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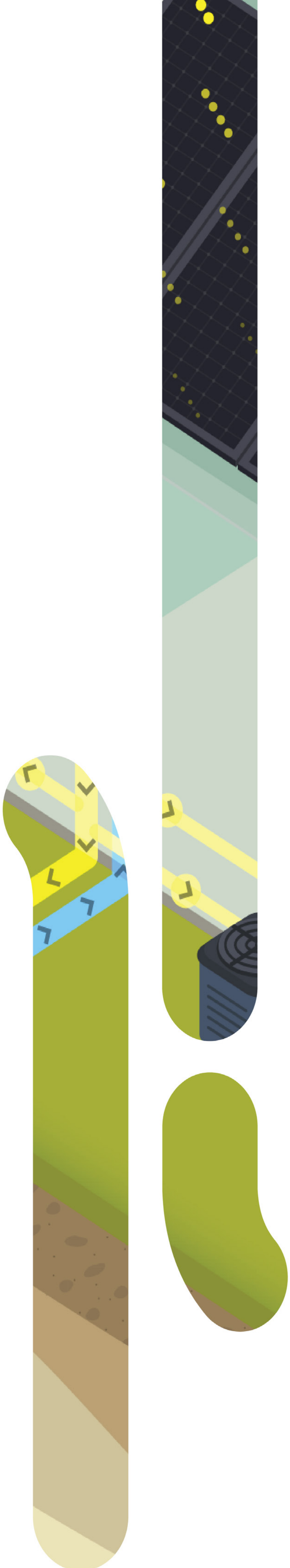
Delivering higher renewable penetration in new land and housing developments through edge-of-grid microgrids

Case Study: Huntlee Energy Utility



May 2016

This report was produced with support from the Australian Renewable Energy Agency (ARENA). ARENA was established by the Australian Government as an independent agency on 1 July 2012 to make renewable energy technologies more affordable and increase the amount of renewable energy used in Australia. ARENA invests in renewable energy projects, supports research and development activities, boosts job creation and industry development, and increases knowledge about renewable energy. More information about ARENA can be found at: www.arena.gov.au

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Acronyms

AER – Australian Energy Regulator
BAU – Business as usual
BEA – Brookfield Energy Australia
BoP – Balance of Plant
Co-gen – Cogeration
CAGR – Compound Annual Growth Rate
DG – Distributed Generation
DSO – Distribution System Operator
DUOS – Distribution Use of System Charges
ENA - Energy Networks Australia
GW - Gigawatt
HETA – Huntlee Energy Technology Alliance
HEU – Huntlee Energy Utility
HMM – Huntlee Microgrid Manager
IDNO – Independent Distribution Network Operator
KPI – Key Performance Indicator
LV – Low Voltage
MG – Microgrid
MGMS – Microgrid Management System
MW - Megawatt
MV – Medium Voltage
NEM – National Energy Market
NEO – National Energy Objective
NSW – New South Wales
PDA – Priority Development Area
PV – Photovoltaic
SAIDI – System Average interruption duration index
SAIFI – System Average interruption frequency index
TUOS – Transmission Use of System

Brookfield Energy Australia

Brookfield Energy Australia (BEA) as the lead applicant has management with demonstrated track record in the development and financing of large scale renewable energy projects and the development of decentralised utility models involving last mile infrastructure.

BEA's parent company, Brookfield Infrastructure Group (BIG) is the leader in community utilities in the Australian market place. Through its local subsidiaries Flow Systems, BEA and TasGas, BIG has been successful in building nine local energy and water communities covering over 25,000 homes when fully developed. BIG has pioneered the concept of last-mile infrastructure innovation through its GTC subsidiary (http://www.gtc-uk.co.uk/) and in low carbon district schemes through its Metropolitan business (http://www.met-i.co.uk/) both in the UK. In the US BIG owns the largest district heating and cooling company, Enwave.

flow systems

Flow Systems (Flow) is the organisation within BEA that delivers, operates and retails local utilities including; Central Park energy and water infrastructure which is comprised of a district heating, cooling and embedded electricity scheme and a local water recycling facility. Flow is a single retailer entity service servicing both water and energy at Central Park. Flow is currently delivering the local edge-of-grid water utility on the Huntlee site and will have billing relationships with every resident. Flow will be the billing agent for Huntlee Energy.

LWP

LWP is one of Australia's most innovative developers that prides itself on sustainability. Applying New Urbanist principles putting people at the centre of their developments.

