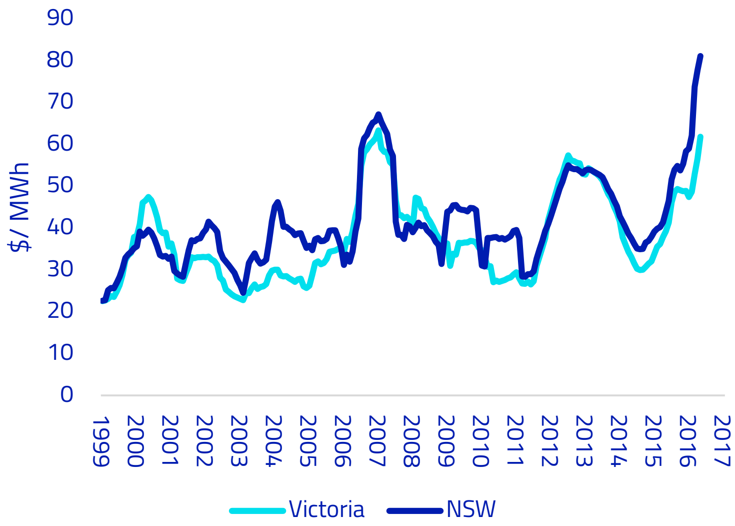
Current Australian market conditions and foreseeable technology suggest the following potential scenario

1. Growth in renewables long-term depends upon growth in storage
   Initial need to firm capacity eventually overtaken by larger need to time shift energy
2. Transition will be from big coal to big renewables, skipping big baseload gas
3. Rooftop solar is limited by area so grid-scale solutions are required
4. Big renewables plus big storage will dominate our energy landscape
5. New market rules needed once electricity is storable

Structural drivers of electricity price

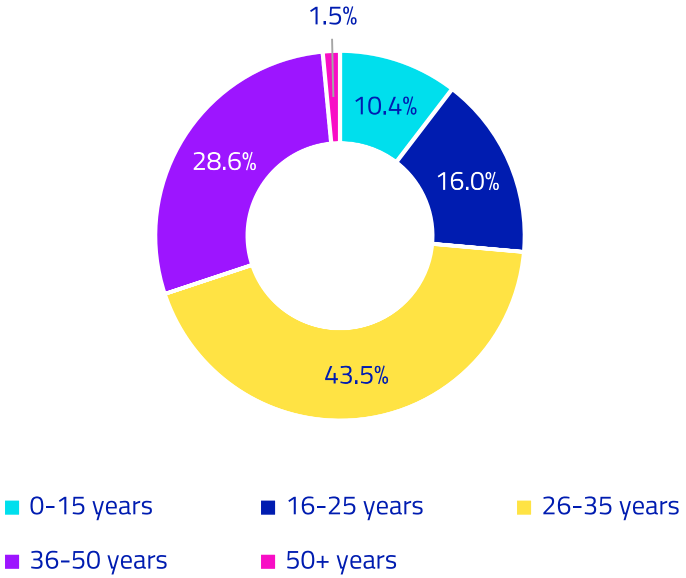
How did we arrive at today's wholesale market?

