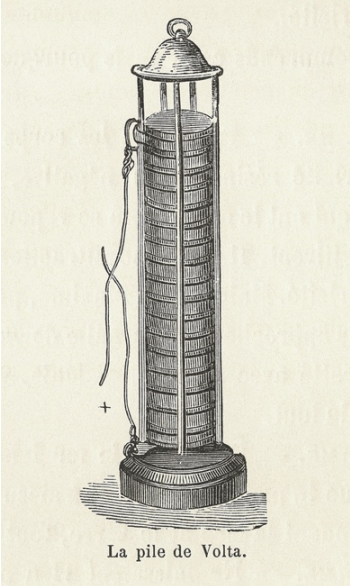


The Australia Institute
Research that matters.

# Securing renewables

## How batteries solve the problem of clean electricity

***Battery and other energy storage technologies are ready to solve the problem of variability of renewable energy.***

Research report

Dan Cass
April 2016

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Any errors and omissions are my own responsibility of course.

# FIGURES

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- Figures 1 & 2 : Lazard, New York
- Figure 3: Citigroup, New York
- Figures 4, 13: International Renewable Energy Agency, Abu Dhabi
- Figure 10: AECOM, Melbourne
- Figure 12: Professor W. Antweiler, University of British Columbia
- Figure 14: Younicos, Berlin

# Summary

Critics put forward two key arguments against widespread adoption of renewable energy: price and intermittency. Solar and wind costs have fallen so rapidly over the past decade that they are now competitive with fossil fuels, so the price argument is losing traction.

Battery and other forms of storage technology are rapidly overcoming the variability argument. As batteries become more widespread, this will answer the final objection to vigorously developing our clean energy resources.

> [T]he lithium-ion battery is the technology of our time
> *The Economist*

Like renewable energy development, battery storage is popular with the public. New polling by The Australia Institute is reported here for the first time, as chapter 2 below, and shows that storage is a popular option with consumers:

- 81% of solar owners say they are considering buying batteries
- Interest in owning storage batteries across the population has increased from 49% to 63% over 12 months
- 23% of respondents choose unplugging from the grid as a reason to get batteries
- 39% of respondents choose independence from their energy company as a reason to get batteries
- 34% of respondents say they are prepared to invest in storage batteries with a payback period of 5 years or more
- 71% of respondents say they would consider voting for a party that supported distributed small-scale solar and storage

As storage technologies become cheaper, they could deliver significant cost savings to consumers and the whole economy. Their adoption could reduce emissions from the electricity sector and cut local pollution caused by coal and gas extraction and burning.

All parties in this election year should commit to opening up the energy market to fair competition from storage and distributed energy and to support innovation in this area.

Chapter 1 shows the reductions in costs of storage globally and in Australia.

Chapter 3 is a primer on energy storage technologies and applications.

Chapter 4 showcases exciting examples of battery storage products and applications from Australia and around the world. It shows one aspect of our competitive advantage - we are already innovators in this area.

Chapter 5 explains the obstacles and risks of current policy and our failure to rapidly to support the emerging market reality of competitive battery storage. It explains the conflict between the spending on 'gold plating' the existing electricity network and the better investments we should be making in storage. It explains that the ending of state based feed in tariffs in 2016 is likely to drive many solar homeowners to be the early adopters of batteries and the risks of investment in the wrong infrastructure leading to an the electricity industry 'death spiral'.

The Paris climate conference set an ambitious goal of preventing dangerous climate change, which is a de facto commitment to replacing most fossil fuels with renewable energy over the next few decades. Given that the electricity network is a long-term infrastructure investment, we must urgently shift our investment focus from 'gold plating' the old model to accelerating the new. Storage is the lynchpin of this shift.

# Table of Contents

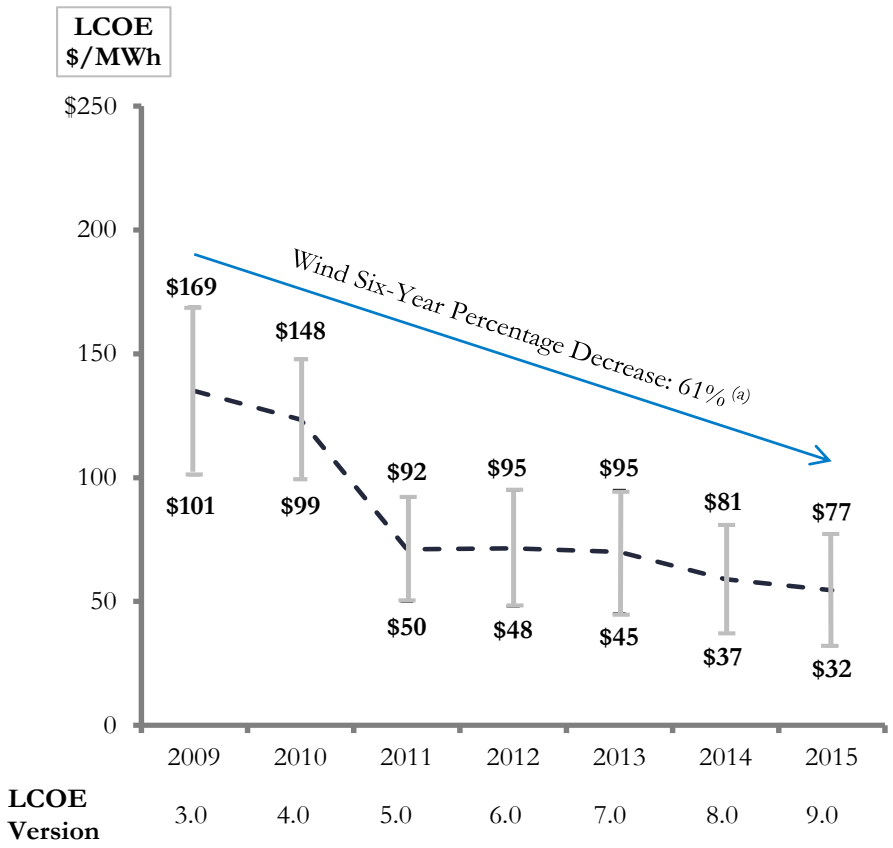
# Introduction

## STORAGE SOLVES THE FINAL OBJECTION TO RENEWABLES

Australia is a vast, sunny country with abundant renewable energy resources. A super-majority of the population support renewable energy in preference to coal. However, a lack of leadership has led to us falling behind the global race towards renewable energy.

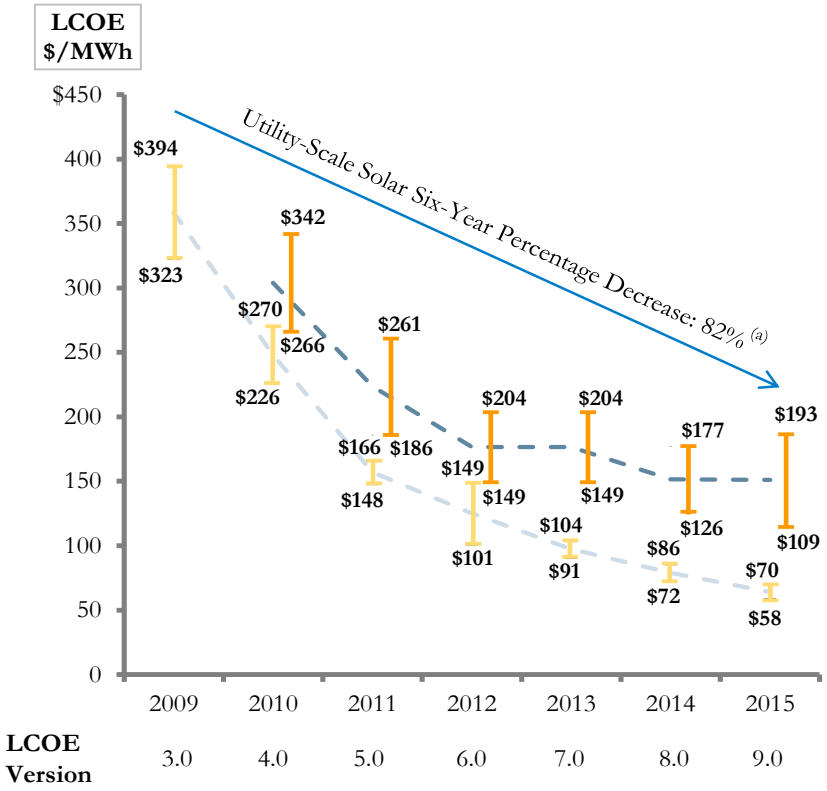
Critics of renewable energy have had two key arguments; cost and variability. Over recent years the cost argument has largely been solved. Constant incremental improvements have reduced the price of solar, wind and other renewable energy technologies as shown in Figures 1 and 2 below:

**Figure 1: Declining levelised cost of wind energy in America 2009-2015**




Source: Lazard, (2015b) Lazard's Levelised Cost of Energy Analysis - Version 9.0 (November) Lazard: New York, p.10

**Figure 2: Declining levelised cost of utility-scale solar PV energy in America 2009-2015**




Source: Lazard, (2015b) Lazard's Levelised Cost of Energy Analysis - Version 9.0 (November) Lazard: New York, p.10

These two graphs (Figures 1 and 2) show how quickly renewable energy costs have declined. Lazard, a financial advisory and asset management firm, has shown in its latest analysis of American energy that the cost of wind has plunged 61% in six years (to about US$55/MWh LCOE) and the cost of utility-scale solar PV has plummeted 81% in six years.[1] It is now cheaper to build renewable energy than conventional energy in many markets around the world, including Australia.