LWP are part owner and project manager of the project and have extensive knowledge and experience in new town and community development. LWP aim to make Huntlee the premiere greenfield development in NSW.

SIEMENS

Given the complexity of microgrid projects, Brookfield has determined that partnering with a global expert in Microgrid technologies would be vital to ensure that the project is delivered on time. Brookfield conducted a market sounding including; Siemens, ABB and Schneider- the market leaders in Microgrid technology globally. Brookfield selected Siemens based on their high level of design experience in Australia (they recently implemented the Barangaroo microgrid) and quality of local staff.

Brookfield is working with Siemens in an alliance partnership contract. As part of the measure Siemens are delivering the core modelling, design, implementation and performance guarantee for the core microgrid power system and control components.

BAKER & MCKENZIE

Baker McKenzie are leaders in the Australian market in legal advice in the areas of energy and environmental markets. They have provided significant legal and regulatory advice as part of this grant and have become an integral partner in resolving some of the more complex regulatory barriers that have confronted the project.

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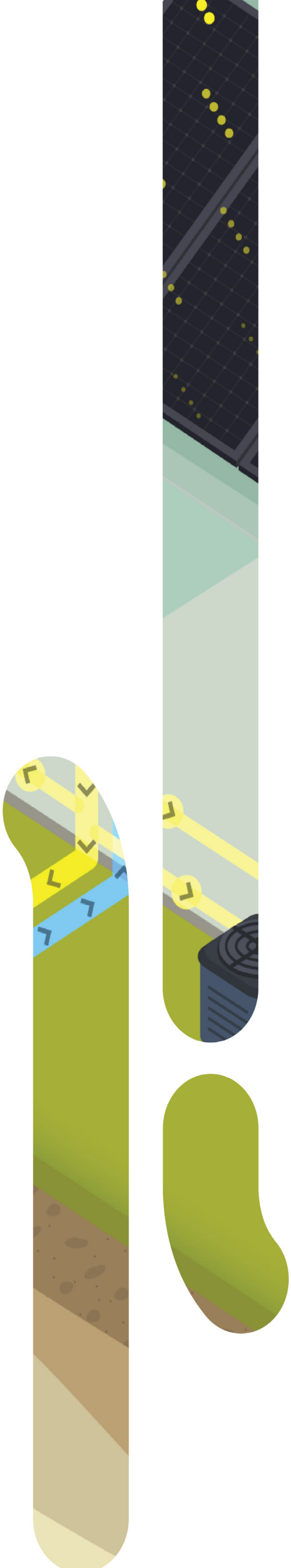
EXECUTIVE SUMMARY



1. EXECUTIVE SUMMARY

This report demonstrates that Microgrids built on the edge of networks of large mixed use communities, such as the 7,500 home community of Huntlee, can deliver significantly higher amounts of renewable generation compared to traditional non-sustainable energy provision. It also demonstrates key benefits to the energy market and society, including affordability and reliability. Importantly, it concludes that there are no insurmountable barriers to delivery and that all barriers can be managed.

The demonstration project proposes the establishment of a local community energy utility (the 'Huntlee Energy Utility') providing generation, network and retail services.

- **Virtual Solar** – 3-6kW on 95% of homes
- **Solar Farm** – 4MW expandable central solar farm to ensure sufficient solar penetration
- **Smart Microgrid** – Microgrid Management System' and smart controllers at each customer connection
- **Energy Centre** – Gas generators, large battery storage
- **Home Energy Packages** – A variety of air-conditioning, hot water, heat pump and EV charging station options integrated with home controller
- **Community Retail Services** – smart metering, data management, billing and customer services

The Huntlee study shows how a Microgrid can be implemented economically while delivering key national energy objectives of affordable, reliable, secure and safe supply.

1.1 Lessons learnt

Many of the commercial, technical, regulatory issues in relation to edge of grid Microgrids are similar in nature to existing issues being considered in the energy market more widely. The innovation of the Huntlee Microgrid meant that it pushed the boundaries on many of these issues and in some case required re-thinking of the concepts.