Rolling 12-month average electricity price since NEM formation



Source: AEMO

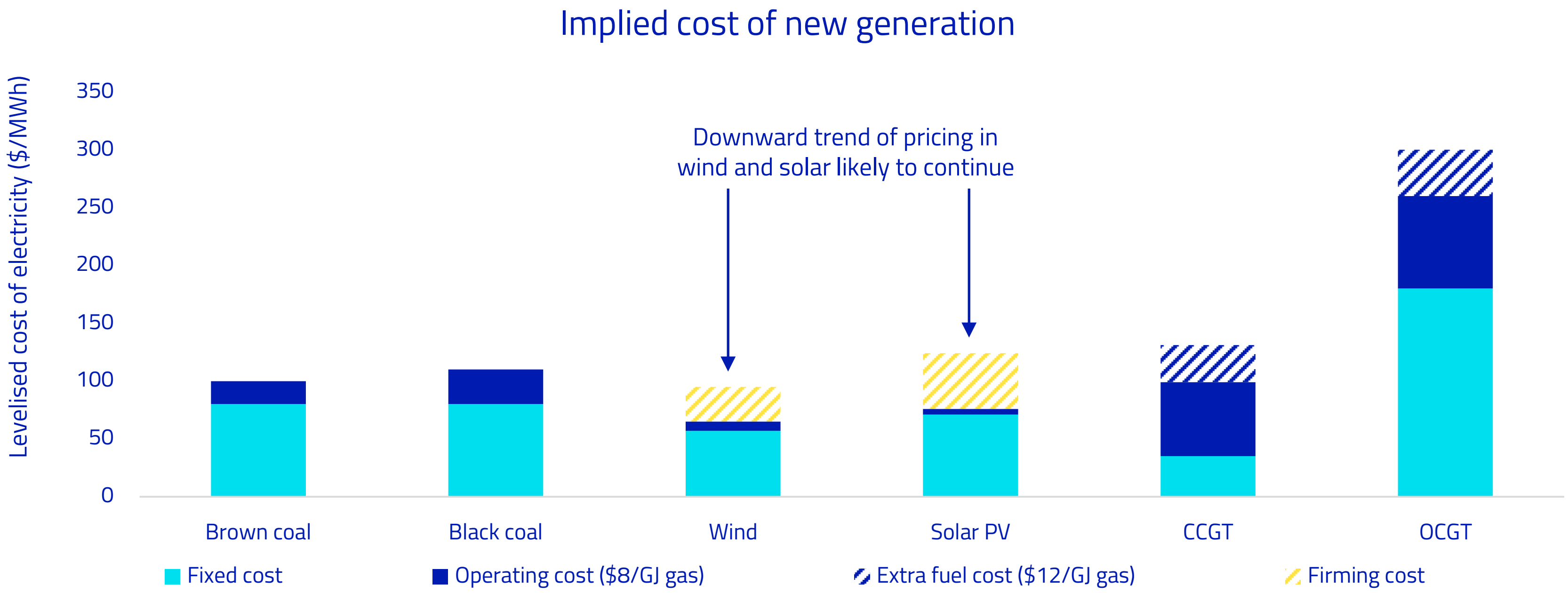
NEM thermal generation fleet by age



Source: University of Melbourne, 2014

Cost of new development favours renewables

A major program of new build baseload thermal development in Australia is unlikely

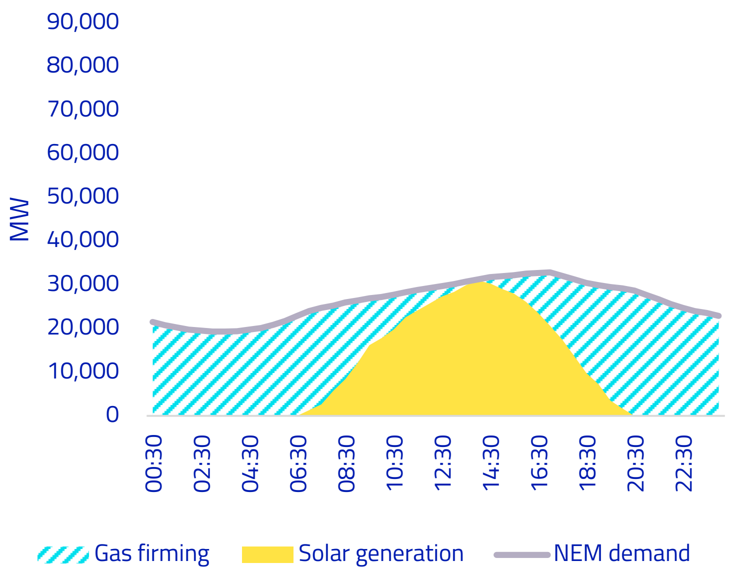


Source: AGL estimates; assumes capacity factors of 40% for wind, 25% for solar, 75% for CCGT and 10% for OCGT; heat rates of 8 for CCGT and 10 for OCGT.