The variability argument rests on the obvious observation that when the sun goes down and the wind stops blowing, solar panels stop generating and the wind turbines stop turning. However, with rapid improvements in storage technology, this criticism is being answered.[2]

[1] Lazard, (2015b) *Lazard's Levelised Cost of Energy Analysis - Version 9.0* (November) Lazard: New York

[2] It is important to note that this criticism has been overstated by many critics. According to the CEO of 50 Hertz, a German transmission grid company, Germany can safely manage up to about 70% renewable energy with smart grid management, before requiring any grid-tied storage. (see Parkinson, Giles (2015e) 'German grid operator sees 70% wind + solar before storage needed', *RenewEconomy*, (7

# CRITICS ANSWERED

Former Prime Minister John Howard stated the standard variability argument in 2007 when he said you can't run power stations on solar and wind energy; "You either run them on the way they're run now, it's predominantly coal or gas or sometimes hydro, or you run them, in the future, with nuclear."[3]

A later Prime Minister, Tony Abbott, reiterated this variability talking point to radio broadcaster Alan Jones in 2013

> you've gotta have backups because when the wind doesn't blow and the sun doesn't shine, the power doesn't flow. So this is an obvious problem with renewable energy in the absence of much more sophisticated battery technology than we have right now.[4]

Nationals Senator Ron Boswell has elaborated on the variability objection in some detail on a number of occasions,

> The wind only blows strongly enough to operate wind turbines about 30 per cent of the time, and the power industry says the reliability factor of wind power, from a planning perspective, is a very low 8 per cent or less.[5]

> It is accepted that wind has the capacity to work around 30 per cent of the time. That means for 70 per cent of the time it is useless and it means you have to have massive conventional backup to maintain supply.[6]

Independent Senator Nick Xenophon, who advocates action on climate change, has said that we need what he calls 'baseload renewables', because 'You are not going to get rid of coal fired power stations if you have unreliable forms of renewable energy.'[7]

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December) http://reneweconomy.com.au/2015/german-grid-operator-sees-70-wind-solar-storage-needed-35731 Accessed 6 April 2016.)

[3] 'Howard on global warming, water, Hicks', (2007) Lateline, 5 February Australian Broadcasting Corporation ABC1, presenter T. Jones, http://www.abc.net.au/lateline/content/2006/s1840963.htm Accessed 2 February 2016

[4] Ewbank, L. (2013) 'Tony Abbott gets it wrong on wind farms and renewables', *RenewEconomy* (12 November 2013), http://reneweconomy.com.au/2013/tony-abbott-gets-it-wrong-on-wind-farms-and-renewables-80014 Accessed 2 February 2016

[5] Boswell, R. (2013) 'Energy taxes are the nail in the coffin of local manufacturing', *The Australian* (8 May 2013), http://www.theaustralian.com.au/national-affairs/opinion/energy-taxes-are-the-nail-in-the-coffin-of-local-manufacturing/story-e6frgd0x-1226637139010 Accessed 2 February 2016

[6] Cth. Parliamentary Debates. Senate. 21 June 2010, Renewable Energy (Electricity) Amendment Bill 2010; Renewable Energy (Electricity) (Charge) Amendment Bill 2010; Renewable Energy (Electricity) (Small-Scale Technology Shortfall Charge) Bill 2010, p.3741

Battery and storage technology addresses the concerns of critics of renewable energy. It also fits well with Prime Minister Malcolm Turnbull's vision for Australia:

> ...is agile, that is innovative, that is creative. We can't be defensive, we can't future-proof ourselves. We have to recognise that the disruption that we see driven by technology, the volatility in change is our friend if we are agile and smart enough to take advantage of it.[8]

There are significant commercial opportunities for Australia to innovate in the new markets for 'baseload' renewable energy storage.[9] Prime Minister Turnbull should appreciate the enthusiasm expressed in *The Economist*, that 'the lithium-ion battery is the technology of our time'.[10]

Batteries and other storage technologies are solving renewable energy's variability problem. For many years the critics were right – storing renewable energy was difficult and expensive. But that was then and this is now.

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[7] Cth. Parliamentary Debates. Senate. 12 February 2014, Climate Change Authority (Abolition) Bill 2013, p.179

[8] Turnbull, M. (2015) 'Transcript: Vote on the Liberal Party Leadership', Malcolm Turnbul MPl (14 September), http://www.malcolmturnbull.com.au/media/transcript-vote-on-the-liberal-party-leadership Accessed 2 February 2016

[9] Hackett, S. (2015) 'The new power game', *Global report on technology and the economy*, Vol 18, No. 19 (18 May), Strategic News Service

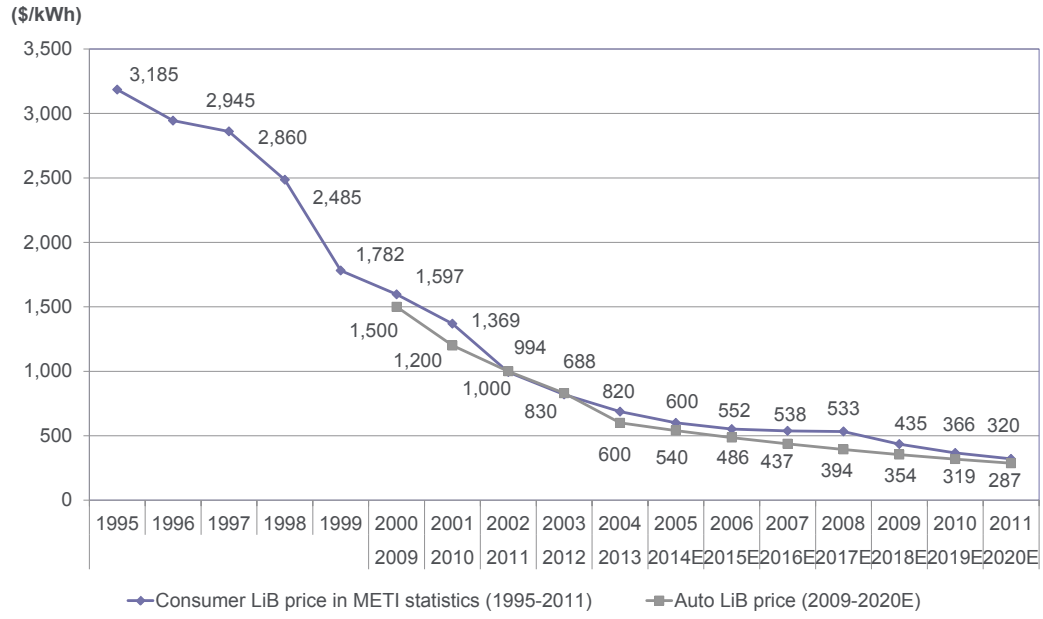
[10] Anonymous (2016) 'A plug for the battery' *The Economist* (16 Jan 2016) http://www.economist.com/news/leaders/21688394-virtual-reality-and-artificial-intelligence-are-not-only-technologies-get-excited-about Accessed 19 January 2016.

# Chapter 1: That was then, this is now

The storage technology getting the most attention in 2016 is the most common battery in the world; the lithium-ion battery that powers smartphones and laptops.

Mass production and continual innovation has brought the cost of lithium-ion consumer batteries down 90% over 16 years from US$ 3,185/kWh in 1995 to US$ 320/kWh 2011, according to Citigroup (see figure 3 below). Costs continued to decline from 2011-2014 by almost another third.[11]

**Figure 3: Historical costs of lithium-ion consumer and automobile batteries**




Note: We assume ¥100/$ for consumer lithium-ion battery prices.
Source: Company data, TSR, METI, Citi Research

Source: Citigroup (2015) *Investment themes in 2015: dealing with divergence* New York, NY: Citi GPS, p.54

Other, less common technologies are also making considerable progress. For example, the Australian company Redflow is leading the commercialisation of a 'flow battery'

[11] Kille, L.W. (2015) 'Electric vehicles, battery technology and renewable energy: Research roundup' *Journalist's Resource,* (9 April 2015) http://journalistsresource.org/studies/environment/energy/electric-vehicles-battery-technology-renewable-energy-research-roundup Accessed 10 March 2016

design (see Chapter 3) and claims it has cut the cost of this technology by more than 50%.

Battery storage is becoming competitive with conventional generation. Giles Parkinson and others have predicted that 2016 is the year in which residential battery storage will 'explode' onto the Australian market with twenty-fold growth.[12] In Australia the initial natural market for growth is probably going to be domestic storage. Solar consumers will use storage batteries to maximise the benefit of their own home-made energy, by storing what they do not need during the day and consuming it during evenings.

The Australian Energy Market Operator has predicted that we might see up to 40% of Australian homes install battery storage within twenty years, even without a dedicated national policy to drive the transition from coal and gas to a renewable energy powered smart grid.[13] This would revolutionise the electricity sector.

The Australian Energy Market Operator's National Transmission Network Development Plan contains two scenarios for change in the energy sector up to 2035. The Gradual Evolution scenario predicts residential battery storage will grow to 3,858 MW (8GWh) installed capacity by 2035. The Rapid Transformation scenario predicts that 40% of Australian homes will get batteries, a total of 11,188 MW(19.1GWh) installed capacity.

US Investment bank Lazard produced its first analysis of storage competitiveness in the US in late 2015.[14] It says that storage is already cost competitive in many grid-tied and also remote off-grid applications in America. Lazard says that storage can compete with conventional technologies in several markets:

- **Peaker replacement:** utility-scale installations of storage on the electricity network can replace peaking plants. These provide quick-start generation to provide electricity to cope with fast rises in demand such as during heatwaves when millions of households and commercial buildings are using air conditioning or in the early evenings when residential solar is not producing and households are at peak consumption.
- **Network investment deferral:** utility-scale installations of storage at various points on the network can minimise the expensive 'gold plating' upgrades to both local distribution and long distance transmission networks

[12] Parkinson, G. (2015d) 'Home battery storage market expected to "explode" in Australia in 2016', *RenewEconomy*, (13 November 2015) http://reneweconomy.com.au/2015/networks-to-spend-another-50bn-on-australias-dumb-and-dumber-grid-26649 Accessed 11 January 2016.

