CLIMATE CAPITAL
rebalancing nature and humanity

Australian energy storage market assessment

Opportunities in the emerging domestic energy storage market place

2016

Contents

2. Executive summary 1

3. Defining the market 3

3.1 Australian Energy market 3
3.1.1 Supply side 4
3.1.2 Demand side 5
3.2 Energy storage market definition and scope 9
3.3 Customer identification 9
3.3.1 Supply side applications for energy storage 9
3.3.2 Supply side barriers to entry 11
3.3.3 Supply side market opportunities 12
3.3.4 Demand side applications for energy storage 12
3.3.5 Demand side barriers to entry 15
3.3.6 Demand side market opportunities 17
3.3.7 Off-grid applications 18
3.4 Market sizing 21
3.4.1 Supply side market sizing 23
3.4.2 Demand side market sizing 24
3.5 Market penetration uncertainties 25

Tables

TABLE 1 Addressable storage market assessment summary Data (MW) 2
TABLE 2 Australian electricity market total generation capacity 3
TABLE 3 Supply side storage applications 10
TABLE 4 Demand side applications for energy storage 14
TABLE 5 Off-grid user profiles 18
TABLE 6 Distribution of demand from the off-grid sectors 19
TABLE 7 Off-grid opportunities for energy storage 21
TABLE 8 Australian Supply-side total market size (MW) 23
TABLE 9 Capacity of off-grid distribution by fuel type 25
TABLE 10 Australian off-grid total market size (2016) 25

Figures

FIGURE 1 Energy Supply Chain 1
FIGURE 2 Addressable storage market assessment summary (MW) 2
FIGURE 3 Australian Electricity Markets 3
FIGURE 4 Energy Supply Chain 4
FIGURE 5 Peak Demand Periods increasing against lower energy consumption 6
FIGURE 6 NEM price duration curve post-carbon tax 6
FIGURE 7 Californian Net System Load as at 31 March 2015 7
FIGURE 8 Price impact Of High Renewable Penetration on QLD and SA networks 7
FIGURE 9 Average Market Spot Prices Above $300/MW across NEM networks 8
FIGURE 10 Average $300/MWh cap futures contract prices ($/MWh) 8
FIGURE 11 Solar and storage network regulation barriers 17
FIGURE 12 Off-grid generation in Australia 19
FIGURE 13 Australia's installed Storage Capacity FY2016 22
FIGURE 14 Energy storage Annual Instalation forecast by customer segment 23
FIGURE 15 Demand-side on-grid market size estimate 24

Glossary

Term	Definition
AC	Alternating Current
AEMO	Australian Energy Market Operator
AER	Australian Energy Regulator
ARENA	Australian Renewable Energy Agency
CCGT	Combined Cycle Gas Turbine
CEC	Clean Energy Council
CSO	Community Service Obligation
DC	Direct Current
DNSP	Distribution Network Service Provider
EDL	Energy Developments ltd
ESCRI-SA	Energy Storage for Commercial Renewable Integration. South Australia
ESD	Energy Storage Device
FCAS	Frequency Control Ancillary Services
GTM	Greentech Media
GUSS	Grid Utility Support System
GW	Gigawatt
GWh	Gigawatt hour
HVDC	High Voltage Direct Current
I-NTEM	Interim-Northern Territory Energy Market
IPP	Independent Power Producer
IRR	Internal Rate of Return
KW	Kilowatt
KWh	Kilowatt hour
LCOE	Levelised Cost of Electricity
LMP	Locational Marginal Price
LNG	Liquefied Natural Gas
MW	Megawatt
MWh	Megawatt hour
NCAS	Network Control Ancillary Services
NEM	National Electricity Market
NEO	National Energy Objective
NPV	Net Present Value
NSP	Network Service Provider
NT	Northern Territory
O&M	Operations and Maintenance
PPA	Power Purchase Agreement
PV	Photovoltaic, Solar
QLD	Queensland
SA	South Australia
SME	Small-to-Medium Enterprise
SRAS	System Restart Ancillary Services
SWIS	South West Interconnected System
SWOT	Strength Weakness Opportunity Threat analysis
TESS	Thermal Energy Storage Solution developed by CCT
TNSP	Transmission Network Service Provider
TWh	Terawatt hours
UK	United Kingdom
WA	Western Australia
WEM	Western Australian Energy Market

2. Executive summary

Australia's energy storage technology has applications across the energy supply chain. The energy supply chain can be broken down into the supply side and demand side, with sub categories of generation and transmission in the supply side and distribution, retail and customer in the demand side. There are also a range of customer-demand off-grid applications for energy storage that are worth considering such as transport, island (remote) grids and commercial users.

FIGURE 1 **ENERGY SUPPLY CHAIN**

Supply side		Demand side		
Generation	Transmission	Distribution	Retail	Customer

It is widely accepted that the further down the energy supply chain storage technology can be deployed, the greater the economic value to the energy user.

Supply-side applications of energy storage focus on network regulation and ancillary services which support power quality across the energy networks. These centre on reducing intermittency, increasing supply reliability and increasing generation flexibility through frequency regulation or localised voltage regulation (at the generation source). Supply side energy storage applications also include backup power applications at customer and local levels and can be used to assist with grid black-start capability[1]. The storage requirement to address these events is rapid (i.e. instantaneous) and requires high energy density solutions.

Barriers to entry for supply-side applications are high and complex, consisting of regulatory hurdles for generators and retailers, lack of a standardised assessment framework for storage technologies and a fleet of existing and mature alternatives which represent multi-billion dollar investments.

Despite these barriers, there exists opportunities for storage technologies to be deployed to facilitate the integration of renewables into Australia's broader energy generation mix, and to participate in pricing arbitrage events.

Demand-side applications refer to customer-applications for energy storage. As a result of a number of supportive legislative structures (feed-in tariffs), rooftop solar uptake has been widespread over the five years to 2016 in both the residential and commercial sectors. However, as these supportive legislative regimes reach their sunset, there is a growing impetus placed on solar systems integrators to secure the economic benefit for their customers. This has resulted in the widespread aggregation of a range of residential-scale storage technologies across top and mid-tier integrators.

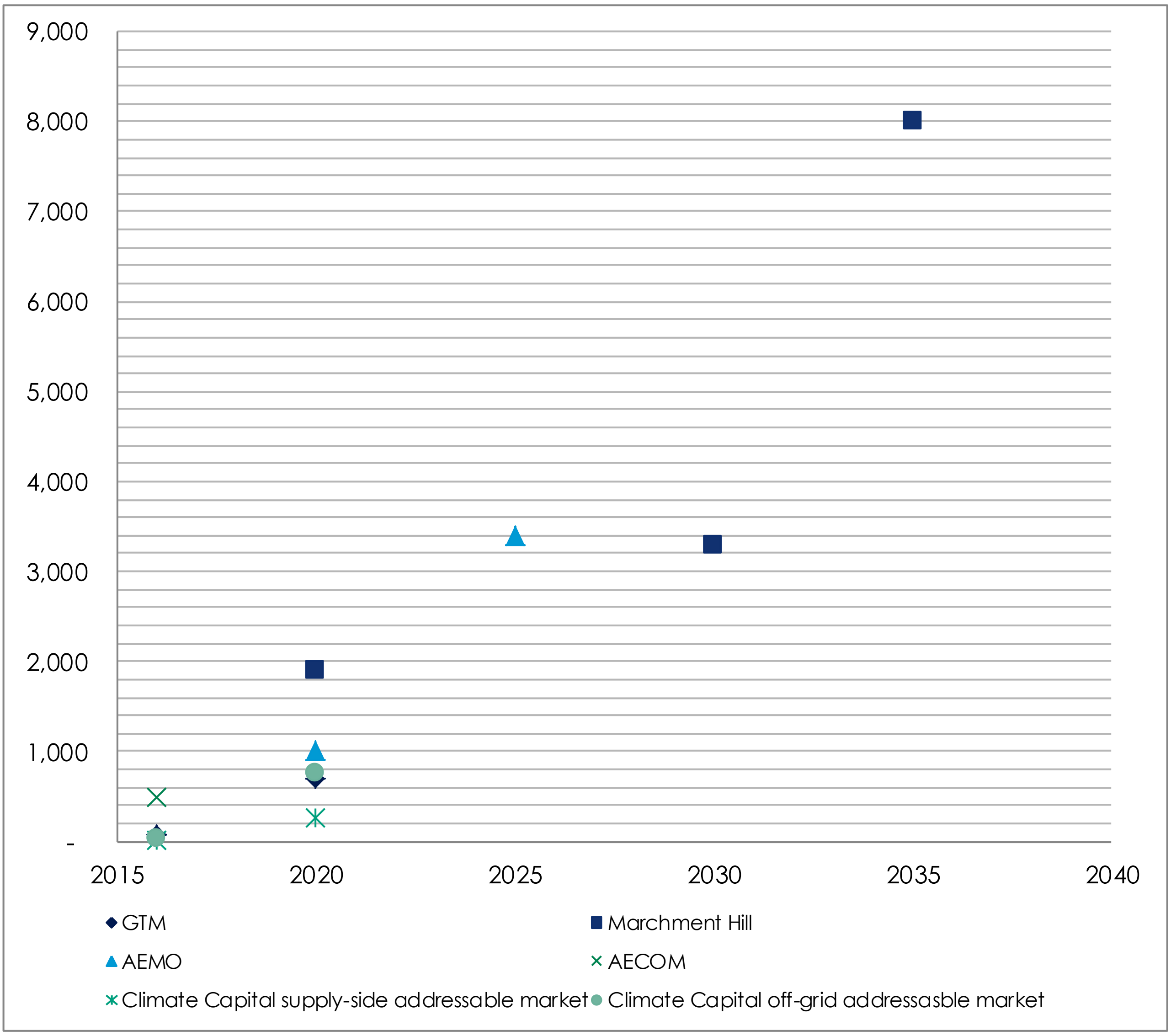
Off-grid applications in remote communities and microgrids present the largest opportunity for energy storage technology due to the extremely low population densities, diseconomies of scale and high energy demand.