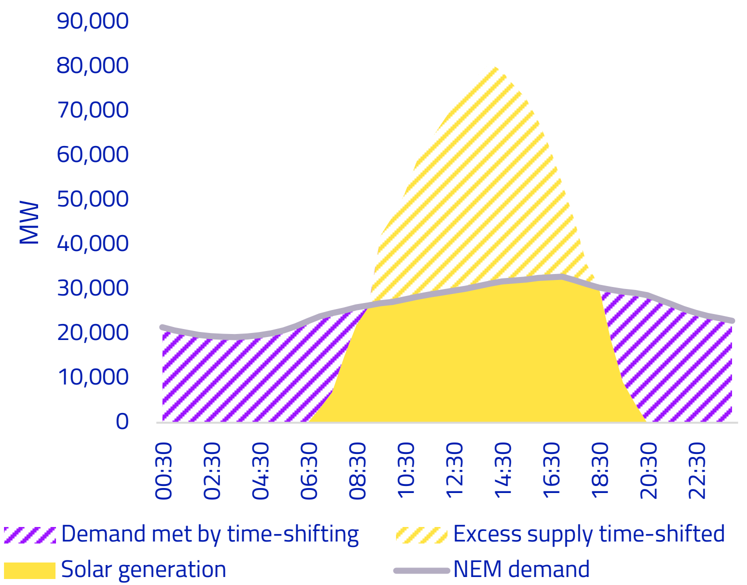
But big growth in renewables depends on storage

Without storage, renewables capacity will always be limited

Gas firming example



Time-shifted solar example



Source: AGL estimates; AEMO

Potential development need is colossal

~$250 billion of renewables and storage investment could be required across the NEM

		Today (~15% renewables)	2050 (if 100% renewables)
National Electricity Market demand		170 TWh	200 TWh
Thermal capacity		45 GW	Backup only
Renewables capacity (25% capacity factor)	Rooftop	5 GW	15 GW
	Grid-scale	10 GW	75 GW
Implied load-shift requirement (i.e. implied battery demand): 90 GW x 24 hours x 25% capacity factor x 65% time-shifted			350 GWh battery storage
@ $2m real per MW construction cost – 75 GW new renewables			~$150 billion
@ $300k estimated real per MWh construction cost – new batteries			~$100 billion