[13] Australian Energy Market Operator (2015) *National Transmission Network Development Plan*, (November) AEMO: Melbourne, p.4, 10, 42, 44

[14] Lazard, (2015a) *Lazard's Levelised Cost of Storage Analysis - Version 1.0* (November) Lazard: New York

- **Demand charge management**: a large number of small storage installations at households and businesses allows those consumers to smooth out their demand peaks in order to keep their total demand purchased from the grid below the level at which they would incur higher 'capacity' charges
- **Ancillary services:** utility-scale or aggregations of many small installations provide frequency, 'spinning reserve' and other control services that maintain the quality of electricity supply, which were traditionally provided by fossil fuel plants
- **Diesel micro-grids:** medium-scale installations paired diesel generators at remote 'off-grid' communities including mining operations can prevent the high capital expense of building long distance interconnections to the electricity network

The Lazard calculations are confirmed by other authorities. For example, two US energy utilities, Southern California Edison and San Diego Gas & Electric, have recently confirmed the Lazard analysis that batteries are now competitive with conventional peaker plants.[15]

The International Renewable Energy Agency notes that batteries are better at providing ancillary services to balance the quality of energy in the grid than the fossil fuel generators that have traditionally provided these services. IRENA points out that if energy markets are opened up to fair competition then this segment will grow naturally without expensive subsidies.[16]

Australia's large geographical area makes us a great test site for micro-grids, including those that integrate renewable energy so they do not rely solely on diesel. AECOM has calculated that the value of energy storage paired with solar in remote, off-grid locations is $120/MWh. This is less than half the cost of conventional, diesel-only generation (which AECOM calculates at $346/MWh, assuming a diesel price of $1.30 per litre).[17]

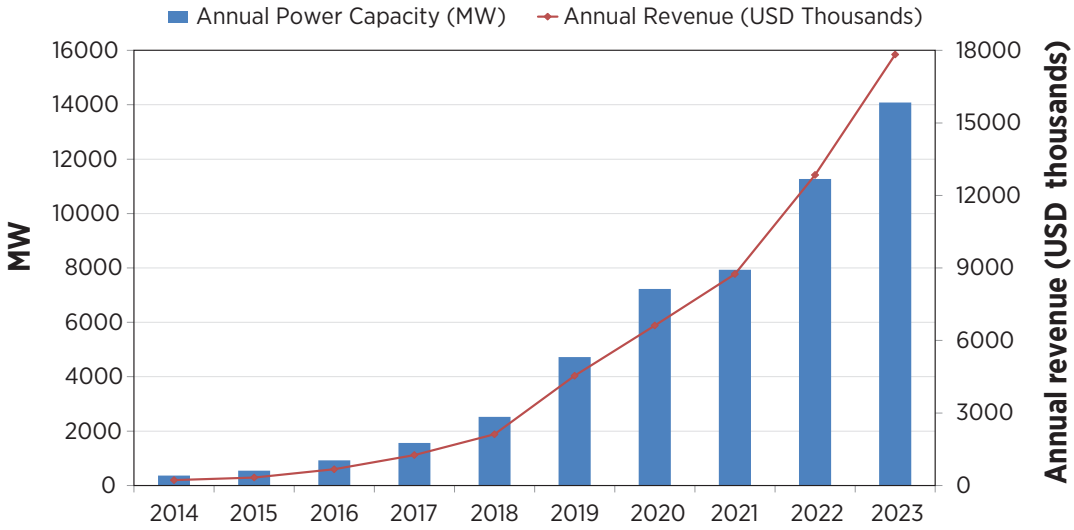
[15] Chediak, M. (2015) 'Battery Makers See a Big Break Coming No, Seriously This Time' (19 October) http://www.bloomberg.com/news/articles/2015-10-16/batterymakers-see-a-big-break-coming-no-seriously-this-time Accessed 14 January 2016.

[16] Kempener, R. and Borden, E. (2015) *Battery storage for renewables: Market status and technology outlook*, International Renewable Energy Agency, Abu Dhabi p.40

[17] Christiansen, C. & B. Murray (2015) *Energy Storage Study: funding and knowledge sharing priorities*, AECOM, Sydney, p.69

Bloomberg New Energy Finance predicts that by 2020, 11.3 GW of battery storage will be installed globally.[18] Given that battery storage is currently a very small sector, mostly limited to remote telecommunications applications, this is impressive exponential growth. To put this in perspective, consider that Navigant Research found that the global tally of storage projects announced in 2014-15 was less than one GW (700 MW).[19] The International Renewable Energy Authority has compiled data to show that installed capacity is likely to double almost four times over between 2016 and 2023 (see Figure 4 below).

**Figure 4: Global forecast of battery storage capacity (MW) and annual revenue (USD) for utility scale applications 2014-2023**




Source: Kempener, R. and Borden, E. (2015) Battery storage for renewables: Market status and technology outlook. International Renewable Energy Agency, Abu Dhabi p.24

In 2015, Morgan Stanley predicted 2.4 million Australian homes will install storage by 2035. In 2016, Morgan Stanley updated this prediction to 3 million homes.[20]

[18] Chediak, M. (2015) 'Battery Makers See a Big Break Coming No, Seriously This Time' (19 October) http://www.bloomberg.com/news/articles/2015-10-16/batterymakers-see-a-big-break-coming-no-seriously-this-time Accessed 14 January 2016.

[19] Navigant Research (2016) 'Energy Storage Tracker 1Q15' http://www.navigantresearch.com/research/energy-storage-tracker-1Q15 Accessed 13 January 2016.

[20] Parkinson, G. (2016) 'Incumbent utilities and battery storage: They still don't get it', *RenewEconomy*, (24 March) http://reneweconomy.com.au/2016/incumbent-utilities-and-battery-storage-they-still-dont-get-it-23531 Accessed 24 March 2016.

A key point about these growth markets for batteries is that they use information and computer technology to extract the maximum value from the storage assets. This is a rich field for innovation and provides a significant opportunity for Australia. We have the worlds largest interconnected electricity network, which means we are particularly well suited for storage. If Australia is smart then we can create local jobs and generate export opportunities right across the value chain, from the storage hardware, to control software and in creative new finance and business models that can power the smart grid of the future.

This is good news for policy makers and politicians, because many Australian homes have already invested in solar PV and solar hot water and a super majority of the public supports renewable energy generally. New polling by the Australia Institute shows a high level of support for storage (see Chapter 2). It should be easy to get cross-party support for good policies that support the rise of storage and smart grids, create jobs, improve productivity and reduce pollution.

# Chapter 2: Polling shows high support for energy storage

New polling by The Australia Institute shows that there is significant public support for distributed solar power and battery storage as a consumer choice and a national policy priority. Between 29 February and 8 March 2016 The Australia Institute conducted a national opinion poll of 1412 people through Research Now, with nationally representative samples by gender, age and state or territory. The full text of the questions asked is included in the appendix to this report.

### Key results

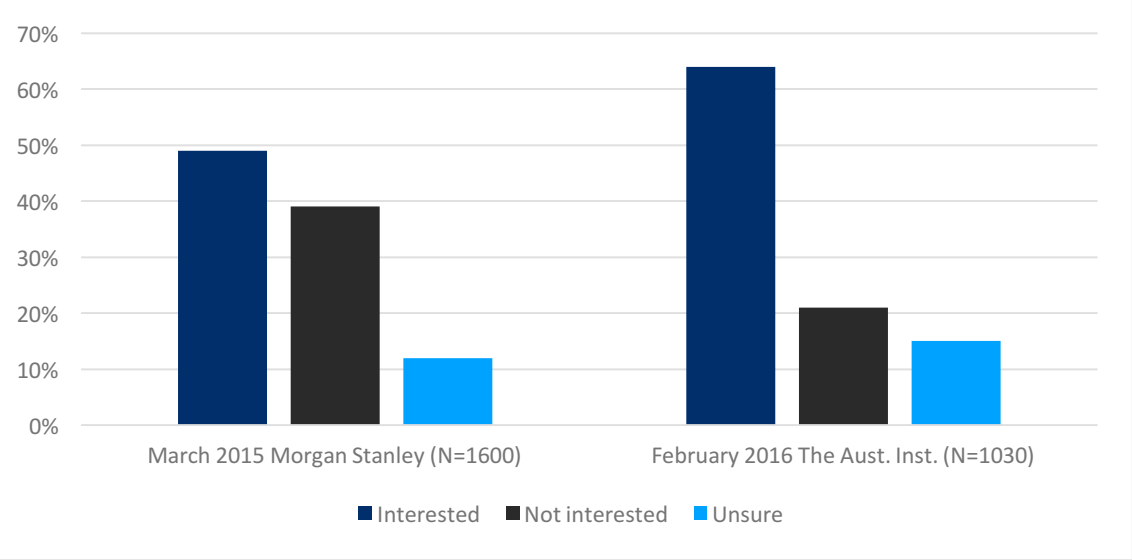
- Interest in owning storage batteries across the population has increased from 49% to 63% in one year (Figure 5)
- 81% of solar owners say they are interested in getting batteries (Figure 6)
- 23% of respondents choose unplugging from the grid as a reason to get batteries (Figure 7)
- 39% of respondents choose independence from their energy company as a reason to get batteries (Figure 7)
- 34% of respondents say they are prepared to invest in storage batteries with a payback period of 5 years or more (Figure 8)
- 71% of respondents say they would consider voting for a party that supported distributed small-scale solar and storage (Figure 9)

In March 2015 Morgan Stanley commissioned polling, including both solar owners and households without solar (Figure 5). Their survey found that 49.4% of people surveyed were interested in getting a solar PV and battery storage system.[21]

Our survey in February 2016 found 64% of people surveyed were interested in getting a solar PV and battery storage system.[22]

[21] 20.5% percent of respondents answered 'Yes, most definitely' to the question 'Would you consider installing solar panels and battery storage in your household?' and 28.9% answered 'Yes, maybe', for a total of 49.4%. 12.1% answered 'Don't know', 20% answered 'No, probably not' and 18.5% 'No, definitely not', as reported in Parkinson, G. (2015b) 'Morgan Stanley sees 2.4m Australia homes with battery storage', *RenewEconomy*, (20 May). http://reneweconomy.com.au/2015/morgan-stanley-sees-2-4m-australia-homes-with-battery-storage-20668 Accessed 13 January 2016

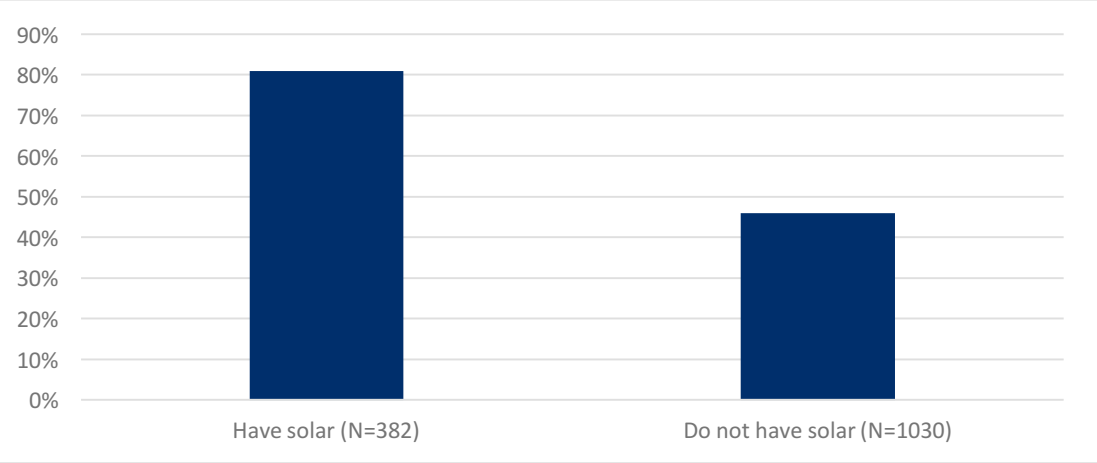
## Figure 5: High and rising interest in storage




Sources: Morgan Stanley, The Australia Institute.