Despite only accounting for 2% of Australia's population, remote and island grids account for more than 7% of Australia's annual energy consumption – approximately 15,000GWh per annum.

A number of studies have been undertaken by various industry bodies and stakeholders in attempts to quantify Australia's energy storage market. To perform our own independent assessment of these markets, we have drawn on these reports as well as our analysis of supply and demand-side energy usage, generation capacity, barriers to entry and opportunities. FIGURE 2 below summarises Climate Capital's assessment of addressable markets by storage capacity (MW).

[1] Black-start process refers to the restoration of a generation plant without relying on electricity provided from the external transmission network.

FIGURE 2 **ADDRESSABLE STORAGE MARKET ASSESSMENT SUMMARY (MW)**



Source: Climate Capital analysis

TABLE 1 **ADDRESSABLE STORAGE MARKET ASSESSMENT SUMMARY DATA (MW)**

	2016	2020	2025	2030	2035
GTM	75	703	n/a	n/a	n/a
Marchment Hill	n/a	1,900	n/a	3,300	8,000
AEMO	n/a	1,000	3,400	n/a	n/a
AECOM	500	n/a	n/a	n/a	n/a
Climate Capital supply-side addressable market	**15**	**268**	**n/a**	**n/a**	**n/a**
Climate Capital off-grid addressasble market	**25**	**767**	**n/a**	**n/a**	**n/a**
Mean	**154**	**928**	**n/a**	**n/a**	**n/a**
Median	**50**	**767**	**n/a**	**n/a**	**n/a**

Source: Climate Capital analysis

3. Defining the market

3.1 Australian Energy market

Australia's electricity markets are characterised by geographically vast transmission and distribution networks connecting generators and customers. Australia has three electricity networks: the National Electricity Market ["NEM"], the Western Australian Energy Market ["WEM"] and the Interim-Northern Territory Energy Market ["I-NTEM"].

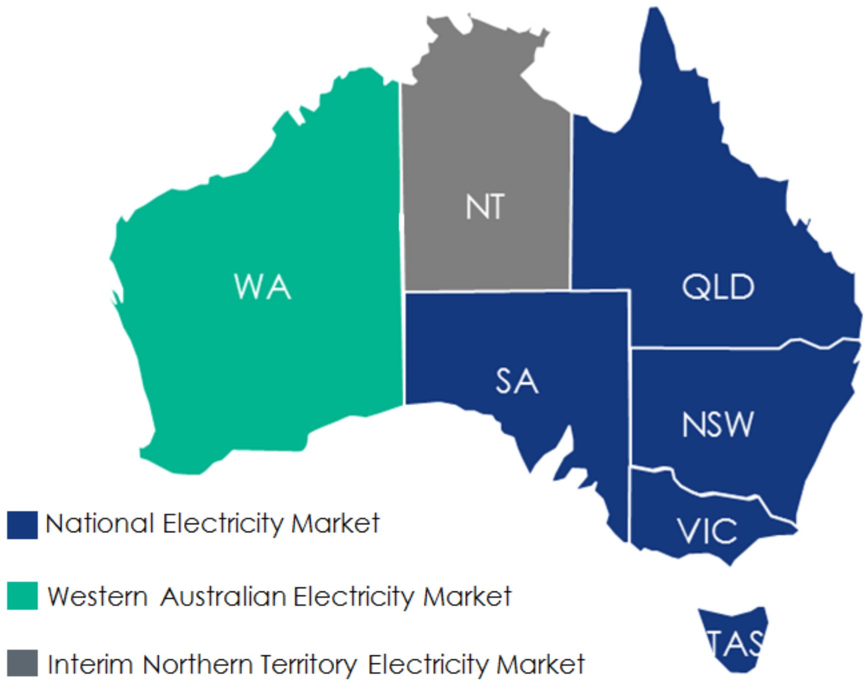
TABLE 2 **AUSTRALIAN ELECTRICITY MARKET TOTAL GENERATION CAPACITY**

Network	Capacity (MW)
National Electricity Market	47,641
Western Australia Electricity Market	6,547
Northern Territory Electricity Market^	600
Total generation capacity	**54,788**

Source: AER 2016, Western Australia Department of Finance 2016, Territory Generation 2016

^estimate

FIGURE 3 **AUSTRALIAN ELECTRICITY MARKETS**



The five years to 2015 has been characterised by softening demand as a result of:

- Customer demand management practices, including in response to the price signal of significant increases in network charges;
- Milder weather patterns; and
- Major industrial users exiting from the Australian market.

The result of downward price pressure has been the decommissioning of over 4,000MW of fossil fuel generators across the NEM in 2015. Decommissioning and mothballing will outstrip new generation over the next decade, which will alleviate the oversupply that has been present for several years across the NEM.

Renewables account for approximately 11% of generation capacity with the highest concentration of renewable generation (excluding hydroelectricity) in South Australia ["SA"] (40%). The penetration of solar photovoltaic ["PV"] is around 40% of residential customers in SA.

Increased volatility in electricity prices due to renewable generation and interconnector capacity constraints provide a glimpse into the future for increasingly renewable-integrated grids and highlights the opportunity for storage.

The energy storage market has applications across the energy supply chain. There are also a range of customer-demand off-grid applications for energy storage that are worth considering such as transport, island (remote) grids and commercial users.

FIGURE 4 **ENERGY SUPPLY CHAIN**

Supply side		Demand side		
Generation	Transmission	Distribution	Retail	Customer

The relatively simple supply side-demand side dynamic sometimes breaks down in the Australian market — as in the UK — where the respective risk profiles of generator (exposed to downside price risks and lower volatility) and retailers (exposed to upside price risks and higher volatility) have led to vertical integration of generators and retailers. These drivers are reinforced by the prudential capital requirements of operating in the NEM.

The trend to vertical integration is strongest amongst the larger (top tier) market participants. In Australia, these include AGL, Origin Energy and EnergyAustralia. However, each business has some degree of mismatch, leaving residual market exposures to be managed. Several second and third tier retailers are also active in the market, but do not have the capital to invest in internally-owned generation.

In the next section we will discuss key supply side and demand side issues in Australia's energy supply chain that creates opportunities for energy storage applications.

3.1.1 Supply side

The supply side of the energy value chain typically has highest voltage on the network and Includes large scale (MW) generation stations, transmission lines, transmission substations and transmission connected (high energy intensity/usage) customers.

As shown in TABLE 2 above, total national generation capacity is estimated to be in excess of 54GW and is serviced by a mix of fossil and renewable generation technologies. Renewables account for less than 11% of total generation (excluding Tasmania's hydroelectric generation capacity), but the proportion of renewables is growing.

Integral to the smooth operation of the energy supply system is the provision of ancillary services. In Australia, AEMO uses ancillary services across the network to manage the power system safely, securely and reliably. These services maintain key technical characteristics of the system, including standards for energy frequency, voltage, network loading and system restart processes. AEMO operates 8 separate markets for the delivery of frequency control ancillary services ["FCAS"], focusing on different time horizons up to 5 minutes, and purchases network control ancillary services ["NCAS"] and system restart ancillary services ["SRAS"] under agreements with service providers.

FCAS providers bid their services into the FCAS markets in a similar manner to generators bidding into the energy market. Payments for ancillary services include payments for availability and for the delivery of the services.

Synchronous generators currently provide nearly all of the ancillary services required including system inertia and frequency control and contribute significantly to maintaining system fault levels and system voltage control. Without additional storage devices, including flywheels, wind and solar PV plant cannot currently provide such system ancillary services at the levels required given their inherent variability. As the level of renewable energy generators increases and as more synchronous generators are retired, there is the potential for very low levels of synchronous generation to be on-line, resulting in a large scale systems outages unless alternative solutions, such as energy storage, are integrated.

A study by AEMO and Electranet in 2014 [the "Study"] has indicated that there may be a risk that system outages could occur in South Australia. South Australia is connected to Victoria through two high voltage interconnectors, being the twin circuit alternating current ["AC"] connection via Heywood, and the Murraylink high voltage direct current ["HVDC"] link. It should be noted that the Heywood Interconnector's nominal transfer capacity is planned to be increased by 190 MW in 2016; however constraints will still exist at times in the transmission network between Para and South East terminal stations. With low or zero synchronous generation on-line the Study showed a number of potential scenarios involving the Heywood interconnector that may lead to significant load and/or generator shedding; or even a state-wide power outage. While presently the complete disconnection of the Heywood interconnector while in operation is considered a non-credible contingency, the Study recommended a range of prudent actions, including a better understanding the role of rooftop PV and the inertia in spinning wind turbines in such circumstances to ensure that system security can be maintained.

In addition to the issue of synchronous generation, there have been a number of high FCAS pricing events in South Australia at times when there is a credible risk of separation from the NEM, as noted in the most recent update to the Electricity Statement of Opportunities published by AEMO, which indicates that this situation is likely to deteriorate unless new solutions emerge. Extreme peak pricing events are an increasing issue across most energy supply chains, as discussed in the next section.