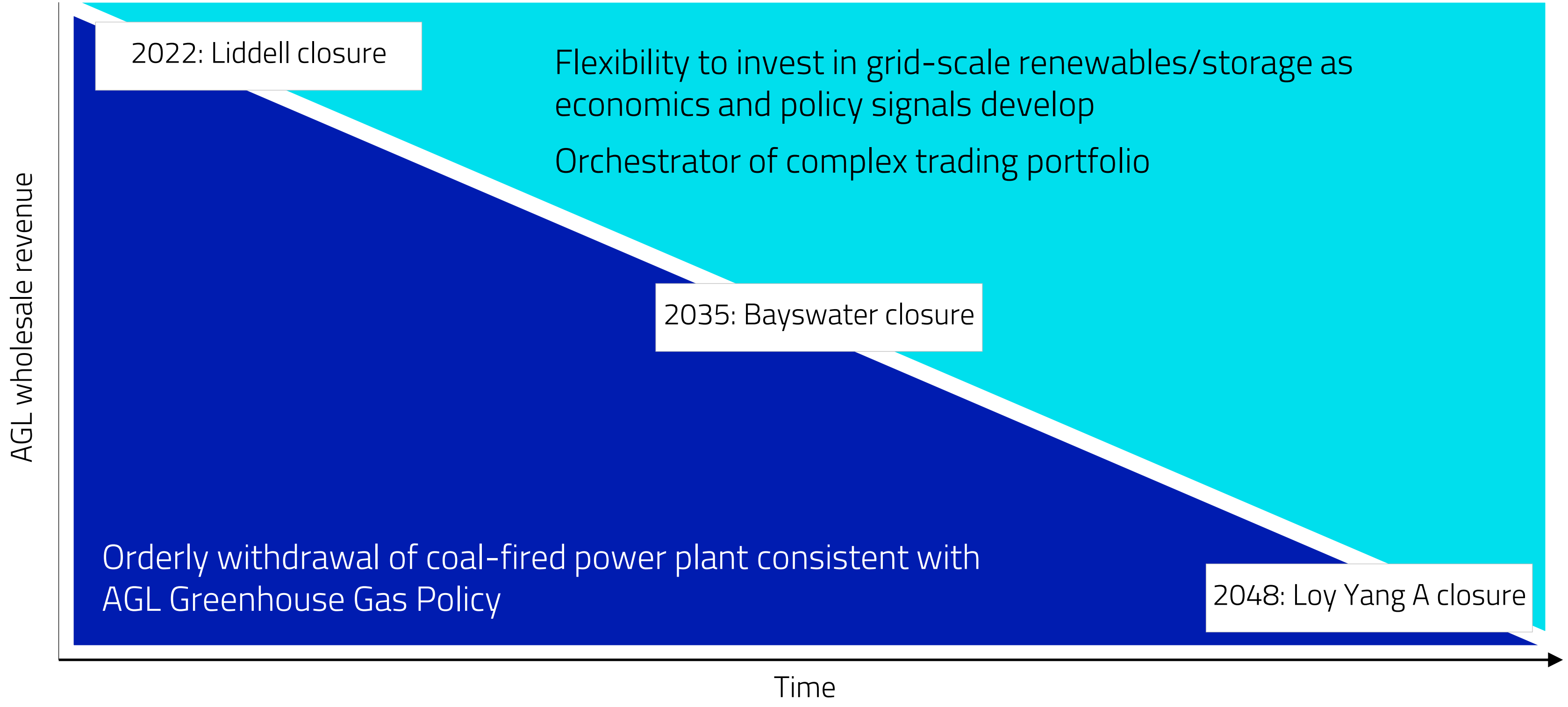
Storable electricity changes everything

We need to reimagine the fundamentals of the NEM

1	**Storage cost is lead indicator**	Lower storage cost = more storage = more renewables = less coal Outlook for storage becomes key to predicting long-term change
2	**Firm capacity needed**	Short term, we need to solve for intermittency and incentivise storage investment
3	**Orderly closure will reduce transition cost**	Medium term, coal withdrawal must be predictable or transition will be more painful Building new infrastructure needs long-term advance signals
4	**Network configuration changes**	From few to many sources of generation, networks' role must evolve with new investment likely needed to manage different energy flows
5	**Looking ahead, shape reverses**	Supply, not demand, will define "peak": more solar means off-peak price will be daytime Load will shift to when renewables are produced, increasing % renewables used without storage Tariff reform, particularly time of use, critical to smoothing physical change

AGL is uniquely placed to lead this transition

AGL wholesale business will lead the shift to renewables and storage



On track to deliver FY17 guidance

Underlying Profit after tax expected to be in the upper half of $720-800m guidance range, subject to normal trading conditions

Electricity: impact of rising wholesale prices expected to continue

- Forward curve points to sustained improvement
- Impact phased over time due to competition, customer affordability and timing of contracted positions

Gas: headwinds as previously flagged

- Lower margin on rollover of Queensland wholesale contracts, mild July/August weather and supply issues
- Resulting in $84m lower first-half gas margin; at least $100m lower margin FY17 vs. FY16

Discipline around cost and price management to continue

Rising wholesale electricity prices continue to drive-up short term margin calls; impact on FY17 cash flow will reverse in following years

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Speaker notes for presentation to Macquarie Securities conference, 2 May 2017

[Slide 1]

Good afternoon everyone; thank you for joining me for this presentation.

Thank you also to Macquarie for putting on an excellent conference as always.

I can see a lot of familiar faces out there and also some I don't know.

For those I haven't met, let me introduce myself.

My name is Brett Redman and I am chief financial officer of AGL Energy Limited, Australia's largest integrated energy company.

The title of my presentation today considers a future scenario of storable renewable energy.

Over the next 20 minutes or so, I am going to talk about how we think renewable energy combined with large-scale storage will shape Australia's sustainable energy future.

In particular, I want to talk about how we are increasingly contemplating the possibility that the National Electricity Market or NEM here in Australia could transition directly from being dominated by coal-fired baseload to being dominated by storable renewables.

The economics of battery storage, in particular large-scale battery storage, will be the bow wave that drives this transition.

But before we begin, let me show you a quick 30-second video.

[Slide 2]

[AGL television commercial plays]

Many of you will have seen this television ad, or a version of it, over the last week or two.

The new AGL brand position is about demonstrating how we are shaping a sustainable energy future for Australia.

We think it's pretty unambiguous: even if you don't accept the scientific orthodoxy on climate change, it increasingly appears that technological developments in renewables will outpace the efficiency of thermal energy in coming years.

As the biggest private coal-fired energy generator in the NEM, the largest private developer of renewable energy projects in Australia, and one of Australia's biggest energy retailers – we're uniquely placed and, I think unique, in the extent of our commitment to driving change.

My presentation today speaks directly to that.

[Slide 3]

First, let me give you some strategic context.

We talk at AGL about two key strategic imperatives that drive our agenda: to prosper in a carbon-constrained future, and to build customer advocacy.

We use three key objectives to inform our decision making and deliver against those imperatives: to move from mass retailing to delivering a more personalised energy experience to the customer; to move from being an operator of large assets to an orchestrator of both large and small assets; and to move from high emissions to lower emissions technology.