Solar owners are even more interested in getting battery storage than the general population, with 81% saying they are considering making this addition to their solar system.[23]

## Figure 6: Solar consumers more interested in getting battery storage




Source: The Australia Institute.

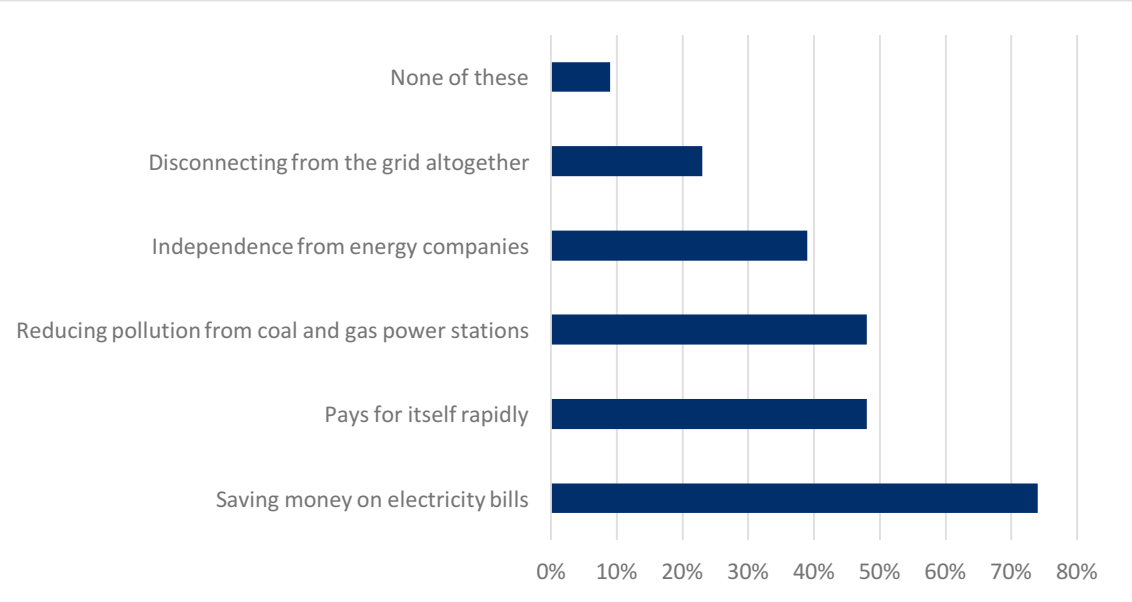
[22] 64% answered 'Yes' to the question, 'Would you consider installing solar PV and battery storage in your household?' 21% answered 'No' and 14% answered 'Don't know/Not sure'. Sample size 1030.

[23] 81% answered 'Yes' to the question 'Storage batteries are an emerging technology that allows homeowners to store electricity generated by their solar panels during the day and use it at night or during times when they are consuming a lot of electricity (e.g. running an air conditioner on a hot day). Would you consider installing battery storage in your household?' 8% answered 'No' and 11% answered 'Don't know/Not sure'. Sample size 382.

These results are consistent with other recent research. In late 2015 Energy Consumers Australia commissioned polling of solar households and reported that 'In a sign of a major disruption to the current business model of networks, 81 per cent of households who have installed, or are looking to install, solar panels, are also looking to add battery storage to enhance the effectiveness of the solar PV.'[24]

Our polling asked people to nominate reasons for their interest in battery storage. The most popular reason, cited by three quarters of respondents (74%), is to save money (see Figure 7). Other popular responses were reducing fossil fuel pollution and rapid pay back, both at almost half of respondents.

**Figure 7: Cost is the key driver of support for storage**




Source: The Australia Institute. Question (34) Which, if any, of the following things are important to you when considering whether to install batteries to store solar power in your home?

Four in ten respondents want to gain independence from energy companies. The data shows that almost one quarter of respondents (23%) say their reason for considering whether or not to install storage is to disconnect from the grid entirely.

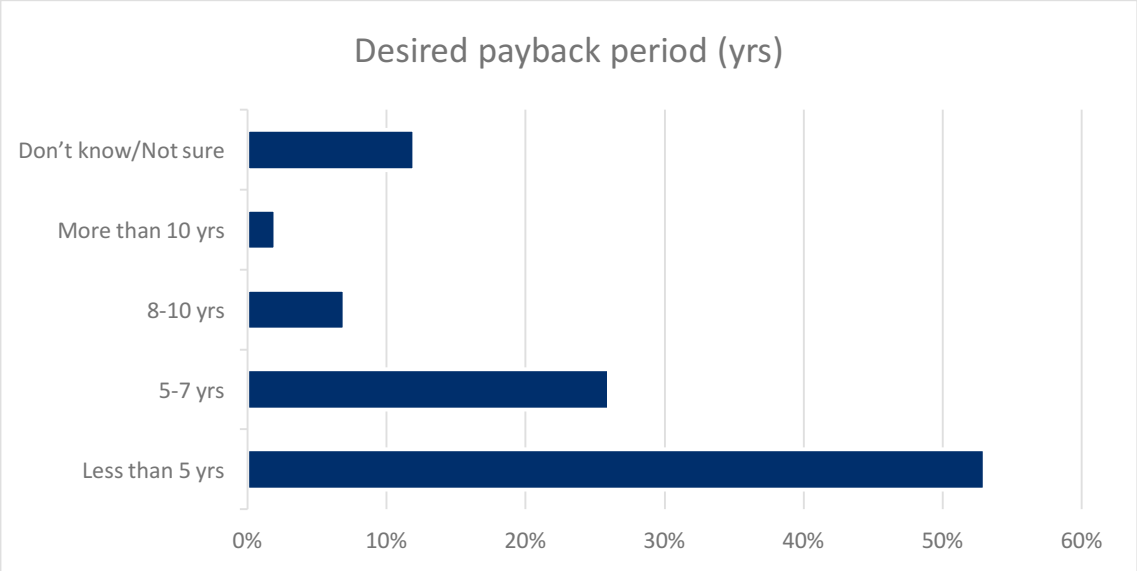
These results are a rejection of business-as-usual in the electricity sector and show that Australians are keen to use technologies that threaten established energy companies.

[24] Energy Consumers Australia (2015). '9 in 10 households turning to technology to tackle expensive electricity bills', (5 November) http://www.energyconsumersaustralia.com.au/media-releases-1/nov-5-2015-media-statement Accessed 12 January 2016.

We also asked people how long they would be prepared to wait for a battery storage system to pay for itself. Our results found that early adopters of storage are likely to be a significant market, driving down costs and increasing community awareness of the benefits of the technology. Up to one in ten (9%) of respondents are prepared to wait for their battery system to pay itself back over 8 or more years (see Figure 8).

An impressive 34% of people surveyed are prepared to invest in a home battery storage system that takes more than 5 years to pay itself off.

**Figure 8: Early adopters have confidence in storage**




Source: The Australia Institute. Question (35) Over time battery storage can pay for itself in savings on your electricity bill. If you were to install a home battery storage system, what is the longest time you would be prepared to wait for it to pay for itself? 1. Less than 5 years 2. 5-7 years 3. 8-10 years 4. More than 10 years 5. Don't know/Not sure. Note that total may not sum to 100% due to rounding.

Our opinion research also compared six policies that would drive an increase in clean energy in Australia and found that small-scale, distributed energy is the most popular option (see Figure 9). When asked whether respondents would be more likely to vote for parties with particular policies, distributed solar and storage came out on top, with almost three quarters of people supporting these technologies.

**Figure 9: Distributed solar and storage are the most popular clean energy policies**

| Policy | Much more likely | More likely | Total support |
|---|---|---|---|
| **Invest in large-scale solar and wind** | 26% | 41% | 67% |
| **Gradually transition Australia to 100% renewable energy by 2030** | 24% | 40% | 63% |
| **Ensure solar is installed on every home that is suitable and on buildings like hospitals and schools** | 28% | 44% | 72% |
| **Accelerate the uptake of electric vehicles** | 13% | 32% | 45% |
| **Help solar consumers get battery storage so the power they generate can be used around the clock** | 24% | 47% | 71% |

Source: The Australia Institute. Question (40) Would you be more likely or less likely to vote for a party which had the following policies? Question response options listed in table above.