The following are some of the key lessons learnt in this process:

1. Expect that the Huntlee development would have up to 30MW of additional solar capacity at full development.
2. If the Huntlee model could be successfully deployed nationally it could lead to as much as 400 MW additional capacity brought on line by 2041.
3. Large scale microgrids have many of the challenges of the macrogrid , however microgrids enable better solutions to the issues faced by the macrogrid due to local control system capabilities. Managing peak demand is one of the key areas where Microgrids can outperform the wider network.
4. If implemented correctly, Microgrids have many benefits for developers of land and housing developments in terms of reduced costs and product differentiation.
5. If implemented with the right commercial model, Microgrids in land and housing developments will be well received by customers buying into those communities.
6. Microgrids in land and housing developments have significant environmental, social and economic benefits and significantly improve delivery of the National Energy Objective, ARENA's mandate and social objectives.
7. Modelling these projects is extremely complex as there are few precedents and many variables.
8. Battery prices in the short term were less commercial than anticipated for this application and will become commercial more commercial in a 5 year horizon based on current price curves. It became clear that managing solar spill through diverse load profiles was far more crucial than deploying batteries in the short term.
9. It is critical that these microgrids are implemented in a manner that considers and balances the goals of all stakeholders: developers, residents, grid operators and owners and the wider community. There needs to be financial returns for each stakeholder along with a clear social license to operate.
10. Given the innovative models and funding requirements of Microgrids the most efficient way to ensure wide-spread adoption of Microgrids is for a hybrid co-operative/ investor model otherwise known as a multi-user local ownership model.
11. Microgrids are near to being financeable, however there is a gap due to the current pricing of batteries, the regulatory uncertainty, and in particular the issues associated with being a global first in terms of the obligations that are required to ensure that a developer and the community are comfortable with the project.
12. The ideal context for Microgrids are communities which have significant servicing challenges or other drivers such as resilience or sustainability.
13. The future introduction of carbon pricing will likely make Microgrids more economic than the wider grid.

1.2 Barriers

As with any innovation considerable barriers have emerged during this research.

Some of the key barriers included:

1. Dealing with the franchise rights of Ausgrid (the local distribution company) to operate as a monopoly in areas designated to them under NSW Energy Supply Act.
2. Educating and working with the home builder supply chain rather than just the developer is essential for maximising the energy efficiency and demand management potential
3. Consumer lack-of understanding of microgrids
4. Appropriate regulatory framework for Multi-user local ownership model for microgrids
5. Lack of clarity in legislation for private electrical infrastructure in public roads
6. The need for clear operator of last resort framework for independant distribution companies
7. Lack of common technical standards for microgrids
8. Lack of recognition of the social, economic and environmental benefits of microgrids in the process of allocation of government infrastructure funding arrangements.

These barriers have been addressed in this report, either with resolutions or with suggestions provided to regulators.

1.3 Recommendations

The key barrier to emergence of this market is the regulatory environment. The key recommendations for regulators:

1. Establish a clear regulatory framework for microgrids
2. Establish the rules of engagement for microgrid in terms of retail, generation and network operation and ownership
3. Establish clear rules of engagement between existing distributors and the new microgrids

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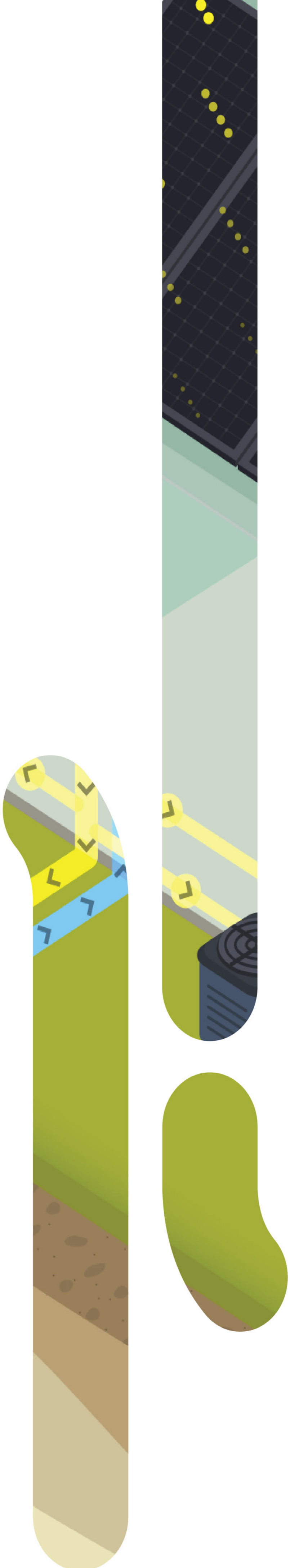
OPERATIONAL APPROACH



2. OPERATIONAL APPROACH

2.1 Background

Microgrids offer an alternative for servicing new land and housing developments. This measure will demonstrate that an edge-of-grid Microgrid technology will deliver higher renewable penetration into these new developments than traditional approaches and will thereby deliver strongly on ARENA objectives to reduce the costs and increase the use of renewable energy in Australia. The report also demonstrates that this technical approach delivers strongly on the National Energy Objectives for safe, secure, reliable and affordable power.