Today’s topic speaks directly to the first strategic imperative, prospering in a carbon-constrained future, and to the third objective, moving to lower emissions.

But it should also be relatively apparent that investing in our leadership role in addressing Australia’s energy challenges will also support AGL’s licence to operate in the eyes of the community and help build customer advocacy.

[Slide 4]

So, what assumptions are we making?

We are headed for a low carbon future.

Absent a staggering change in the scientific consensus and the community’s expectations, it is a matter of “when” and “how quickly” – not of “if”.

Current Australian market conditions – and it’s important to emphasise that the dynamics in other markets may be quite different – inform five key concepts, which paint a scenario of what a low carbon future might look like.

The first key concept is that, from where we are today, the long-term growth rate of renewables is largely dependent on the growth rate – and therefore the evolving economics – of storage.

Short term, the focus will be on firming capacity, but long term it’s about time shifting energy.

Second, the energy transition we have all been anticipating will skip “big baseload gas” as a major component of the NEM’s base-load generation and instead largely be a case of moving from “big coal” to “big renewables”.

Third, rooftop solar is limited by area so grid-scale solutions are required.

Fourth, large, storable, renewable energy will come to dominate our energy landscape.

Fifth, and finally, both to respond to and to facilitate all this, we need new market rules.

[Slide 5]

Now, a brief bit of history for those who are not as familiar with the Australian electricity market.

Much of Australia’s capacity was built in the 1970s and 1980s, to the point that the market was over-supplied and no new capacity was required for decades.

This was a key driver behind state governments selling off their electricity assets through the 1990s and 2000s.

Coupled with a series of asset write-downs, this led to consumers and businesses getting used to electricity costs that were well below international comparisons as fuel was cheap and the cost of new capital was not a factor.

The chart on the left shows average wholesale electricity prices in Victoria and NSW since the formation of the NEM in 1998.

It shows that demand destruction, added to the over-supply in the market, meant that by mid-2014 price had fallen to as low as 30 to 35 dollars per megawatt hour

That is close to the cash cost of running a coal-fired power station at about 30 dollars per megawatt hour for black coal and about 20 dollars for brown coal.

Incidentally, this was the year AGL purchased the Macquarie Generation black coal generators in New South Wales following the earlier purchase of the Loy Yang A brown coal generator in Victoria 2012.

We have now reached a point, after decades of limited new investment, at which the generation fleet in the NEM is old.

In fact, as the pie chart on the right-hand side of this slide shows, by 2014, more than 75 per cent of thermal generation was past its original design life.

The fleet is overdue for renewal.

Going back to the chart on the left, in the last few years, price has started to lift.

The first wave of increase was a result of rising fuel costs.

Black coal increases have had some effect, but the big swing has been the rise in the gas price, which has resulted in gas-fired generation being largely withdrawn from the market.

This change in fuel cost saw prices rise from about 30 to 40 dollars per megawatt hour to 50 to 60 dollars per megawatt hour.

The second wave of increase has been driven by the retirement of old plant such as the recent high profile closure of Hazelwood, a 53-year old brown coal plant in Victoria.

All that surplus capacity, which has been around for decades, is starting to be removed.

And price is now starting to reflect the cost of new capital.

So, if we need to build, the question becomes, what makes long-term sustainable economic sense?

Piercing through the volatility of recent times, the cost of new build points towards the new normal for long-term wholesale prices.

[Slide 6]

Rising wholesale prices then give context for us to consider the current long-run marginal cost of new development for various fuels in Australia.

Ultimately the wholesale price must reflect the cost of new development.

It is only by bringing that development cost down that we will deliver the sustainable price reductions that the community wants.

Keeping that cost down means planning for an orderly transition from high emissions technologies.

And it means selecting fuel sources for new build that are economically sustainable to ensure the return required over time for investment in long-term infrastructure.

You will notice that nuclear is not on this chart.

That is because I do not consider it relevant.

The Australian public, post Fukushima, has no appetite for nuclear power and – even setting that aside – the cost and market design implications of adding large-scale nuclear power to the NEM make it impractical.

Coal, shown here in the two left-most bars, is also arguably no longer relevant to the debate.

We do not anticipate anyone building large-scale new coal in Australia for two reasons.

First, without a workable way to capture carbon, it is unlikely to be acceptable to the community.

Second, once you start to factor in a carbon cost, which is not included in the chart I'm showing now, it does not present as the lowest cost solution.