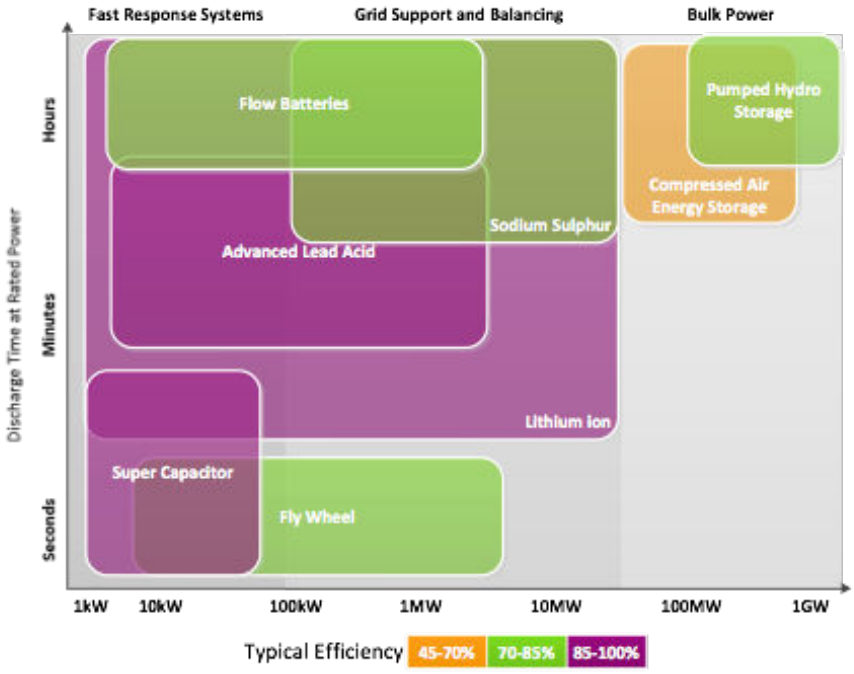
# Chapter 3: Primer on technologies and applications

There are a variety of energy storage technologies and some are particularly well suited for particular applications. The various factors that determine the best role for a storage technology include:

- capital expenditure (capex) and operating expenditure (opex)
- rated power: the amount of energy stored
- speed of discharge
- size and weight
- safety and sustainability

The AECOM chart reproduced below compares several storage technologies (see Figure 10). For example, the horizontal axis shows that lithium-ion batteries are suited to a very wide range of storage capacities, from 1kW households to over tens of MW in utility-scale installations.

**Figure 10: Storage technologies comparison across application types**




Technologies graphed to show key applications, with power capacity on the horizontal axis and discharge time on the vertical axis. Source: Christiansen, C. & B. Murray (2015) *Energy Storage Study: funding and knowledge sharing priorities*, AECOM, Sydney, p.27

The vertical axis shows that lithium-ion can discharge over a wide time range, from seconds to hours. The colouring purple indicates that lithium-ion has high efficiency, in the 85%+ range. This chart is only indicative of course, as the technologies are evolving rapidly but it shows how important it is for Australia to gain experience across a range of technologies if we are to maximise the value of storage.

## WIDELY DISTRIBUTED, SMALL-SCALE BATTERIES

There are more than 1.5 million Australian households with solar PV systems. This is likely to be the first major market for storage, regardless of whether we have a supportive national plan for the development of this technology. This uptake will shift the energy system from the old centralised model to a new decentralised model based around renewable energy, which will offer improved competition, increased energy security as well as lower pollution. As the International Renewable Energy Agency (IRENA) says 'The use of batteries for self-consumption of renewables could revolutionise the electricity system.'[25]

The centralised model was designed around a small number of large coal, gas and nuclear, 'base-load' generators that provide a steady stream of energy and gas peaking plants that provide rapid increases in generation during spikes in demand. The new distributed energy model sees generation spread across millions of households and businesses, who are connected by clever information and computer technology to allow them to coordinate output to match ever-changing consumption. Some traditional energy companies, such as the multinational utility Engie, are promoting this transition from centralised to decentralised generation. Engie predicts that storage will facilitate this process and result in decentralised energy accounting for about 50% of total capacity.[26]

Electrochemical batteries are expected to dominate the market for small household and commercial storage systems. The most common form is the lithium-ion battery, of the kind used in smartphones and laptops. The wisely publicised Tesla Powerwall is the best known of these lithium-ion batteries but there are actually many companies already offering similar products and competition is expected to keep pressure on prices and spur technological innovation.

[25] Kempener, R. and Borden, E. (2015) *Battery storage for renewables: Market status and technology outlook*, International Renewable Energy Agency, Abu Dhabi p.2

[26] Parkinson, G. (2016) 'Hazelwood owner Engie launches push for 1,000GW of solar' *RenewEconomy* (19 January) http://reneweconomy.com.au/2016/hazelwood-owner-engie-launches-push-for-1000gw-of-solar-36363 Accessed 19 January 2016.

In 2015 there was only 1.9MW of battery storage installed in Australian homes, but as prices drop, this is set to rise exponentially. As our polling in Chapter 2 showed, there are many consumers who are prepared to finance their own storage batteries on relatively long payback times, driven by motivations that are not purely economic.

Morgan Stanley predicts that payback times for a 7kWh Tesla battery and a 3kW solar system are as low as 4.7 years in the case of retrofits of storage onto solar households in South Australia who are on an EnergyAustralia tariff.[27] Early in 2015 UBS predicted that a payback time for residential storage systems could be as fast as about 6 years.[28]

The reason that payback periods are becoming attractive at the residential level is because solar consumers pay far more for their electricity consumption (the 'residential price') than they get paid for electricity they generate (the 'export tariff').

Some solar consumers are on high feed-in tariff programs that were designed to increase the update of rooftop solar. But when these expire solar households will be paid for the energy they send to the grid at the export tariff rate. Export tariff rates vary between states and retailers. (There is also added complexity because of a range of fixed and variable charges.) Bloomberg New Energy Finance gives an indicative range of the nominal prices (see Figure 11).

A key driver for uptake of storage will be the expiry this year of state based feed in tariffs, particularly the premium tariffs which paid solar household up to 60c/kWh for the energy they exported to the grid. These programs are expiring:

- Victoria's Transitional and Standard Net metering programs end on 31 December 2016,
- South Australia's Customer Group 4 Net metering program ends on 30 September 2016 and
- New South Wales $0.60/kWh and $0.20/kWh Solar Bonus Scheme ends on 31 December 2016[29]

[27] Parkinson, G. (2015b) 'Morgan Stanley sees 2.4m Australia homes with battery storage', *RenewEconomy*, (20 May) http://reneweconomy.com.au/2015/morgan-stanley-sees-2-4m-australia-homes-with-battery-storage-20668 Accessed 13 January 2016.

[28] Parkinson, G. (2015a) 'UBS: Tesla Powerwall can deliver 6-year payback in Australia', *RenewEconomy*, (19 May) http://reneweconomy.com.au/2015/ubs-tesla-powerwall-can-deliver-6-year-payback-in-australia-63386 Accessed 13 January 2016.

[29] Global Sustainable Energy Solutions (2015) 'Solar feed-in tariff programs end soon. So what happens next?' (9 December 2015) *One Step off the Grid* http://onestepoffthegrid.com.au/solar-feed-in-tariff-programs-end-soon-so-what-happens-next/ Accessed 14 January 2016.

**Figure 11: Nominal residential consumption and export price gap for electricity 2015**

| | Export tariff (c/kWh) | Residential consumption price (c/kWh) | Price difference |
|---|---|---|---|
| **ACT** | 8.5 | 19 | 124% |
| **NSW** | 7.7 – 12.9 | 26 | 238% |
| **NT** | 25.6 | 26 | 2% |
| **QLD** | 6.0 – 6.5 | 26 | 333% |
| **TAS** | 5.6 | 29 | 418% |
| **VIC** | 8 | 27 | 238% |
| **WA** | 7.1 – 50 | 25 | 252% |

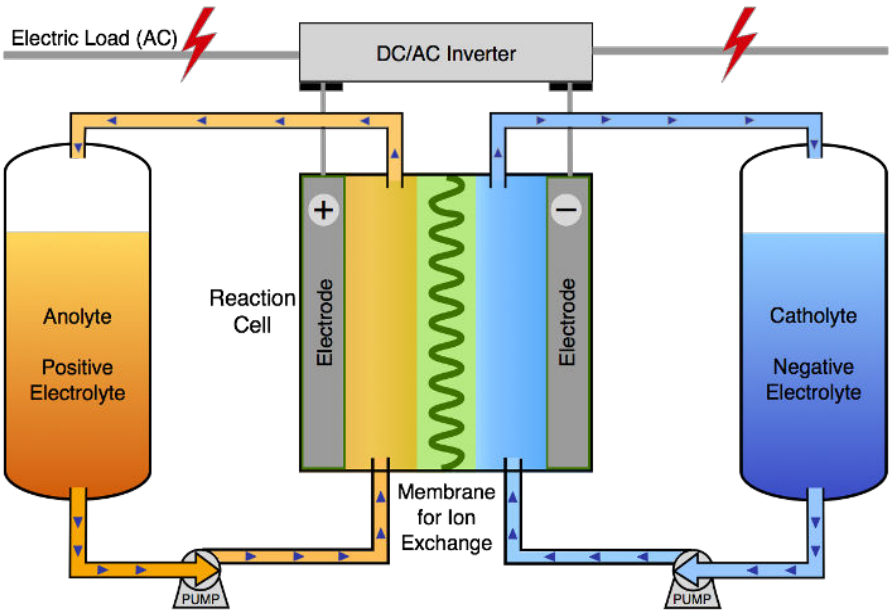
The price difference is the % maximum difference between consumption and export prices.
Source: Kobad Bhavnagri (2015), *Economics of End-user energy storage in Australia,* Bloomberg New Energy Finance: Sydney (NB: SA excluded in original data)

Lithium-ion also faces an important competitor for small-scale and also large-scale applications from flow batteries (see Figure 12). Flow batteries are a form of battery that has properties of a fuel cell, where the charge is stored in liquid form. There are competing flow battery technologies but they all consist of two electrolyte liquids which circulate in separate circuits and exchange ions, generally across a membrane.[30]

The lithium-ion battery is a 'power' battery - it is particularly suited to deliver a large burst of energy, such as when accelerating an electric car. The flow battery is an 'energy' battery, which is particularly well suited to constant input and output of energy, being fully discharged and fully charged many times per day. The Australian company Redflow has brought a flow battery to market (see Chapter 4).