There are many drivers that make a structural network change necessary. A worldwide goal of reducing carbon emissions has led to emission policies aiming to produce electricity from less carbon intensive resources (AEMC 2012). The increased integration of renewable energy, particularly rooftop solar PV units, and local cogeneration are making the current centralized grid structure in the national energy market (NEM) inappropriate for the future needs of customers. Distributed generation penetration, new technologies, energy efficiency, rising prices and other factors have resulted in a yearly decline in energy consumption since 2010. The demand in 2013 was 4.3 percent lower than in the peak year of 2009 (Saddler 2014). The current NEM infrastructure is not able to adapt to all these changes in its current form requiring a structural change in the NEM is required in order to ensure reliable, secure supply at an efficient price.

These changes are also impacting on the process of land release of developable land for new housing supply in Australia. There are many developers who seek to develop new communities that are sustainable environmentally, economically and socially. They are also recognising that they have a duty of care to their customers to provide infrastructure that is future proof, given many of these developments are 30 year projects. These developers align with the goals of ARENA and are recognising that Microgrids are a technology that will deliver on their objectives.

This measure relates to a live opportunity to implement the most ambitious, privately-funded Microgrid project in land and housing developments globally with the objective of lowering prices for end customers. The Huntlee development in the Hunter Valley is a 7,500 home development being implemented by LWP, a developer who prides themselves on innovative and sustainable place-making.

LWP and a consortium of industry leading partners led by Brookfield Energy Australia (BEA) and Flow Systems (Flow) have been working on this project for several years and this measure is an integral part of demonstrating the feasibility and detailed design of this project. The outcomes of this measure will be the validation that this innovative approach can be practically implemented, to outline barriers, to suggest solutions to these barriers and to create a re-usable knowledge base. The aim will be to increase industry capacity and remove regulatory and commercial roadblocks to wide-scale deployment of similar microgids in the future. In addition to delivering these knowledge outcomes, this measure is a preparatory activity for the commercial deployment of the Microgrid in Huntlee which will become the exemplar for developers who are considering similar projects.

The measure will create knowledge and information that will give LWP and future developers comfort that the Microgrid concept is technically and commercially feasible. This knowledge will also build capacity in the market for high penetration renewable Microgrids within Australia and potentially drive a market with significant export potential in an area that Australia has significant competitive advantage given its history of implementing remote networks.

It is important to note that although there are several options to the deployment of Microgrids in terms of business models, this report investigated only the approach taken by Huntlee which is often referred to as the "multi-user" local ownership model for Microgrids, an approach that is widely seen as the most appropriate model to ensure wide-spread adoption of the technology.

2.2 Research approach

The unique aspect of this research is that it was conducted on a live project opportunity, which will be the subject of a future ARENA project grant application. While there was a process used to produce this report and the relevant findings, there has been a simultaneous process in place to implement the actual project. As such the technical and commercial aspects of the research have been conducted on the basis that they must produce a "bankable" project.

It became clear that there are significant interdependencies between technical, commercial and regulatory issues. The development of technical and commercial models was a highly iterative process, as new learnings in one area would drive changes in other areas. The reality is that there are no existing technical, regulatory or commercial frameworks that entirely capture the intent of the large scale community micro grid proposed in this study.

The following is an overview of the approach to commercial, technical and regulatory aspects of the project.

2.21 Commercial Process

The process involved a number of steps. Firstly it was important to understand the core drivers of the key project stakeholders being the financier (BEA) and the developer (LWP). Understanding the constraints of risk and the perception of the opportunity was critical to identification of the commercial roadblocks. A set of key performance indicators (KPI's) was identified by both parties which created a set of feasibility "gates" that required satisfaction in order for the project to proceed. Differing expectations and gates were established for the developer and financier.

2.22 Regulatory Model

The approach taken to understanding and applying the current regulatory regime was to gain a broad appreciation of the current legal frameworks that would apply to this area. As we moved through the commercial issues we would set our commercial objectives against the regulatory model. Once we had fairly strong understanding of the current regulatory environment we were able to test the findings by seeking feedback from the Australian Energy Regulator and other government agencies and through participation in various AER and AEMC market sounding processes.