3.1.2 Demand side

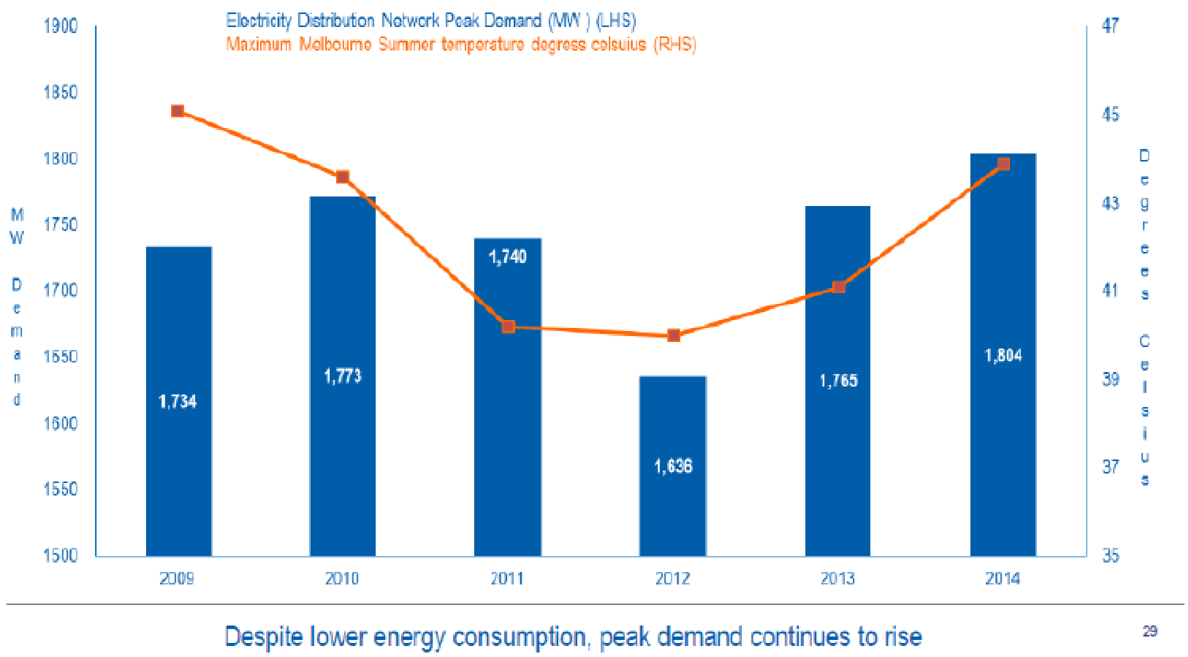
The demand side of the supply chain consists of distribution, retailers and customers.

Distribution

Energy distributors are the owners of the distribution infrastructure including electricity powerlines, poles and associated infrastructure that carry electricity to customers. Distribution infrastructure upgrades are typically driven by peak demand events that occur only a few times per year. These market peaks would have less impact if they were reasonably predictable in number and/or timing. However, market volatility is rising in the NEM, partly due to increasing penetration of renewables. This is common to most mature and well-functioning energy markets.

FIGURE 5 below highlights this phenomenon, showing the increasing peak demand periods across the NEM against declining total energy consumption. The peak demand phenomenon is discussed in more detail in the retailer and supplier section.

FIGURE 5 **PEAK DEMAND PERIODS INCREASING AGAINST LOWER ENERGY CONSUMPTION**



SOURCES: SP AusNet

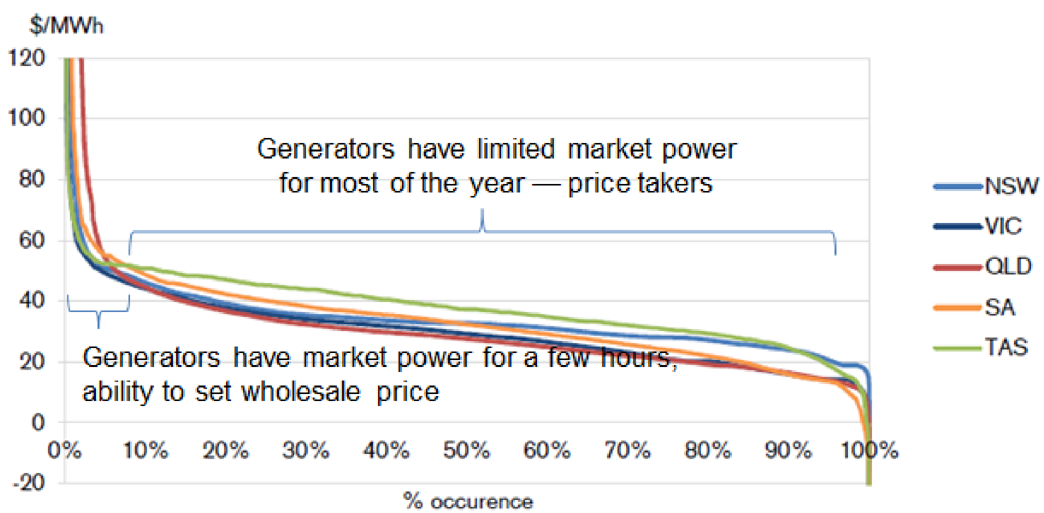
Increasing peak demand events put pressure on distribution businesses to increase major distribution infrastructure investment in order to meet these events. By using incremental amounts of energy storage at specific congestion points around a distribution network for momentary peak events, distribution businesses may be able to defer large capex investment or deploy capital elsewhere.

Retailer and Customer

In many respects, the interests of the customer and retailer are aligned, as the retailer effectively manages a portfolio of energy risk management products on behalf of the customer, and provides billing and customer services for that customer. The basic risk faced by retailers and customers is high energy prices.

A key risk for retailers and customers is peak pricing. As shown in FIGURE 6 below, generators generally have limited market power. However, for short periods, extreme price events can occur, such as when there are transmission constraints or demand is at risk of exceeding supply.

FIGURE 6 **NEM PRICE DURATION CURVE POST-CARBON TAX**

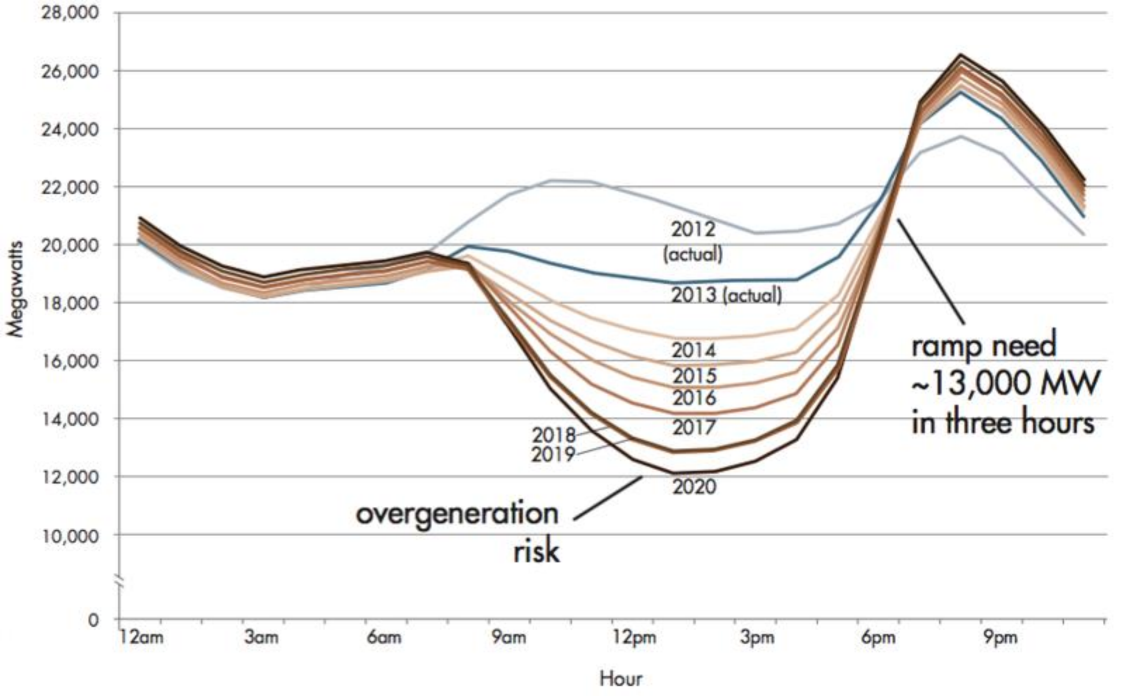


Source: AEMO, Credit Suisse estimates

The few market peaks would have less impact if they were reasonably predictable in number and/or timing. However, market volatility is rising in the NEM, partly due to increasing penetration of renewables. This is common to most mature and well-functioning energy markets.

High penetration of solar power depresses the level of demand that must be supplied by other generators during the day, while increasing the speed at which other generation must ramp up to meet late afternoon/early evening peaks. This is known as the "duck curve", and is demonstrated by the impact of solar in California, shown in FIGURE 7 below.

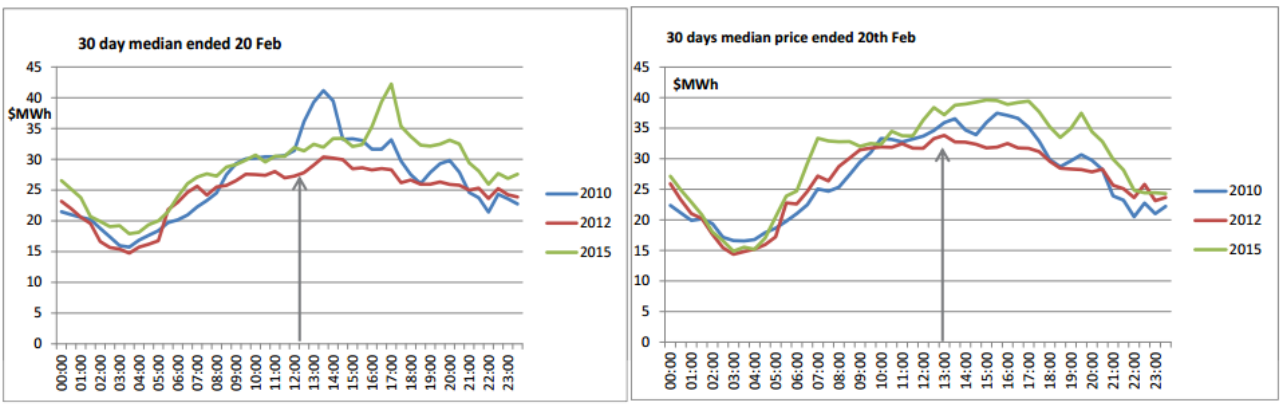
FIGURE 7 **CALIFORNIAN NET SYSTEM LOAD AS AT 31 MARCH 2015**



Source: CAISO

In Australia, there is emerging evidence that this is having a price impact in some NEM regions, particularly Queensland, which also has a high degree of solar PV penetration.