[30] Energy Storage Association (2016) 'Flow batteries', http://energystorage.org/energy-storage/storage-technology-comparisons/flow-batteries Accessed 19 January 2016.

**Figure 12: Schematic diagram of a flow battery**



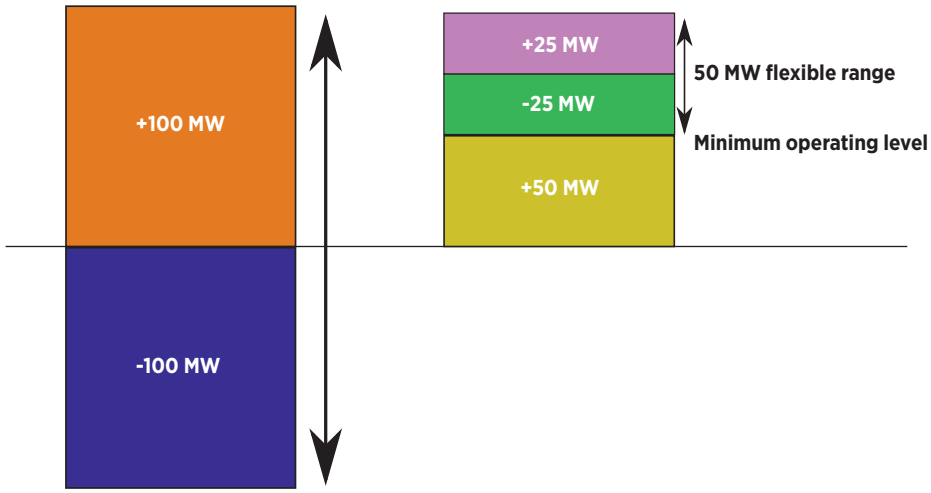

Source: Antweiler, W. "Can flow batteries solve the electricity storage problem?" Blog, University of British Columbia, September 28, 2015, http://strategy.sauder.ubc.ca/antweiler/blog.php?item=2014-09-28 Accessed 19 January 2016.

# LARGE-SCALE STORAGE

Even as we make the transition from centralised 'base load' model to a decentralised smart grid model, there will be many situations where large-scale or utility-scale storage is useful. Large-scale storage is likely be supplied by a range of technologies other than lithium-ion batteries. Large-scale, grid-tied storage addresses the market niches raised by the Lazard report quoted in Chapter 1: gas peaker replacement, network investment deferral and ancillary services such a frequency control.

One of the technical advantages of storage over any form of generation is that storage is a two way process; it can both export energy and import energy. Figure 13 gives us a hypothetical comparison between a 100 MW gas turbine and say, a battery stack, with the same nominal capacity. If a large gas turbine has an optimum operating output of 75% and a minimum operating level of 50% then its operational range is 50MW. It will be generating energy at the most efficient and cheapest rate when outputting 75MW.

**Figure 13: Flexibility comparison between 100 MW battery storage (left) versus 100MW gas turbine (right)**




Source: Kempener, R. and Borden, E. (2015) *Battery storage for renewables: Market status and technology outlook*, International Renewable Energy Agency, Abu Dhabi, p.21

The battery however, can discharge across its full 100MW range but further to that, unlike the gas turbine which can only produce energy, the battery can import energy, across a 100MW range. It therefore has a total range flexibility of 200MW, versus the 50MW of the gas turbine. This shows an important way that storage can be a superior alternative to conventional fossil fuel technologies.

At the other end of the technological and capacity spectrum from lithium batteries, more than 99% of global storage capacity is provided by a physical storage medium: water. Pumped hydro storage uses pumps to move water uphill to a reservoir. When energy is required the water is released and flows through a turbine, which generates electricity. About 200 large pumped hydro installations around the world account for about 127,000 MW of capacity.[31]

A range of electrochemical batteries are likely to be competitive for large-scale applications. Sodium sulphur batteries operate at a high temperature and are used for large-scale applications. Japan has over 190 installations, ranging in size up to the 34 MW (245MWh) system at Rokkasho which is used for multiple or 'stacked' services: smoothing output from a 51MW wind farm and providing frequency response to the network.[32]

[31] Energy Storage Council (2015), Global Energy Storage Market Overview & Regional Summary Report 2015, Energy Storage Council, Mawson ACT, p.5

[32] International Renewable Energy Agency (2015) *Case studies: battery storage*, IRENA: Abu Dhabi, p. 13

Interestingly, the manufacturer NGK Insulators bought the sodium sulphur intellectual property (IP) from Ford Motor Company in the 1960s. In 2014 NGK had 48% of the global market share of utility scale installations.[33] Ford has worked on the battery for the purpose of powering electric vehicles, which it anticipated would be a profitable market segment in the event of federal subsidies for zero emissions vehicles. In 1966 Ford claimed that its sodium sulphur powered electric cars had a number of additional advantages over petrol powered cars: faster acceleration over the first four seconds, quietness, lower potential operating cost.[34] Ford failed to stay at the forefront of electric vehicle development.

Electric vehicles (EV) are a very important development because they are pushing the development of lithium-ion battery and energy management technologies. They also provide a large base of storage batteries. When the cars are parked and these batteries are plugged in, they can provide storage for the electricity network. This could be monetised through arbitrage - buying electricity when it is cheap and selling when it is expensive.

We are also starting to see a secondary market in used EV batteries. These could be valuable for large grid-tied applications because a lithium-ion battery pack in a car will lose its value to the driver in a matter of years, because it loses its ability to provide maximum acceleration as a 'power battery'. But this battery pack is still useful as an 'energy battery', where it can provide less intense energy output, which is suitable for grid applications.

In addition to pumped hydro storage there are other physical storage processes which can be utilised for large-scale applications. Pumped heat electricity storage uses argon gas to heat crushed rock. The gas circulates between this hot store and a cold store. When energy is introduced to the system it is stored as heat and when energy is dispatched from the system, the gas cools and expands, driving a generator.

A South Australian innovation uses sand, which is obviously a relatively cheap and abundant resource, to store and dispatch heat. The system is being designed to provide a range of storage services, from small-scale to up to hundreds of megawatts,

[33] Energy Storage Council (2015), *Global Energy Storage Market Overview & Regional Summary Report 2015*, Energy Storage Council, Mawson ACT, p.7 and Kempener, R. and Borden, E. (2015) *Battery storage for renewables: Market status and technology outlook*. International Renewable Energy Agency: Abu Dhabi p.24

[34] Berman, B (2011), 'Ford's Electric Car Battery Breakthrough from 45 Years Ago', (Brad Berman · 27 October 2011), *Plugin Cars*, http://www.plugincars.com/ford%E2%80%99s-electric-car-battery-breakthrough-45-years-ago-109417.html Accessed 7 March 2016

for grid and off-grid applications, including arbitrage, renewables integration and commercial heat.[35]

Air can be used to store energy at a large-scale. It can be compressed and stored in large areas underground, including disused mines or in specially made pipes which can be installed where the energy is needed. Air can also be used to store energy in a phase change, by cooling air until it liquefies and storing this in a tank. The liquid air is brought back to its gaseous state by the warmth of ambient air or cogenerated or industrial waste heat and the resulting expansion force used to drive a turbine which generates electricity.

Flywheels use a spinning rotor, which is often made of composite materials and is machined to very precise specifications so it can spin rapidly and smoothly. It is mounted in an evacuated cylinder. It is spun to a high speed and can store energy when it is cheap and then dispatch energy by driving a generator when energy is in demand. NextDC's data centre in Melbourne uses a combination of solar panels and a flywheel in its energy management system.

Concentrating solar power is a utility scale application that focuses the heat of the sun using mirrors to superheat air, steam or molten salt. There are a range of technologies here, from the tall power towers surrounded by a massive field of tracking mirrors, to parabolic dishes that look like mirrored radio telescopes. Australia has a strong track record in this area and the Australian Renewable energy Agency and CSIRO are leading on R&D efforts.

As well as R&D, Australia is already commercialising utility scale storage. Ergon is installing twenty storage units in remote Queensland to improve reliability and defer the need to invest in network upgrades.[36] Each of the Grid Utility Support Systems (GUSS) will comprise 50 Lithium-Ion batteries and supply 100 kilowatt hours nominal capacity. These batteries are cost effective now – without subsidy. It is important to note that these will also provide 'stacked' services in addition to deferring network upgrade costs, by contributing to a higher quality service for consumers. This increases the economic value of the storage assets.

Ergon's storage units are being installed on SWER (single wire earth return) lines. These are the single wire electricity lines that are common in remote areas around the

[35] Spence, A. (2015) 'Sandy solution for renewable energy storage' *The Lead* (10 November 2015) http://www.theleadsouthaustralia.com.au/industries/research-development/sandy-solution-for-renewable-energy-storage/ Accessed 19 January 2016.

[36] Ergon Energy (2015) 'Battery technology on electricity network an Australian first' (3 July 2015) *Ergon*, https://www.ergon.com.au/about-us/news-hub/media-releases/regions/general/battery-technology-on-electricity-network-and-australian-first Accessed 14 January 2016.

world. They are very simple and relatively unstable compared to higher voltage, multi-wire networks. Ergon maintains an incredible 65,000 kilometres of SWER network, which services over 25000 properties in Queensland. Battery storage is very valuable on these sparse networks, because it is a more cost effective way of improving reliability than building bigger substations and more complex lines.

Victorian network owner Powercor announced in August 2015 that this year it will install the largest battery in Australia—a 2 MW lithium-ion unit to be deployed on its regional grid near Ballarat.[37] The battery will be used to reduce stress on the network on peak days, improve reliability, and reduce capital expenditures. Again this is economic now without subsidy.

In addition to delaying the need for network upgrades, Powercor's battery will provide additional stacked services. By increasing the supply of electricity during peak loads it should minimise brownouts and blackouts, resulting in improved quality of services to customers. It should also reduce stress on existing components, thus reducing maintenance costs for network.

The Rocky Mountain Institute is a leader in energy innovation and is working on case studies and theoretical approaches to fully exploit the economic value of 'stacked services'. This is where batteries are used to deliver multiple benefits, such as the owner 'behind the meter' and the network and these are appropriately remunerated to maximise the return on investment.[38]

Australia needs to modernise our energy markets to that owners of batteries get paid for the full value of these assets, using a stacked services methodology.