Once the formal position of the AER was understood we re-set the approach in order to come up with a final position.

2.23 Technical Approach

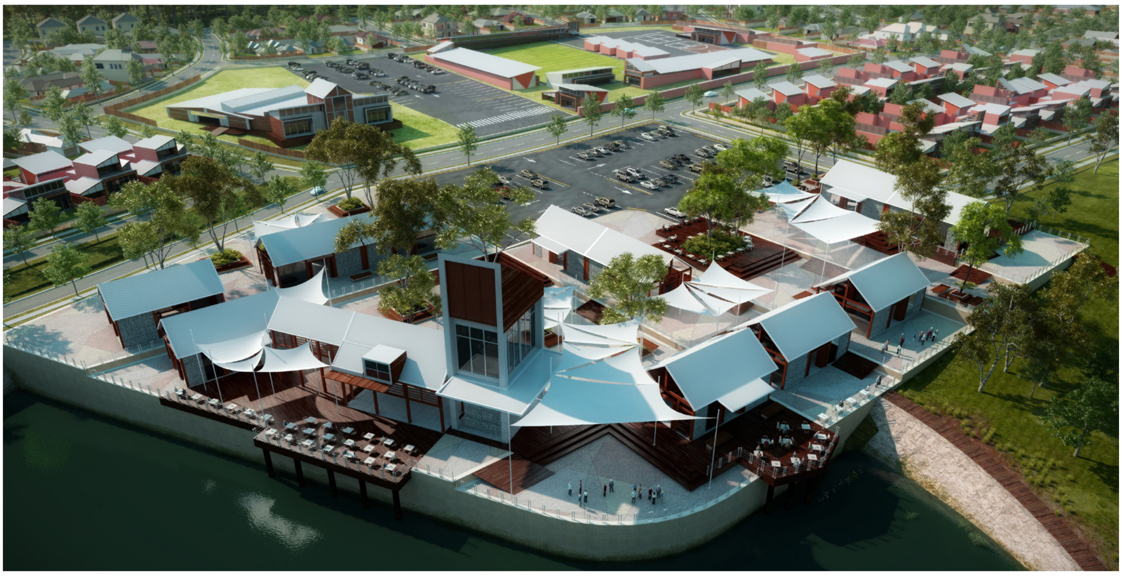
The approach taken to the technical models was similar to any integrated resource planning approach for an integrated network/retail energy market. A long term understanding of load was developed and mapped against home and commercial energy usage futures. An understanding of seasonal peak demands and then extreme weather events was determined and this drove the approach to peaking plants and demand management. The optimal generation mix was developed using a long run marginal cost approach. This overlayed a set of assumptions with respect to technology price curves and energy cost indexing. Customer pricing was set against long term NEM pricing expectations, which created an effective cap on revenue potential[1].

A part of the project was consideration of the impact of network augmentation on the developer however the current technical approach did not consider the integrated resource planning across the wider NEM in detail. The calculation of benefits of non-network options in network planning is complex as it requires consideration of demand mitigating options against the traditional options such as rewiring, network reconfiguration and installation of protection devices. In addition to these are the social questions around differing network options (Martins, 2011). The concept of non-network solutions to the challenge of the NEM has been well documented and explored in a recent process driven by the University of Technology Sydney[2].

1 Best Practices in Electric Utility Integrated Resource Planning Examples of State Regulations and Recent Utility Plans
2 http://www.uts.edu.au/research-and-teaching/our-research/institute-sustainable-futures/our-research/energy-and-climate-1

2.3 Case Study: Huntlee Development

Huntlee is located 2.5 hours from Sydney or 50 minutes from Newcastle. It is a $1.5 billion, 25-year project which will yield 7,500 new dwellings and 20,000 new residents. It is to be developed as four villages around a central town centre. It will include housing, education, commercial, health and recreational facilities and aims to create 3,000 new jobs.



In 2013 LWP established a working group to explore innovative concepts, particularly around local utility services. The Huntlee Enterprise and Technology Alliance (HETA), led by Damian Griffith, produced a series of reports investigating the feasibility of an off-grid local network owned by a local utility. These reports included regulatory advices, energy efficiency, high penetration solar and biomass generation options. HETA was successful in launching a local water utility which is servicing the community. This water utility is being implemented, operated and owned by Flow. These early advices have formed the groundwork for this measure, and the measure builds on this to get to a final model that is financeable and replicable.

The developer (LWP) was motivated by its innovative culture, and a desire to be a placemaker and build a community and not just do a typical subdivision. LWP also wanted to drive down the cost of living for residents, contribute to the environmental benefits and offer a differentiated product.