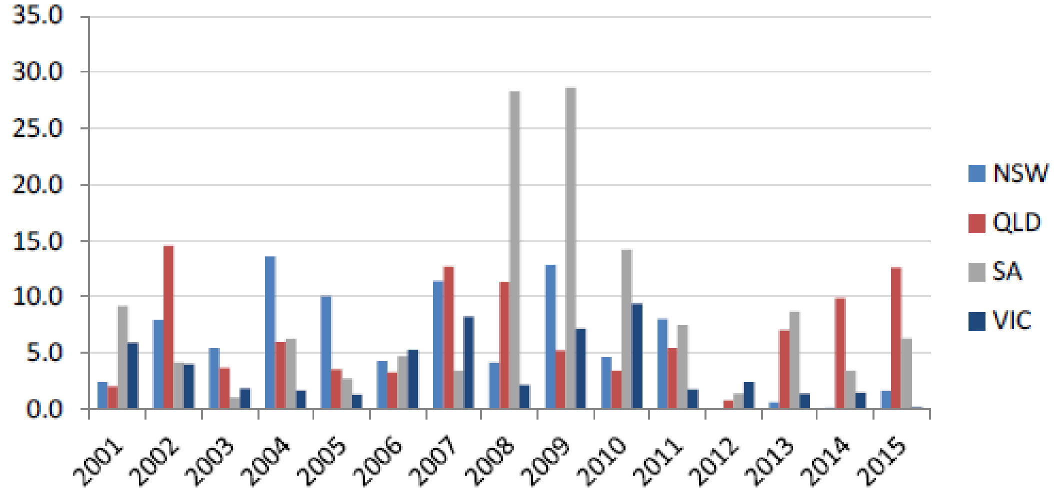
FIGURE 8 **PRICE IMPACT OF HIGH RENEWABLE PENETRATION ON QLD AND SA NETWORKS**



Source: NEM Review

The increasing market volatility is shown in FIGURE 9 below:

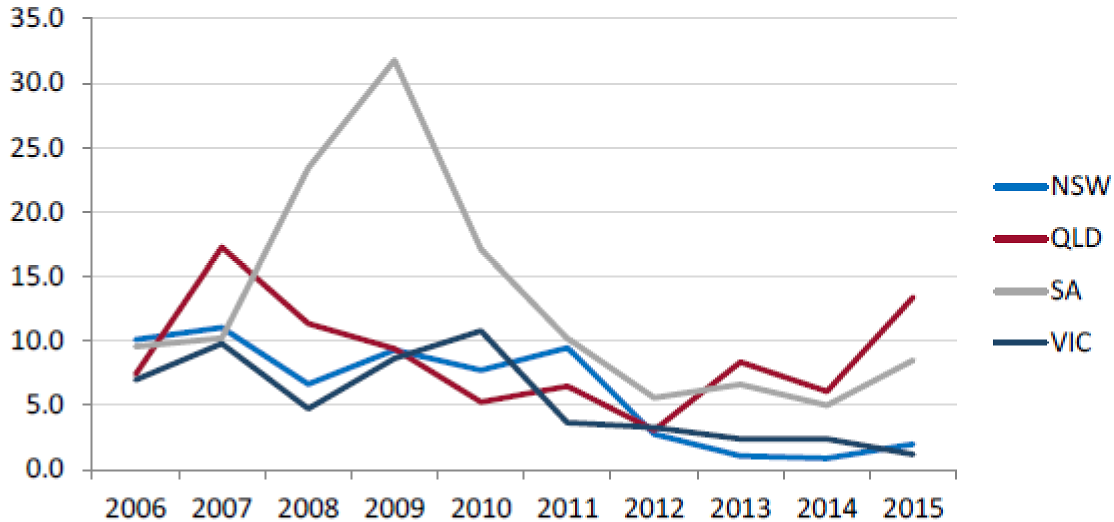
FIGURE 9 **AVERAGE MARKET SPOT PRICES ABOVE $300/MW ACROSS NEM NETWORKS**



Source: AEMO, Credit Suisse estimates

The price of cap contracts has risen in SA and Queensland in recent years, in line with the increasing spot price volatility.

FIGURE 10 **AVERAGE $300/MWH CAP FUTURES CONTRACT PRICES ($/MWH)**



Source: Bloomberg, LLP

Retailers generally are not fully hedged against these price events, as it this would mean they are over-contracted or pay contract premia that make them uncompetitive in the market. Accordingly, they utilise a portfolio that includes:

- financial risk management products, especially cap contracts and futures, which only come into effect when the spot price exceeds a nominated level;
- internally-owned open-cycle gas turbine generation; and
- Demand-side management contracts across several customers.

Few commercial and industrial customers have the detailed understanding of energy market dynamics to manage any spot market risks, even though their overall energy costs are higher as a result of transferring this risk to retailers.

The customers that are willing to take spot market risks often have capacity to manage this risk through behind-the-meter generation (including diesel or cogeneration) or operating flexibility to reduce energy consumption for short periods in response to price signals, which is known as demand-side management (or demand-side response).

Whether a customer manages extreme price risks through a retailer, which in turn uses the financial contract market, or through on-site generation and energy management, it requires a capacity solution given the short periods involved.

Aside from peak pricing, another risk for retailers and customers that retain a wholesale price exposure, is uplift in average prices, which could be driven by medium term tightness in the supply side and higher input costs. This phenomenon has been amplified by increasing volatility in input commodity prices.

3.2 Energy storage market definition and scope

Energy storage is set to change the face of the Australian electricity market over the next five years. Storage technologies have the ability to solve a range of problems faced by generators, networks and customers including:

- Smoothing intermittency of renewables;
- Providing quality support;
- Managing peak demand; and
- Reducing customer's cost of electricity through demand augmentation.

The energy storage market as a whole is in its infancy and is characterised by a range of technologies and new entrants seeking to capitalise on first-to-market advantage. Mature technologies in the space including lead-acid and pumped hydro have proven success in some applications and remain incumbent in those applications. However, they have limited further applications due to their underlying technology.

Continued advances across a range of storage technologies points to 2016 as being the tipping point for residential storage take-up domestically, with commercial and utility scale storage following soon thereafter. The total market opportunity for energy storage technologies (before considering stacked applications) is estimated to be as much as $500 million by 2020.

The range of supply and demand-side applications, as well as 'stacked' applications presents a significant revenue opportunity for participants in the storage market who can demonstrate technologies which are:

- scalable;
- reliable; and
- at a price point at or below the long-run marginal cost of fossil fuel generation.

Energy storage technologies have primary and secondary applications across every level of the energy supply chain, as well as off grid applications.

3.3 Customer identification

3.3.1 Supply side applications for energy storage

Supply-side applications of energy storage focus on network regulation and ancillary services which support power quality across the energy networks. These centre on reducing intermittency, increasing supply reliability and increasing generation flexibility through frequency regulation or localised voltage regulation (at the generation source). Supply side energy storage applications also include backup power applications at customer and local levels and can be used to assist with grid black-start capability[2]. The storage requirement to address these events is rapid (i.e. instantaneous) and requires high energy density solutions.

[2] Black-start process refers to the restoration of a generation plant without relying on electricity provided from the external transmission network.

While existing conventional alternatives exist to address these issues, they are not without significant challenges, including:

- Transmission and distribution network's reduced capital investment expenditure as determined by the relevant regulator;
- Variability in underlying gas and diesel commodity prices; and
- The difficulty in shifting solar generation periods to better facilitate PV integration into grid networks.

The table below lists the potential applications and opportunities for storage technology in the supply-side of the energy supply chain, as well as existing conventional alternatives.

TABLE 3 **SUPPLY SIDE STORAGE APPLICATIONS**

Application	Description	Existing alternatives
Black Start	In the event of a grid outage, black start generation assets are needed to restore operation to larger power stations in order to bring the regional grid back online	Gas turbines Diesel engines Industrial lead acid battery
Distribution services	Energy storage systems installed at substations to provide responsive peaking capacity, reducing instability	Distribution system upgrade Gas turbine
Energy Arbitrage	The purchase of wholesale electricity while the locational marginal price (LMP) of energy is low (typically during nighttime hours) and sale of electricity back to the wholesale market when LMPs are highest	Gas turbines
Frequency Regulation	Frequency regulation is the immediate and automatic response of power to a change in locally sensed system frequency to ensure that system-wide generation is perfectly matched with system-level load	Gas turbines
Peaker replacement	Large-scale energy storage designed to replace gas turbine peaker plants	Gas turbines Diesel engines
PV integration	Energy storage systems designed to reduce intermittency associated with solar PV generation	Gas turbine Diesel engines Shifting of solar generation profile
Spin/Non-Spin Reserves	Spinning reserve is the generation capacity that is online and able to serve load immediately in response to an unexpected contingency event, such as an unplanned generation outage	Gas turbines
Transmission system	Large-scale energy storage to improve transmission grid performance and facilitate integration of large-scale renewables	Transmission line upgrade Gas turbines
Voltage Support	Voltage regulation ensures reliable and continuous electricity flow across the power grid.	Gas turbines

Source: Lazard, RMI and Climate Capital

3.3.2 Supply side barriers to entry

Regulation

The services described in TABLE 3 above are provided by network generation and transmission businesses.

Rules regarding their operations are subject to a high level of regulation by the Australian Energy Regulator ["AER"]. Currently, economic regulations are focused on services provided rather than the regulation of specific assets. A key component includes of this service-based regulation includes the NEM 30MW dispatch hurdle for the described services.

Regulation is focused on regulating a network business's maximum revenue to ensure that it is consistent with the National Electricity Objective ["NEO"]. There are specific rules that the AER must apply in evaluating a network business's capex and opex forecasts as part of the regulated revenue calculations.

A combination of complex regulations, opaque rules and discriminatory tariff structures present barriers to entry for energy storage (and other distributed generation) technologies in supply-side applications.

Standardised storage technology benchmark

Currently, Australia is at the early stage of standards of code development for energy storage systems, with the current focus on grid connection (AS4777) but with lesser focus on the design, installation, testing, maintenance or safe housing of battery systems. This represents a significant barrier for the safe, reliable and repeatable installation of battery systems which are currently entering the market.