Australia has a clear role to play in the development of storage technologies at all scales. It will benefit residential consumers who install small battery units and large industrial users and the networks themselves. We can use batteries to create new industries, generate jobs and export income and help improve the performance of our electricity network, at the same times as reducing greenhouse emissions.

[37] Powercor (2015) 'Powercor installs Australia's largest battery in Ballarat South' (20 August) https://www.powercor.com.au/news-and-media/latest-news/powercor-installs-australias-largest-battery-in-ballarat-south/ Accessed 14 January 2016.

[38] Fitzgerald, Garrett, James Mandel, Jesse Morris, and Hervé Touati. (2015) *The Economics of Battery Energy Storage: How multi-use, customer-sited batteries deliver the most services and value to customers and the grid*. Rocky Mountain Institute, September 2015.

# Chapter 4: Showcase

Tesla has received the lion's share of coverage on storage for its Powerwall lithium-ion battery but there are many other developments which may be more important in the long run and some of them are being created in Australia.

## REDFLOW - A NEW BATTERY ON THE MARKET

The Australian company Redflow has commercialised a zinc bromide 'flow battery', originally developed by the University of Queensland. It is well suited for grid applications from households to utility-scale. Flow designs are characterised as an 'energy' battery to differentiate them from the lithium-ion 'power' battery used in computers and electric vehicles. Where the power battery is suited to deliver the sprint of large burst of energy, the energy battery is suited to the marathon of constant charging and discharging.

Grid-scale batteries have to be cost effective which means they should be manufactured out of relatively common materials and be intrinsically robust and require low maintenance. Flow batteries meet these criteria and have additional benefits in terms of reliability, because they can be charged and discharged fully over a large number of cycles and they can store energy in the electrolyte solutions for long periods.

While the technological principles of flow batteries are not new Redflow is leading the market with a commercially available product. Redflow is also targeting the household market, with the 10kWh Zcell.

Each standard individual Redflow battery in its main product line is a zinc bromide module (ZBM), about half the size of a fridge, weighs about 240kg and storages 11kWh. To get the storage rating up to grid-scale, 60 ZBMs are integrated into a standard 20 foot shipping container, which equates to 660kWh of storage.

Redflow says that it has more than halved nominal levelised cost of energy (LCOE) of its zinc bromide batteries, bringing it to about $US0.20c/kWh.[39]

[39] Vorrath, S. (2015) 'Redflow to offer 'plug and play' home battery storage, after cutting costs by 50%', *RenewEconomy* (26 August), http://reneweconomy.com.au/2015/redflow-to-offer-plug-and-play-home-battery-storage-after-cutting-costs-by-50-19431 Accessed 19 January 2016.

# YOUNICOS: PIONEERING GRID STORAGE SOFTWARE AND BUSINESS MODEL

Younicos is a German company which built Schwerin Battery Park, Europe's first commercial grid storage utility, in 2014. The company is technology agnostic in terms of battery hardware but has its own software for energy management and trading. Their philosophy and business model was developed in response to the rapid rise of renewable energy in Germany and the need to optimise the fluctuating production from wind and solar. They have pioneered the use of batteries to provide frequency control in grids where there is a high proportion of renewable energy.

Younicos's Schwerin Battery Park uses lithium-ion batteries and has a capacity of 5MWh, which can be upgraded to 10MWh. It includes control software and hardware, including 5 transformers, which is designed to maximise the delivery of frequency services to the grid at the same time as optimising the output and life of the

**Figure 14: Battery rack at Younicos 2.6 MW battery system on Gracioca Island**

batteries.[40] Younicos says it can respond to grid frequency fluctuations in 200 milliseconds, which is 3,000 faster than a conventional power plant.[41]

## REPOSIT: MAKING A HOUSEHOLD AN ENERGY COMPANY

Reposit is an Australian energy and information technology start-up which is leading the world in turning individual households with solar and storage into virtual energy companies. Reposit does not manufacture unique batteries or solar panels, it is essentially a software and business model innovator. The Reposit power meter and software communicates with the grid and the solar producer-consumer ('prosumer'). It sells back energy to the grid at times of high demand and high prices and credits this to the prosumer.[42]

In 2016 many Australian solar households will lose their premium feed in tariff payments. They will start to be paid very low rates for the solar energy they export. Since they already own the solar panels it will make economic sense, and emotional sense as innovators, for them to invest in storage. This investment could well be a system like Reposit's, which allows solar consumers to earn a higher price for their energy exports (see Figure 11 above).

## STEM - AGGREGATING BATTERY STORAGE CONSUMERS USING INFORMATION AND COMPUTER TECHNOLOGY

Stem is an American start-up with funding from major players in energy including the European utility RWE, Japan's Mitsui and GE Ventures. It uses behind the meter storage and new business models to create the financial value to support large battery installations at the consumer end of the grid. Like Younicos, it is relatively agnostic technologically, buying lithium-ion batteries and inverters from other providers and integrating these with its own software and control hardware.

[40] Younicos (2014) 'Schwerin Battery Park', http://www.younicos.com/download/Younicos_Reference_Project_Schwerin_US_Web.pdf Accessed 19 January 2016.

[41] Younicos (2016), 'Battery parks', http://www.younicos.com/en/solutions/battery_parks/ Accessed 19 January 2016.

[42] Reposit (2016) 'Reposit power', http://www.repositpower.com/ Accessed 19 January 2016.

The unique selling point of the Stem system is that it constantly monitors a building's energy usage for peaks in consumption and even learns about patterns of consumption and predicts future peaks. It dispatches battery energy to coincide with consumption peaks, which prevents them from causing a spike in power drawn from the grid. By preventing spikes in power imported from the grid, users can avoid demand charges that are levied in relation to the maximum spikes in demand. In California, Hawaii and New York almost half a commercial user's electricity bill can be demand charges.[43]

Stem has been commissioned by Pacific Gas & Electric and California grid operator CAISO to provide 85 MW of distributed batteries as part of a demand-response pilot project. The aim is to aggregate hundreds or thousands of individual consumer sites into a virtual peaker plant.[44]

[43] St John, J. (2015) 'Germany's RWE Leads Funding Round for Stem's Behind-the-Meter Batteries' *GTM* (13 August 2015) http://www.greentechmedia.com/articles/read/germanys-rwe-leads-30m-round-for-stems-behind-the-meter-batteries Accessed 19 January 2016.

[44] Wesoff, E. & St. John J. (2014) 'Stem Wins Big With 85MW of Energy Storage in SCE Procurement' *GTM* (5 November 2014) http://www.greentechmedia.com/articles/read/Stem-Wins-Big-With-85-MW-of-Energy-Storage-in-SCE-Procurement Accessed 19 January 2016.

# Chapter 5: Risks and opportunities

The rapid uptake of batteries is going to drive a very Australian energy revolution. It is being driven by grassroots consumer demand rather than a consistent national policy. It will gather momentum because of the vast size of our electricity network and relatively low population density, consumer self-interest, unpredictable technological innovation, environmental concern and perversely, a conservative electricity industry that is generally resisting the transition to the smart grid future that storage technologies enable. Consumers are going to turn to storage whether or not reforms to the electricity sector encourage them.

The ending of feed in tariffs in 2016 will provide incentives for solar households to be the early adopters of batteries. If solar households do embrace battery storage then this will lead to lower prices for future market segments, which are less adventurous.

Unfortunately, Australia does not yet have a framework in place that would allow storage to compete on a level playing field with coal and other conventional energy assets. Regulators are yet to acknowledge this officially, but privately they see that batteries are radical and beneficial disrupters, because they can enable genuine competition. For example, Dr Ron Ben-David, Chairperson of Victoria's Essential Services Commission, gave a speech in a personal capacity, which he provocatively titled, '*If the retail energy market is competitive then is Lara Bingle a Russian cosmonaut?*[45]

Storage presents a range of opportunities to improve electricity sector productivity and competition, which will benefit consumers, the economy and the environment. The federal government has set a target to improve Australia's energy productivity by 40% by 2030, which is supposed to delivered by the COAG Energy Council, through the National Energy Productivity Plan.

In his Forward to the Plan, Josh Frydenberg, Minister for Resources, Energy and Northern Australia, says 'New technologies, innovative services, the transition to a low

[45]Ben-David, R. (2015) 'If the retail energy market is competitive then is Lara Bingle a Russian cosmonaut?', paper written for NEM Future Forum 2015 (25 June 2015) http://www.esc.vic.gov.au/getattachment/fc947897-7d4f-4772-97c9-959e3baad0db/If-the-retail-energy-market-is-competitive-then-is.pdf Accessed 1 February 2016.

carbon economy, and changing consumer demands are all major drivers of this change.'[46]

When storage is integrated with renewable energy and smart grid technology, it allows us to integrate a very high concentration of variable renewable energy. This is the key environmental benefit of batteries and other storage technology; it will allow us to replace coal and gas with clean energy. If Australia and other wealthy countries are going to meet our obligations under the Paris climate agreement, then we are going to have to work quickly to slash emissions from our electricity and that requires the rapid growth of storage.

Much of the new clean energy generation and storage assets will be distributed across the network, right down to millions of individual solar households and businesses. This will shift us from the old centralised, one-way energy model to a distributed energy network.