This leaves the comparison between gas and renewables.

Renewable costs are coming down.

Based on our latest analysis, the levelised cost of wind generation is about 65 dollars per megawatt hour and the equivalent cost of solar is about is around 75 dollars.

Wind is coming down slowly while solar is coming down rapidly.

The issue for renewables is the cost of firming their output which using gas peaking increases the like-for-like cost to about $100 for wind and $125 for solar.

Using gas outright for baseload presents a different cost picture.

In Australia, gas prices have risen to 15 dollars per gigajoule and more as demand outweighs supply.

When considering gas generation, a quick rule of thumb is to multiple the gas price by a heat rate of eight to get the fuel cost per megawatt hour for gas baseload CCGT.

The chart considers gas at between eight and 12 dollars per gigajoule, which equates to a range of about 60 to 100 dollars per megawatt hour.

Adding the capital cost of new plant takes the levelised cost of new gas baseload generation to about 100 to 130 dollars per megawatt hour.

That's not including a carbon cost.

On these numbers, it's easy to see how, in an environment where the cost of renewables is falling and the gas price is high, a long-term investment case for baseload gas might not stack up.

In Australia, this points to gas having a near-term role to continue to firm renewables via gas peakers – but not being the lowest cost replacement for baseload coal.

The market already demonstrates this view.

Apart from niche examples, new projects proposed and underway are overwhelmingly renewable or aimed at firming renewable output.

[Slide 7]

My next slide sets out simply the current challenge in renewables and the game-changing impact that storage will have as we consider replacing base-load coal.

We're using solar as a simple example on this slide on a relatively typical January day.

The intermittency of wind is more complex to illustrate, although it is conceptually the same problem.

Up until, say, the 35 per cent of demand that can be met when the sun is shining, using solar energy is a conversation about how we firm capacity.

That is, how do we meet demand for the rest of the day that the sun doesn't shine?

Some firming can come from hydro, but generally new firming capacity has until now been provided by gas peaking.

This is demonstrated in the chart on the left-hand side of this slide.

Many governments and groups in the community are already looking to go beyond the Renewable Energy Target of 20 per cent renewable generation; some to 50 per cent - and maybe more.

It is possible to improve upon the basic 35 per cent with more careful matching of demand to renewable supply – but, fairly quickly, a drive to more renewable energy becomes a conversation about how to time-shift energy using storage.

And once we have the storage capacity to get us to 50 per cent, we will have the technology to go to 100 per cent.

It is just a question of cost and the rate of adoption.

This is different to capacity management or demand management.

You can't satisfy more demand without time shifting renewable energy into other parts of the day – as illustrated in the chart on the right-hand side, which is modelled using assumptions from a real model we have built for a potential grid-scale battery.

When the sun doesn't shine and the wind doesn't blow you need to move your energy around.

So, the answer can only be storage.

[Slide 8]

So, imagine it's the year 2050.

AGL has closed Australia's last coal-fired power station, Loy Yang A, in 2048, in line with the Greenhouse Gas Policy we first articulated in 2015.

Consistent with that policy, the Liddell and Bayswater power stations have been closed in 2022 and 2035 respectively.

And, assuming a rational assessment of cost and carbon efficiency are the drivers, all other coal-fired power will have closed prior to Loy Yang A.

So, think about what that world looks like and what we are going to need to do to get there?

I will build a scenario using assumptions which are not fixed, but are illustrative.

Today, NEM demand is about 170 terawatt hours, which takes about 60 gigawatts of capacity to supply.

Let's assume NEM demand is 200 terawatt hours by 2050.

It might be higher driven by electric vehicles and general growth.

It might be lower driven by energy efficiency and the closure of heavy industry.

Now if you want to supply 200 terawatt hours of renewable energy, you need – again in approximate terms – maybe 90 gigawatts of renewable generation.

That compares with roughly 15 gigawatts of installed today, implying a need for 75 gigawatts of new renewable capacity.

It's fair to assume some of that will come from rooftop solar, especially if complemented by home batteries.

AEMO forecasts another 5 to 10 gigawatts of rooftop solar will be installed by 2035, so let's assume we reach 15 gigawatts rooftop solar by 2050.

The point being rooftop space is limited compared with demand, so while rooftop solar will deliver some of what is needed, the majority still looks like coming from grid-scale installations.

That's an awful lot of installed capacity: indeed, at today's cost of about 2 million dollars per megawatt, you're talking about 150 billion dollars of new capacity.