Establishment of installation and battery housing standards is a very important precursor to the widespread uptake of battery energy storage systems by end-users. It is required to ensure that minimum safety requirements are established prior to any large-scale rollout of battery systems; however it is also important to ensure standards are well thought through so they do not impede innovation. Recently, the Clean Energy Council has received funding from the Australian Renewable Energy Agency ["ARENA"] to investigate and develop battery storage installation safety guidelines with Standards Australia. The aim is to assist in delivery of clear and well-designed installation standards which, when combined with effective training and accreditation of battery installers, is essential for maintaining safety, consumer confidence and the integrity of the industry.

The Clean Energy Council ["CEC"] also has scope to focus on battery materials, system design, installation procedures, operation and maintenance, disposal and recycling.

While this may seem like a trivial barrier in the sense that a stakeholder could undertake their own independent analysis to determine the most applicable technology; standard appraisal can be linked to mainstream acceptance and adoption of storage technologies in the energy supply chain. Until such time, adoption will be limited and occur amongst first movers and early adapters.

Existing mature alternatives

Of the applications identified in TABLE 3 above, a number of the services described primarily relating to frequency and voltage support and, importantly, peaking supply, are currently provided by Australia's existing combined cycle gas turbine ["CCGT"] fleet.

Australia's CCGT fleet generation capacity is estimated to account for approximately 20% of total registered capacity, or 8,933MW, across the NEM in FY2015[3] and represent multi-billion dollar

[3] State of the Energy Market 2015, AER

investments for owners. In addition, gas commodity prices have been subdued in recent years due to a broader market oversupply, thus reducing the operating cost of these plants.

These, and similar existing mature alternatives with long operating lives and that represent major capital commitments present a significant barrier to energy for storage achieving market share in the applications described in TABLE 3 above.

3.3.3 Supply side market opportunities

In light of the barriers to entry we have identified in 3.3.2 above, we consider the following storage applications to be near-term opportunities for utility scale storage solutions which face the least amount of obstruction from the aforementioned barriers:

1. Renewable energy integration; and
2. Energy arbitrage.

We consider these to be the most compelling opportunities for utility-scale energy storage on the basis that the key driver for installation is purely economic. In the case of renewable energy integration, the use of energy storage would increase the amount of energy available for dispatch, by avoiding wind or solar spilling, and thus increase the generation asset's yield. In the case of energy arbitrage, the use of energy storage allows market participants to take advantage of price events.

The opportunistic characteristics of these applications may encourage supply-side stakeholders to behave in a more entrepreneurial manner to realise these up-side revenue opportunities and thus remove (or reduce the friction) of the aforementioned supply-side barriers to entry.

Partnerships with supply-side stakeholders assist in reducing actual or perceived risks in integrating utility-scale energy storage, as demonstrated by Hydro Tasmania at their King Island Renewable Integration Program. The project integrated flywheel and battery storage technologies along with a range of other renewable and dynamic load control technologies. The project was eligible for ARENA grant funding and the successful pilot program has resulted in Hydro Tasmania rolling out similar projects involving flywheel storage technology in Flinders Island (Tasmania), Rottness Island (Western Australia), and feasibility studies at Coober Pedy with Energy Development Limited (Western Australia)[4].

3.3.4 Demand side applications for energy storage

Distribution business applications

As discussed in section 3.1.2 above, the key value-add of energy storage technologies for distribution businesses is through the deferral of major distribution infrastructure investment which is driven by peak demand events. By using incremental amounts of energy storage at specific congestion points around a distribution network for momentary peak events, distribution businesses are able to defer large capex investment or deploy capital elsewhere.

In addition to investment deferral for distribution networks, energy storage can be deployed in between transmission and distribution networks to provide congestion relief to congested transmission corridors during certain periods in the day. By deploying such technologies downstream of congested networks, it allows networks the ability to maintain power quality to customers.

Retail and customer applications

Residential and industrial customer's increasing independence from traditional electricity markets is presenting energy storage technologies with a considerable opportunity. Approximately 1.5 million Australian's now generate their own electricity from PV solar panels. Storing this energy is the next step in independence from traditional transmission and distribution networks. Australia's many

[4] World Leading Technology Power Flinders Island, Hydro Tasmania, 4 March 2015

remote communities and industries rely heavily on expensive and emission-intensive diesel generators. The marriage of storage in these locations has considerable advantages in securitising energy supply at economic levels.

Energy storage also provides opportunities for retailers or customers to manage peak pricing risks by:

- shifting consumption (allowing for net efficiency losses) patterns within the day;
- providing opportunities to store energy from lower price periods and sell into higher price periods; and/or
- increasing the amount of behind-the-meter generation that is consumed on-site rather than exported to the grid.

These energy services are related, as the respective intra-day cycles will overlap. While the latter offers potentially greater rewards, it is more complex, incurs additional network charges and requires finely-tuned software interfaces to optimise the cycles and market dispatch, such as Reposit's solution for residential customers.

A key application, which also overlaps with energy services, is reducing the cost embedded in maximum demand tariffs/maximum demand charge. This charge is backward-looking, and reflects the highest level of energy drawn from the distribution network in a 12 month period. Accordingly, utilising energy storage behind-the-meter can reduce both network charges and energy costs.

With commercial-scale storage, the customer also has options such as taking some spot market exposure — thus avoiding the implied contract and risk management premium paid to retailers — or flexibility to manage variability in on-site energy consumption without drawing on the grid.

Realistically, the end use customer is more likely to be interested in these energy solutions, given the customisation required for individual sites and the scale of fleet required to be material in a retail portfolio. In contrast, the largely ubiquitous nature of solar PV units and emerging Li-on battery technologies makes them more attractive to retailers that can also offer value-added services such as financing off existing customer management platforms.

TABLE 4 below lists the potential applications for storage technology, as well as existing conventional alternatives.

TABLE 4 **DEMAND SIDE APPLICATIONS FOR ENERGY STORAGE**

Application	Description	Existing alternatives
Commercial and industrial	Energy storage systems designed to provide peak shaving to reduce energy costs	Gas turbines Diesel engines Demand profile alteration Utility service upgrades
Commercial appliance	Energy storage systems designed to provide peak shaving to reduce energy costs	Gas turbines Diesel engines Demand profile alteration
Distribution capex deferral	Delaying, reducing the size of, or entirely avoiding utility investments in distribution system upgrades necessary to meet projected load growth on specific regions of the grid	Demand management Substation and distribution upgrade
Island grid	Energy storage systems used to enhance the stability and efficiency of island grids focusing on reliability, diversification and/or cost reduction	Gas turbines Diesel engines Demand profile alteration
Microgrid	Energy storage systems used to enhance the stability and efficiency of microgrids focusing on reliability, diversification and/or cost reduction	Gas turbines Diesel engines Demand profile alteration
Residential	Energy storage systems designed for home use providing backup power, self-generation augmentation or peak shaving	Demand profile alteration Backup generator
Resource Adequacy	Energy storage to incrementally defer or reduce the need for new generation capacity and minimise risk of overinvestment in that area	Gas Turbines
Transmission congestion relief	Energy storage can be deployed downstream of congested transmission corridors to discharge during congested periods and minimize congestion in the transmission system	Incur peak pricing as a result of tranmission congestion
Transmission capex deferral	Delaying, reducing the size of, or entirely avoiding utility investments in transmission system upgrades necessary to meet projected load growth on specific regions of the grid	Demand management Substation and distribution upgrade

Source: Lazard, RMI and Climate Capital

There is a trade-off in the potential models for storage applications by C&I customers between behind-the-meter and in-front-of-meter applications.

Behind-the-meter storage is physically located at the customer's premises, and are connected into the meter on the same side as the customer's load. In many cases, behind-the-meter storage is similar to demand reduction and demand side management.

In this case, storage can trim peak on-site demand and thus reduce exposure to higher intra-day prices, extreme price events and/or network capacity/maximum demand tariffs. In this case, the benefits are achieved through an energy retail agreement, which is essentially inflexible and requires a close association with the retailer or broker.

These customers cannot participate directly in the electricity market as the metering and storage are not set up to capture any associated generation behind-the-meter. As a result, these customers cannot access benefits such as selling into the spot market during high prices, energy arbitrage and avoiding certain network charges. Similarly, the customer cannot utilise the opportunities provided by amendments in recent years to the National Electricity Rules, which include:

- Small Generation Aggregator provisions that facilitate groupings of embedded generators — generally below the 5MW threshold for AEMO registration — to access the market;
- Improved transparency around opportunities for embedded generation (including storage) and processes for connecting embedded generation into the grid; and
- Incentives placed on network service providers to consider and implement non-network solutions to grid management issues.

The inverse applies to in-front-of-meter storage, whether on site or supplied indirectly from another site. In this case, customers can access the market-related benefits of arbitrage and spot market trading or access these through an aggregator, and can provide non-network solutions to network service providers, but cannot influence the embedded costs of peaking capacity built into their retail agreements.

3.3.5 Demand side barriers to entry

Hydro Tasmania's consulting business Entura analysed the potential for mid-sized generation and storage solutions (up to 5MW) for the CEC in late 2015. Its study was based on stakeholder discussions and surveys, and identified several barriers to the application of embedded generation and storage by Distribution Network Service Providers ["DNSP"] and Transmission Network Service Providers ["TNSP"], which included:

1. Perceptions of availability of generation at the required times;
2. Uncommon pricing signals for the provision of incremental network support;
3. Network information not always being readily available to evaluate network support opportunities;
4. Connection processes being complex and generally not aligned to the needs for the provision of network support;
5. Supply reliability, security and quality settings generally set high expectations for providers of network support;
6. Structural disincentives have historically challenged the use of non-network solutions by both generators and networks;
7. Smaller investments (below the regulatory test) are not subject to high levels of reporting and scrutiny, making them harder to assess by proponents;
8. Aspects of the potential value chain, such as avoided transmission use of system charges, are not readily understandable to proponents; and
9. Correspondingly, significant decreases in forecast network investment in the coming 5 to 10 years have reduced the opportunity to explore and demonstrate the potential for these systems to support the grid.