Over 1.5 million households already have solar PV and it makes sense that the early adopters among them will be many of the first buyers of battery storage. The key motivation driving them is price and other consumer sentiments, such as unhappiness with energy companies (see Figure 8 above). This threatens the business model and profits of the incumbents. For example, Morgan Stanley says that the solar consumer rush to storage could cost Origin and AGL $100 million in earnings (before tax and interest) in 2020, only 4 years away.[47]

There is a risk that vested interests will have an undue influence over the reform process and even hold back consumers and others who wish to invest in storage. As the International Renewable Energy Agency (IRENA) warns 'Onerous regulatory barriers play a significant role in this market.'[48] According to economics writer Jessica Irvine, Australia's reform processes are being frustrated by a 'David and Goliath battle' fought by incumbents who profit from the old business model and use their political and policy influence to hold back the inevitable transformation to smarter, cleaner energy.[49]

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[46] COAG Energy Council (2015), *National Energy Productivity Plan*, Canberra

[47] Parkinson, G. (2015b) 'Morgan Stanley sees 2.4m Australia homes with battery storage', *RenewEconomy*, (20 May) Accessed 12 January 2016. http://reneweconomy.com.au/2015/morgan-stanley-sees-2-4m-australia-homes-with-battery-storage-20668 Accessed 13 January 2016

[48] Kempener, R. and Borden, E. (2015) *Battery storage for renewables: Market status and technology outlook*. International Renewable Energy Agency, Abu Dhabi p.2

[49] Irvine, Jessica (2015) 'David tackles Goliath in tribunal battle that will decide electricity bills', *Sydney Morning Herald*, (26 September), http://www.smh.com.au/action/printArticle?id=1000810372 Accessed 13 January 2016

A key flaw in Australia's electricity system is that network businesses and the coal and other generators make higher profits the *less efficiently* that consumers use electricity. For example, when large numbers of households install air conditioners, this puts a cost on the whole electricity network because it has to be upgraded to provide a higher flow of electricity on hot afternoons when people are cooling their houses. Networks businesses benefit because the more that their networks are 'gold plated', the higher the profits they are allowed to make. Likewise, when there are more and higher demand peaks, the price of energy in the energy market is more often at the regulated maximum, which produces windfall profits for electricity generators.[50]

This creates a significant moral hazard, in which consumers and the taxpayer are forced to pay for decisions made by energy companies, that increase waste and decrease productivity. If the federal government is serious about its 40% productivity goal, it will have to be vigorous in its efforts to reform markets and technical systems.

According to Giles Parkinson, editor of *RenewEconomy*, we are going to spend over $130 billion over the 2000-2020 period, on 'poles and wires' expenditure that locks us into the old model of centralised, high-emissions base-load generation. Parkinson calls this investment 'pure folly'.[51] Imagine how much we could achieve in the transition to a clean energy economy if $130 billion was invested in storage, smart grid and renewable technologies.

Solar consumers are not paid a fair price for the energy they export to the grid and while this will accelerate the rise of storage it also carries risks that people will 'defect' from the grid. As detailed above (in Chapter 3), residential consumers are paying vastly more for energy they import than for energy they export from their solar panels or storage batteries. In some cases a solar consumer is paying hundreds of percent more for energy they buy than energy they sell. Put another way, the energy that they generate on their roof earns them several cents per unit (kWh) and when it is sold to their neighbours, the price has mysteriously increased 400%.

This price gap may encourage some consumers to disconnect from the grid and effectively become a microgrid of one household. This is a problem for two reasons. Firstly it means that those households will have less energy security than those which remain connected to the grid. Secondly, it is a waste of a very expensive community resource - the network - and also a sub-optimal use of the privately owned asset of the

[50] This applies directly to 'merchant' sale of energy in the wholesale market, which covers a significant proportion of energy sold by most generators in the NEM.

[51] Parkinson, G. (2015c) 'Networks to spend another $50bn on Australia's dumb and dumber grid', RenewEconomy, (30 October) http://reneweconomy.com.au/2015/networks-to-spend-another-50bn-on-australias-dumb-and-dumber-grid-26649 Accessed 11 January 2016

battery and solar system. Solar battery systems are of more value integrated properly into a fair energy market, where they can support quality of supply for the benefit of the community.

Protectionism of incumbent energy will drive grid defection. Already there is talk of a 'death spiral' in the electricity industry. Jeremy Leggett details that this death spiral has wiped almost half a trillion dollars off the assets of the top twenty European energy utilities, as renewables and energy efficiency rise.[52] If a large number of households unplug from the grid, then this will force prices up for everyone who remains, which will drive more to defect, making the death spiral worse.

The central policy challenge for Australia is to allow storage and distributed renewable energy (and also energy conservation or 'demand management') to compete against business-as-usual assets, including both the coal and gas generators and also the networks themselves.

[52] Leggett, Jeremy (2016) *The winning of the carbon war*, Solar Aid, London, p.23

## CALIFORNIA'S STORAGE PLAN

California's storage industry programs offer a useful case study for Australia. The non-residential storage market in California is already 24 times bigger than all other US states combined.

California has a target of 33% renewable energy by 2020 (compared to Australia's target of around 23% by 2020) and 50% by 2030. In order to reach these goals, California has policies to rapidly accelerate the deployment of battery and other storage technologies to integrate renewables into the grid.

Firstly there is a Self-Generation Incentive Program mandate requiring the purchase of 1325 MW of storage by 2020, which is the largest such programme in America.

Secondly, there are programs to lead the development of technologies and business models. These range from venture capital stimulation through CalCEF, through to the California Energy Commission's R&D and deployment programmes, stakeholder coordination, regulatory development and public outreach work.

The Self-Generation Incentive Program was originally created to reduce peak-load demand in California, in response to the energy crisis of 2000-2001. Since 2011 it is also focused on reducing greenhouse gas emissions.

SGIP subsidises distributed generation technologies owned by customers – including storage and demand management – to offset their electricity demand. It provides incentives for clean and efficient distributed generation, currently worth US$83 million annually. The California Public Utilities Commission manages the program and funds are disbursed via the investor-owned energy utilities.

California's thriving storage sector also benefits from the Federal policies. The SunShot initiative aims to make solar with storage competitive with conventional energy by 2020. The Federal Investment Tax Credit is being reformed to include guidelines for storage to receive funding.

- ***Australia should mandate a national storage target and programmes to accelerate R&D, deployment and sector development***

Sources: Centre for Sustainable Energy (2016), 'SGIP Background' https://energycenter.org/programs/self-generation-incentive-program/background Accessed 23 March 2016; California Public Utilities Commission (2016), 'California Renewables Portfolio Standard (RPS)', http://www.cpuc.ca.gov/RPS_Homepage/ Accessed 23 March 2016; GTM Research / Energy Storage Association (2016) *U.S. Energy Storage Monitor: 2015 Year in Review Executive Summary*, Massachusetts

# Conclusion

Australia faces a combination of factors, which will drive the rapid update of battery storage. The natural drivers for storage in Australia include:

- high value solar resource
- high and rising retail electricity prices
- large number of households with solar
- ending of feed in tariff payments for solar households
- large, sparse grid

Storage will enhance energy productivity and help us meet our climate obligations following the Paris climate conference in December 2015.

If we are smart then we will get ahead of the curve and have a well-informed national conversation about how to embrace storage and the dramatic transformation to smart energy grid that its enables.

Critics of renewables have long based their concerns on the variability of solar and wind, so they should embrace storage because it provides energy security and clean energy simultaneously.

Polling by the Australia Institute has confirmed that the public is enthusiastic about the potential of battery storage and want to invest in it. This provides a great opportunity for policy makers.

Prime Minister Malcolm Turnbull has called for us to be agile and innovative. Whether or not he agrees with *The Economist* that 'the lithium-ion battery is the technology of our time', he should help us harness the rapid progress of storage technologies for his innovation agenda. We already have R&D and commercialisation efforts underway, from start-ups to large projects by established energy companies such as Ergon and Powercor.

In this 2016 election year we will see many solar households lose generous feed in tariffs and be forced to accept lower prices for the energy they generate. This is a political time bomb and all parties should harness it in the national interest, by setting out strong policies that push our transition to a smarter energy future.

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# Appendix - Polling questions

Between 29 February and 8 March 2016 The Australia Institute conducted a national opinion poll of 1412 people through Research Now, with nationally representative samples by gender, age and state or territory.

The extract below provides all the questions that were cited in this report:

[SECTION INTRO] We are now going to ask you a few questions about renewable energy.

ASK ALL, SR

Q31. Do you have a solar PV system at home (i.e. rooftop solar)?

Please select one response only

1. Yes [GO TO Q32]
2. No [SKIP TO Q33]
3. Don't know/Not sure [SKIP TO Q33]

ASK IF CODE 1 IN Q31, SR

Q32. Storage batteries are an emerging technology that allows homeowners to store electricity generated by their solar panels during the day and use it at night or during times when they are consuming a lot of electricity (e.g. running an air conditioner on a hot day).

Would you consider installing battery storage in your household?

Please select one response only

1. Yes
2. No
3. Don't know/Not sure

ASK ALL, SR

Q33. Storage batteries are an emerging technology that allows homeowners to store electricity generated by their solar panels during the day and use it at night or during

times when they are consuming a lot of electricity (e.g. running an air conditioner on a hot day).

Would you consider installing solar PV and battery storage in your household?

Please select one response only

1. Yes
2. No
3. Don't know/Not sure

ASK ALL, MR RANDOMISE

Q34. Which, if any, of the following things are important to you when considering whether to install batteries to store solar power in your home?

Please select all that apply

1. Independence from energy companies
2. Saving money on electricity bills
3. Reducing pollution from coal and gas power stations
4. Disconnecting from the grid altogether
5. Pays for itself rapidly
6. None of these

ASK ALL, SR

Q35. Over time battery storage will can pay for itself in savings on your electricity bill. If you were to install a home battery storage system, what is the longest time you would be prepared to wait for it to pay for itself?

Please select one response only

1. Less than 5 years
2. 5-7 years
3. 8-10 years
4. More than 10 years
5. Don't know/Not sure

ASK ALL, SR/ROW

Q40. Would you be more likely or less likely to vote for a party which had the following policies?

Please select one response per row

**RANDOMISE ROW CODES**

| | Much more likely | More likely | Makes no difference | Less likely | Much less likely | Don't know/not sure |
|---|---|---|---|---|---|---|
| A policy to invest in large-scale solar and wind | 1 | 2 | 3 | 4 | 5 | 99 |
| A policy to gradually transition Australia to 100% renewable energy by 2030 | 2 | | | | | |
| A policy to ensure solar is installed on every home that is suitable and on buildings like hospitals and schools | 3 | | | | | |
| A policy that accelerates the uptake of electric vehicles | 4 | | | | | |
| A policy that helps solar consumers get battery storage so the power they generate can be used around the clock | 5 | | | | | |