Of course, we expect costs to fall further.

But we also need the storage to time shift that generation capacity into the periods of the day when it is required.

So, what we're starting to think more and more about is, what does such a world look like.

How many batteries does it require?

One way of estimating this is using the model we just discussed of moving energy.

That is, if 65 per cent of renewable energy generated has to be time shifted intra-day to match demand, then you roughly need to build 350 gigawatt hours of storage.

In physical terms, with today's technology, if that storage was provided by batteries, this would fill some 350,000 44-foot storage containers, which if laid end to end would stretch from Sydney to Perth with plenty to spare.

The devil as always is in the detail.

You could argue for more storage needed to cover peak days and multiple days for security.

And you could argue for less storage as you start to finesse the matching of demand and supply.

But it gives an order of magnitude.

We assumed a longer-term storage cost of 300,000 dollars per megawatt hour.

This is about a third to a half of today's costs, which feels reasonable given the expected falls to come.

But it still suggests about 100 billion dollars of storage investment could be needed in the NEM.

So, however you look at it, the investment potential for renewables and storage is colossal.

[Slide 9]

So, the introduction of big storage fundamentally changes the market for electricity and enables the transition to big renewables.

Building infrastructure needs longer predictable pathways to be efficient.

AGL continues to argue for good policy which will make this change orderly and predictable – which is another way of saying it will cost less and be more secure for our customers.

My first point here is the lead indicator for change in the scenario presented today is the cost of storage.

The bow wave of change will be falling battery costs, which will enable big investment in storage, which will in turn enable more investment for renewables and allow coal to close in an orderly and secure fashion.

So, policy that enables and supports that falling cost will be welcome.

Second: firming capacity remains essential to the transition because we need to solve for intermittency and incentivise storage investment.

In the short term, AGL is advocating market rule changes that link firming capacity with new renewables build. Initially this is likely to be provided by gas peaking but, as costs fall, this role of firming can shift to storage investment.

This deals directly to energy security.

Third, in the medium term, AGL is advocating for market rule changes that make the closure of coal predictable.

The more predictable, the more space being made in the market, the more new investment can be made with confidence.

Orderly transition deals directly to lower cost.

Fourth: network configuration changes may be necessary as we move from few large-scale sources of generation to many sources, including distributed residential, commercial or community based plants – all trading with each other and with the grid.

The networks' role must evolve accordingly, with new investment probably needed to managed the different energy flows this change entails.

Fifth and finally: in the long term, the fundamentals of supply and demand will shift when peak and off peak pricing occur with the increased supply in the day-time of solar making the day-time off peak.

The way electricity is priced and traded needs to be refreshed to encourage better matching and allow new services such as those provided by storage to be introduced in an orderly fashion.

Again, better market design means more energy security and lower cost.

[Slide 10]

So, let me close with a simple visual of what the future might hold for AGL.

I have set out today a scenario that paced the closure of coal matched by the building of storable renewable energy and how the bow wave of that change will be all about the cost of storage.

AGL is uniquely placed for a transition from coal-fired base-load to storable renewables and our wholesale business will lead the shift.

We have led the way with our commitment via our Greenhouse Gas Policy to close our three coal-fired generators in 2022, 2035 and 2048 respectively.

We are continuing to lead the way as Australia's lead developer of renewables, most significantly via the Powering Australian Renewables Fund which is driving two to three billion dollars of new renewables investment.

We are investing in building storage capability such as the large battery trial we are running in South Australia, the Virtual Power Plant.

Importantly, we are increasingly confident that big renewables and storage-linked revenue streams will replace big coal linked revenue streams.

And we see this paced change as the most stable and predictable means through which not just AGL but all of Australia can prosper in a carbon-constrained future.

[Slide 11]

Now, before I take your questions, it is customary at this conference to provide an outlook update.

AGL's is unchanged compared with the comments we provided at our half-year result stating that we expected Underlying Profit to be in the upper half of our forecast of 720 to 800 million dollars.

Everything on this slide is exactly as stated at our half-year result, with one addition.

That is the final comment on this slide which notes rising wholesale electricity prices have continued to drive up short-term margin calls.

This will have an impact on our FY17 cash flow – as it had begun to in the first half – but it is important of course to remember that ultimately rising prices are good for AGL's earnings and the impact of margin calls will reverse in following years.

Thank you again for your time.

I will now take questions.