FIGURE 11 below demonstrates aspects of the commercial, technical and regulatory frameworks affecting commercial-sale solar and storage that still need to be addressed to harness the potential benefits in network management.

While there have been a number of recent changes to the National Electricity Rules — including connection processes for embedded generation in Part 5A, and incentive programs for non-network solutions for DNSPs — these will take a number of years to exploit and become effective so that the relative value of storage can be understood and shared amongst storage providers, network service providers, wholesale market participants and energy consumers.

Further, the requirement for DNSPs to consider non-network solutions is only binding when the cost of an augmentation would exceed a threshold amount ($5M in the NEM) or is a 'major augmentation' in the South West Interconnected System ["SWIS"] in Western Australia.

Accordingly, overcoming these barriers will require relationships and expert advice, as discussed in section 3.3.2 above.

Customer and retail

Larger businesses manage their generation and financial products as a portfolio. They have the flexibility to choose which new technologies to support and the extent of their support; in order to reduce their overall energy procurement and risk management costs over different time horizons.

The ability to scale up production to levels that can make a material impact in a portfolio are also critical in this decision-making.

Further, these businesses have different diversification strategies. For instance:

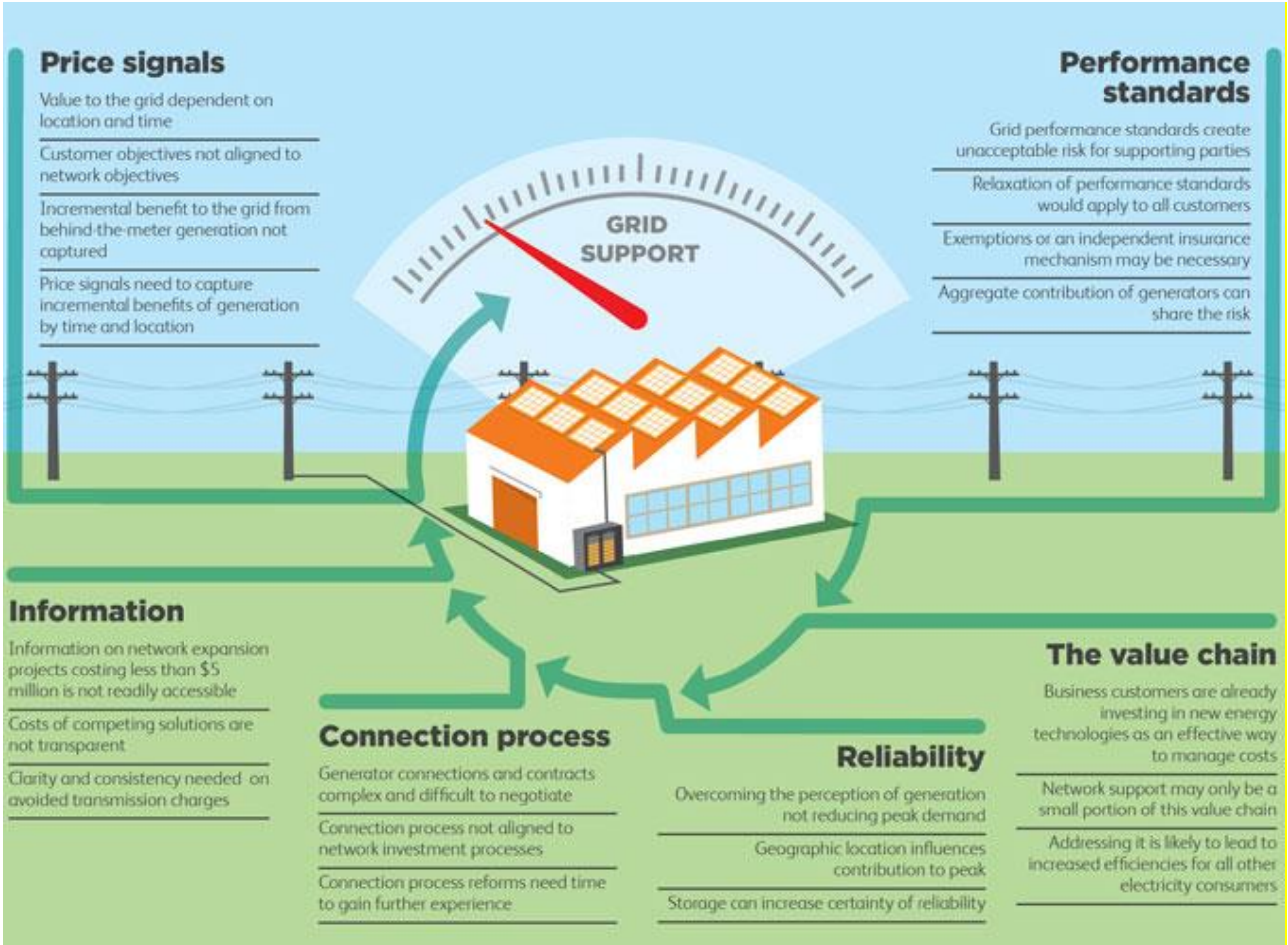
- AGL has a large and growing residential renewables business and is pushing into the provision of energy services;
- Origin has large upstream gas portfolios and downstream LNG interests; and
- ERM Power has recently acquired an energy services business, complementing its focus on the Small Medium Enterprise ["SME"] and commercial and industrial market.

Accordingly, it is important that new technology providers carefully select any partners that may provide a channel into the retail market.

However, a more pressing issue is that energy storage must be considered against other solutions that provide similar risk management opportunities, including:

- for energy products: internally owned generation such as wind and solar; and
- for capacity products: open-cycle gas turbines and diesel.

FIGURE 11 **SOLAR AND STORAGE NETWORK REGULATION BARRIERS**



Source: Entura

3.3.6 Demand side market opportunities

3.3.4 above identifies a range of demand-side applications for storage technology in the Australian energy supply chain.

In light of the barriers to entry we have identified in 3.3.5 above, we consider the following storage applications to be near-term opportunities for commercial and retail storage solutions which face the least amount of obstruction from the aforementioned barriers:

1. Commercial and industrial applications; and
2. Microgrid installations.

We have considered off-grid applications to be a major demand-side market opportunity and have addressed its barriers and opportunities separately in on page 18 in section 3.3.7 below.

The residential (retail) storage sector is poised for exponential growth over the mid-to-long-term. The residential market is characterised by inidivual household energy storage solutions units of storage capacity from 1KW to 15KW (existing retail storage solutions are described in **Error! Reference ource not found.**). On that basis, we consider storage solutions with capacity greater than 15KW to be commercial customer solutions given their:

1. Storage capacity; and
2. Capital cost.

As with the economic drivers identified in 3.3.3, commercial and industrial users also exhibit similar entrepreneurial characteristics that make them an attractive market to solutions with total capacity greater than 15KW as they seek to increase profit by reducing their energy overhead cost.

The commercial and industrial market further lends itself to larger scale solutions that can provide niche solutions to their specific requirements.

3.3.7 Off-grid applications

98% of Australia's energy is supplied using its on-grid networks; the NEM, SWIS and I-NTEM, which service massive geographic areas connecting energy generators and customers in urban, semi-urban and rural areas.

By contrast, the 2% of Australia's population which live in the off-grid energy market currently consumes in excess of 12% of Australia's total energy demand (FY2014) up from 10% the prior period[5] which was supplied by approximately 5GW of generation capacity. Annual consumption for FY2014 was approximately 26,700GWh, 78% of which was from natural gas with the balance mostly from diesel generation[6]. Consumers in the off-grid energy market include agricultural processing, remote mines, small communities and remote infrastructure to support telecommunications and desalination facilities.

TABLE 5 **OFF-GRID USER PROFILES**

Off-grid sector	User description	Typical demand
Industrial	Industrial and commercial segment dominated by mining segment. Also includes Defence, agricultural and tourist facilities.	>1MW
Communities	Communities which include small mining towns, small commercial facilities and remote communities	100kW - 1MW

The off-grid industrial sector consumes in excess of 12TWh per annum or more than 80% of total off-grid energy produced, most of which is consumed by the mining sector. Demand from the mining sector has grown significantly over the last 15 years in particular which has been associated with increasing exploration and production costs. Growth in annual energy demand from the mining sector is expected to stabilise as the industry transitions to production phase after close to a decade of investment and exploration.

Community sector energy users can be split into two sub sectors being:

1. Off-grid systems which are managed by State Government and Territory-owned network service providers;
2. Independent off-grid systems managed by an independent power provider or the community; and

Accounting for 58% of Australia's off-grid community consumption, the Northern Territory ["NT"] has the largest off-grid community demand. As illustrated in FIGURE 12 below, the distribution of existing off-grid generation in Australia largely resides in Western Australia, Northern Territory, Queensland and South Australia.

[5] Australian Energy Update, 2015

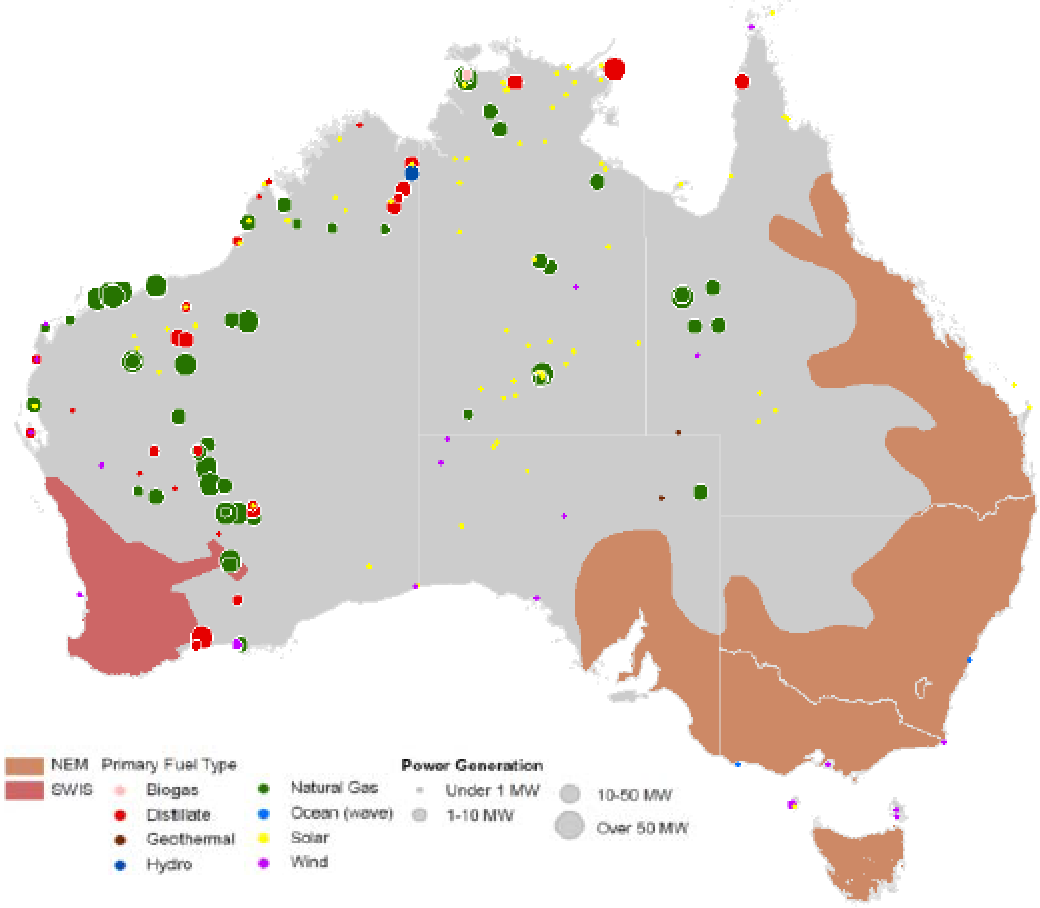
[6] Ibid

TABLE 6 **DISTRIBUTION OF DEMAND FROM THE OFF-GRID SECTORS**

State	Community Consumption (GWh)	Share	Industrial Consumption (GWh)	Share
South Australia	40	17%	196	83%
Queensland	378	11%	3,021	89%
Northern Territory	1,927	59%	1,347	41%
Western Australia	999	11%	7,881	89%
Tasmania	22	96%	1	4%
Total	**3,366**	**21%**	**12,446**	**79%**

Source: BREE, AECOM

FIGURE 12 **OFF-GRID GENERATION IN AUSTRALIA**



Source: Geosciences Australia National Power Stations Database

Mining sector

Electricity consumption in the off-grid industrial sector is largely dominated by the mining sector. The mining sector has experienced unprecedented growth over the last decade and a half and represents almost 10% of Australian's total energy demand[7]. Mining as a contributor to GDP has fluctuated between 7% and 10% of GDP over the last 5 years.

In existing mine operations, energy typically represents a major share of its operational costs with crushing, grinding, and hauling ores being major operational costs[8]. The most energy intensive mining process including:

- Extraction, which includes blasting, drilling, ventilation and dewatering;
- Materials handling; and
- Benefaction and processing, including crushing, grinding and separation.

Despite a tempering of mining investment as a result of softening demand from China and commodity price fluctuations, the off-grid mining sector represents a significant market for energy storage solutions on the basis that:

- Mines will enter normal operating mode as they transition from the development phase and begin to process materials which is energy intensive; and
- Energy supply presents reflects a significant cost and key risk to profitability in light of variable and softening commodity prices.

Communities sector

More than two thirds of Australia's population reside in cities. By contrast, less than 3% of the population live in remote areas of Australia[9]. While some remote communities have experience growth, being those which are near or support mining operations, remote communities in Victoria, New South Wales and Tasmania experienced negative growth. Remote communities are energy needs are primarily supplied by State Government and Territory-owned network service providers ["NSP's"]. The major government owned NSP's are Horizon Power (WA), Ergon Energy (QLD) and Power Water Corporation (NT).

The off-grid community energy market is a combination of islanded micro grid systems supporting communities and mining towns. In off-grid community markets, State Governments pay a subsidy (Community Service Obligation ["CSO"]) to energy suppliers for the supply of electricity to remote consumers. As previously mentioned, energy supply in remote areas, unlike in dense urban populations, is highly expensive due to high fuel costs, lower economies of scale and lower customer density. CSO's paid by state governments have exceeded $1.6 billion per annum since 2014[10]. The Australian off-grid renewable energy is an untapped market with large potential. It offers a variety of opportunities for businesses and government for future growth and development.

[7] Australian Energy Update, 2015

[8] Bloomberg, LLP

[9] National Regional Profile 2009 – 2013, Australian Bureau of Statistics. This is the most up-to-date release published by the ABS. The next release is due to be published in June 2016.

[10] Horizon Power, Ergon Energy and Power Water Corporation annual reports FY2014

TABLE 7 **OFF-GRID OPPORTUNITIES FOR ENERGY STORAGE**

Application	Description	Existing alternatives
Hybridisation	Hybridised generation systems represent the greatest potential area of growth in the off-grid renewable market as fuel costs are high and where fuel supply security risks exist	Diesel engines Demand profile alteration
Industrial / Mining Growth Regions	Western Australia's Pilbara, Mid-West and Great Southern Region currently have over 3.1GW of off-grid generation capacity and thereby represent a large proportion of the market	Gas turbines Diesel engines Renewable generation
System Integration	Increased penetration of renewables in hybridised systems leads to greater integration costs. Energy storage and control technologies can be deployed to support reliable operation of variable renewables.	Demand management Diesel backup engines
Community Growth Regions	Mining towns such as Roxby Downs (SA), Weipa (Qld), Karratha (WA), Newman (WA) and others in the Pilbara have shown significant load growth as a result of fly-in-fly-out and permanent regional population expansion.	Gas turbines Diesel engines Demand profile alteration
Inter-connection	As the population grows and development continues in off-grid mining regions, there is an opportunity to develop the existing interconnected systems and link the adjacent islanded grids.	Gas turbines Diesel engines Demand profile alteration
Aggregation of small projects	Aggregation of micro-loads or project opportunities in a region will likely bring economies of scale in both construction and operation. The state owned NSP's could provide an opportunity for amalgamating a number of community projects.	Network upgrades Demand profile alteration Hybrid systems

Source: BREE, AECOM and Climate Capital

3.4 Market sizing

A combination of economic and legislative factors is set to propel energy storage market participants on a clear growth trajectory over the near-to-midterm provided there is clear demonstration of channels to market and execution of that strategy.

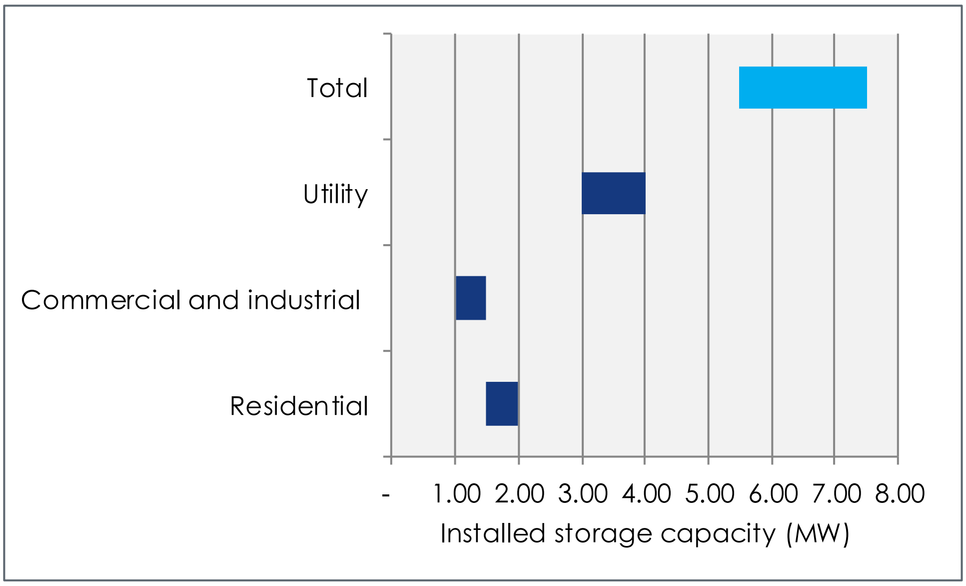
Over the last decade, developments in storage technologies have been driven by increased integration of renewable energy technologies[11]. However residential and industrial customer uptake for storage technologies is expected to drive growth over the next five years as a number of Lithium Ion technologies from Panasonic, Tesla and Enphase reach the market and take advantage of a combination of aforementioned factors including:

- High levels of rooftop solar penetration;
- Increasing network tariffs;
- Variable energy prices; and
- Energy metering costs.

Currently, it is estimated that Australia's total installed energy storage capacity is between 5.5MW and 7.5MW.

[11] Battery Storage for Renewables: Market Status and Technology Outlook, International Renewable Energy Agency, January 2015

FIGURE 13 **AUSTRALIA'S INSTALLED STORAGE CAPACITY FY2016**



Source: GTM Research, CSIRO, AECOM and Climate Capital

A range of studies have been undertaken to determine the growth trajectory of energy storage over the next 5, 10 and 15 years across the utility, commercial and industrial and residential markets.

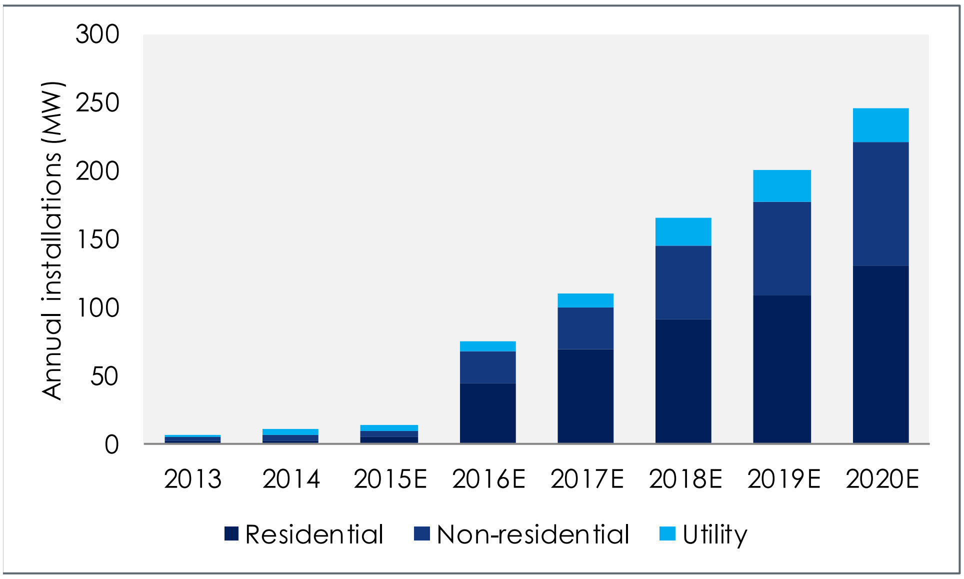
Analysis undertaken by Greentech Media ["GTM"] estimates annual installations of energy storage to increase from as much as 75MW in 2016 to 244MW in 2020. Of those installations, GTM estimates the residential and commercial and industrial sectors to account for 50% and 40% respectively, with the balance of installations occurring at a utility level. The result of these installations is a storage market in excess of 600MW by 2020.

Forecasts undertaken by Marchment Hill for the Clean Energy Council found that beyond the next 5 years, storage uptake could reach levels between 1,900MW and 3,300MW by 2030 driven by a combination of continued solar PV uptake and cost reductions at a storage technology level[12]. Additionally, AEMO has forecast a potential market of 500MW by FY2018, growing to 3,400MW in FY2025 and 8,000MW by FY2035[13].

12 Integrating Renewables Into the Grid: Stocktake Project, Marchment Hill, 2014

13 Emerging Technologies Information Paper, National Electricity Forecasting Report, AEMO 2015

FIGURE 14 **ENERGY STORAGE ANNUAL INSTALATION FORECAST BY CUSTOMER SEGMENT**



Source: GTM Research, 2016

3.4.1 Supply side market sizing

As identified in section 3.3.1 above, energy storage applications on the supply side of the energy supply chain are best suited to frequency, pricing arbitrage and ancillary services which are currently provided by combined cycle gas turbines ["CCGT"] known as peaking plants.

Peaking plants are characterised by their ability to instantly dispatch high volumes of energy virtually instantaneously.

Gas-powered peaking generation capacity accounts for approximately 20% of total registered capacity, or 8,933MW, across the NEM in FY2015 despite accounting for only 12% of total generation[14]. TABLE 8 below summarises our assessment of the total addressable market energy storage technologies could currently capture.

TABLE 8 **AUSTRALIAN SUPPLY-SIDE TOTAL MARKET SIZE (MW)**

Market	(MW)
Total peaking power plant generation capacity	8,933
Actual dispatched peaking power plant capacity	5,356
Energy storage technology addressable market (2020)	268
Energy storage technology addressable market (2016)	10 - 20

Source: Climate Capital analysis

Analysis undertaken by GTM posits that installed utility-scale supply-side storage technology capacity could be as high as 86MW by 2020, having increased at a CAGR of 63% from 7.5MW in 2016. However, we believe that this may underestimate the addressable market storage technologies could access in the supply of a range of transmission and distribution services.

Unfortunately, this market is only theoretical and is exceedingly difficult to quantify. On that basis, we have made a conservative estimate which reflects:

- Pilot and trial programs undertaken by transmission and distribution businesses in integrating energy storage;
- Pilot and trial programs undertaken by generation businesses; and

[14] State of the Energy Market 2015, AER

- Rate of technological advancement to deliver scaled storage solutions

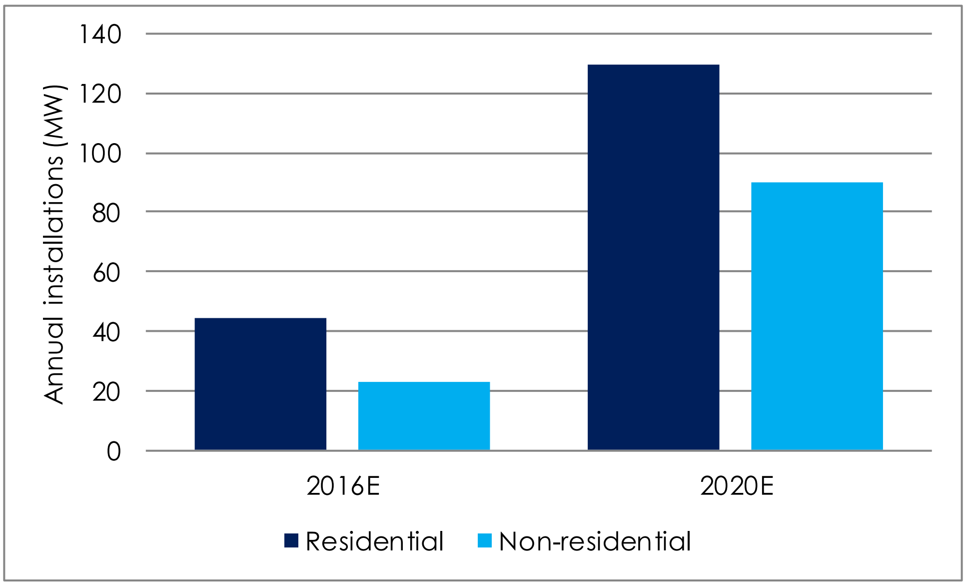
3.4.2 Demand side market sizing

On-grid market size

GTM's analysis posits that installed on-grid storage capacity could grow to in excess of 60MW by the end of calendar year 2016, driven primarily by the residential sector (60% of total installations and 66% of total demand-side applications). Much of the rapid adoption of energy storage is expected to be driven by two key factors; being:

1. The mass adoption of rooftop solar generation over the last five years; and
2. Existing retail-generators such as Ergon Energy, AGL and Origin Energy offering storage solutions to their existing customers.

FIGURE 15 **DEMAND-SIDE ON-GRID MARKET SIZE ESTIMATE**



Source: GTM Research, 2016

Off-grid market size

TABLE 6 above illustrated total demand to be greater than 15,000GWh per annum from community and industrial users (21% and 79% respectively).

Off-grid industrial and community sectors are currently supplied with electricity from either off-grid interconnected systems or islanded power stations. There are also numerous privately owned and operated off-grid electricity generation systems ranging from single household generators to large scale industrial power stations for mines and processing facilities.

Generation in the off-grid industrial sector is characterised by non-renewable thermal generation facilities fuelled by natural gas or liquid fuels (e.g. diesel, heavy oil). Existing generation for off-grid communities on islanded systems are also predominantly diesel fuelled. TABLE 9 below illustrates the capacity of off-grid generation by fuel type.

TABLE 9 **CAPACITY OF OFF-GRID DISTRIBUTION BY FUEL TYPE**

Generation by fuel type	MW	Share
Natural gas	3,614	73.9%
Liquid fuels	1,222	25.0%
Wind	14	0.3%
Solar	4	0.1%
Other	38	0.8%
Total	**4,892**	**100.0%**

Source: BREE, Geosciences Australia

Where TABLE 8 above summarises our assessment of the total off-grid addressable market energy storage technologies could currently capture, TABLE 10 below illustrates our assessment of the Australian off-grid total and addressable market size.

TABLE 10 **AUSTRALIAN OFF-GRID TOTAL MARKET SIZE (2016)**

Market	(MW)
Total off-grid generation capacity	4,892
Diesel and renewable generation capacity	1,278
Energy storage technology addressable market (2020)	767
Energy storage technology addressable market (2016)	20 - 30

Source: Climate Capital analysis

3.5 Market penetration uncertainties

Our assessment of opportunities relies on a range of assumptions we have made regarding external market variables discussed throughout this report. While FIGURE 2 above illustrates the exponential growth expected to be experience by the market domestically over the near and longer-term, the variability in expected market size also highlights the uncertainty of the impact of energy storage technologies.

A summary of these key (and interrelated) external market variables we have identified include:

- The rate of residential storage uptake and the resultant impact on average network demand;
- The timing of the development of standardised energy storage assessment criteria for end-users; and
- The pace at existing regulatory frameworks that govern networks change to accommodate the integration of storage technology on both the supply and demand-side.

It is important to note that these factors are not static and that we have begun to evidence of meaningful change in areas of standardisation and regulation. In May 2016, Standards Australia announced its partnership with COAG Energy Council to develop an energy storage standards framework to support the impending rapid uptake of energy storage technologies domestically. In attempts to stop-gap the lack of ratings framework or assessment standards, both the Clean Energy Council and Australian Energy Storage Council have published their own interim battery installation safety guidelines until Standards Australia publish their findings[15].

The development of the standards follows pressure from the Australian Energy Market Commission on the COAG Energy Council in December 2015 to develop a framework to support their assessment of storage integration with networks and the resultant regulatory implications[16]. However, despite the positive leadership from market regulators, it is still too early to determine

[15] Standards Australia starts work on Energy Storage Roadmap, media release, Standards Australia, 12 May 2016

[16] Integration of Energy Storage – Regulatory Implications, AEMC, 3 December 2015

when guidelines for regulating integration of energy storage technologies will be released and thus uncertainty will remain over the near-to-mid-term.

To mitigate this uncertainty, specific business cases need to reflect future tariff structures (including realignment of fixed, capacity and volume-based charges as well as price level shifts) as network service providers adapt to increased penetration of demand-side embedded generation and storage.

This will be a challenge for the proponent and the energy storage user, particularly where there may be information asymmetries on tariff strategies looking beyond current regulatory determinations.

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