In 2014 LWP sought expressions of interest for the energy project and following a six months tendering process BEA and Flow were awarded the contract to prepare a feasibility study for a local energy utility. This ARENA grant is based on the work done by HETA as well as the work done in the past year by BEA and Flow to deliver a viable concept for an independent community utility.

2.4 What is the Huntlee Energy Utility?

This project revolves around the establishment of a local community utility which is technically implemented as follows:

- High penetration renewable energy with solar panels on each house being owned and operated by the community utility - a local smart microgrid.
- The community's network will be powered by a local energy centre through a Microgrid Management System (MGMS), battery storage and gas generators.
- A centralised solar power plant.
- A set of consumer energy services packages that have been created around the concepts of innovative, extensible, affordable, safe, secure and reliable supply. In addition focus has been given to obtaining and maintaining a clear social license to operate using a community co-operative structure.
- A retail energy function to support metering, meter data management, billing and customer services.
- A smart grid which includes technologies to support better fault detection and management.

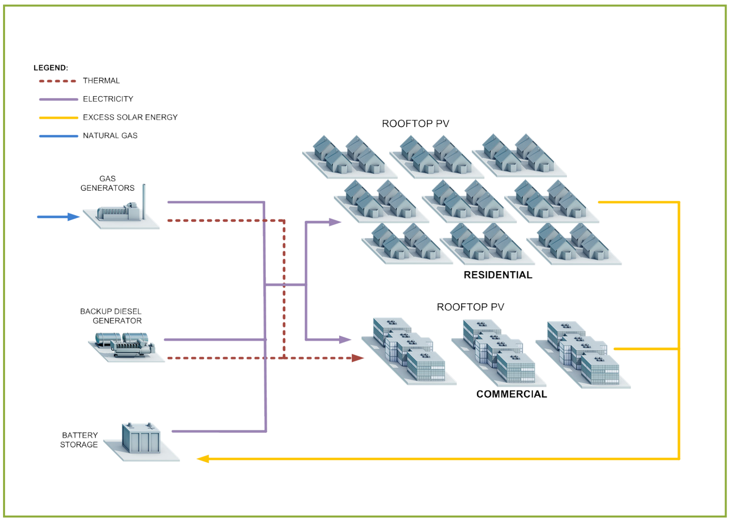


Figure 1: Huntlee infrastructure concept

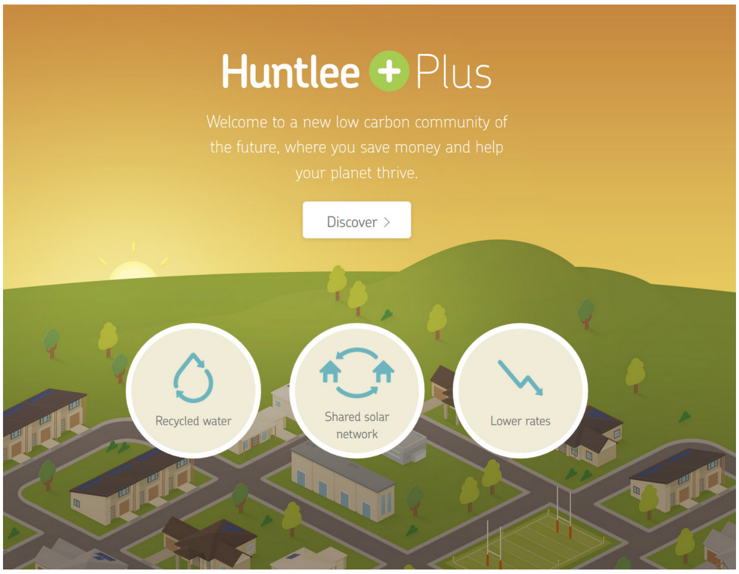


Figure 2: Huntlee energy and water portal

Further information about the technical approach is outlined in the Techno-Economic Analysis in the later part of the document.

2.5 Site Specifics

2.51 Layout and Equipment

The local energy centre will consist of a central building which will house generators and heat recovery equipment. There will also be a solar farm and a large centralised battery storage facility. Table 1 below shows the total installed capacities of the equipment.

Technology Capacity (2,400 lots)	
Solar	10.1MW
Battery Storage	2.3MWh, 1MW max. output
Gas Generators	5.1MW
Diesel Generators	0.9MW

Table 1: Generation Capacity

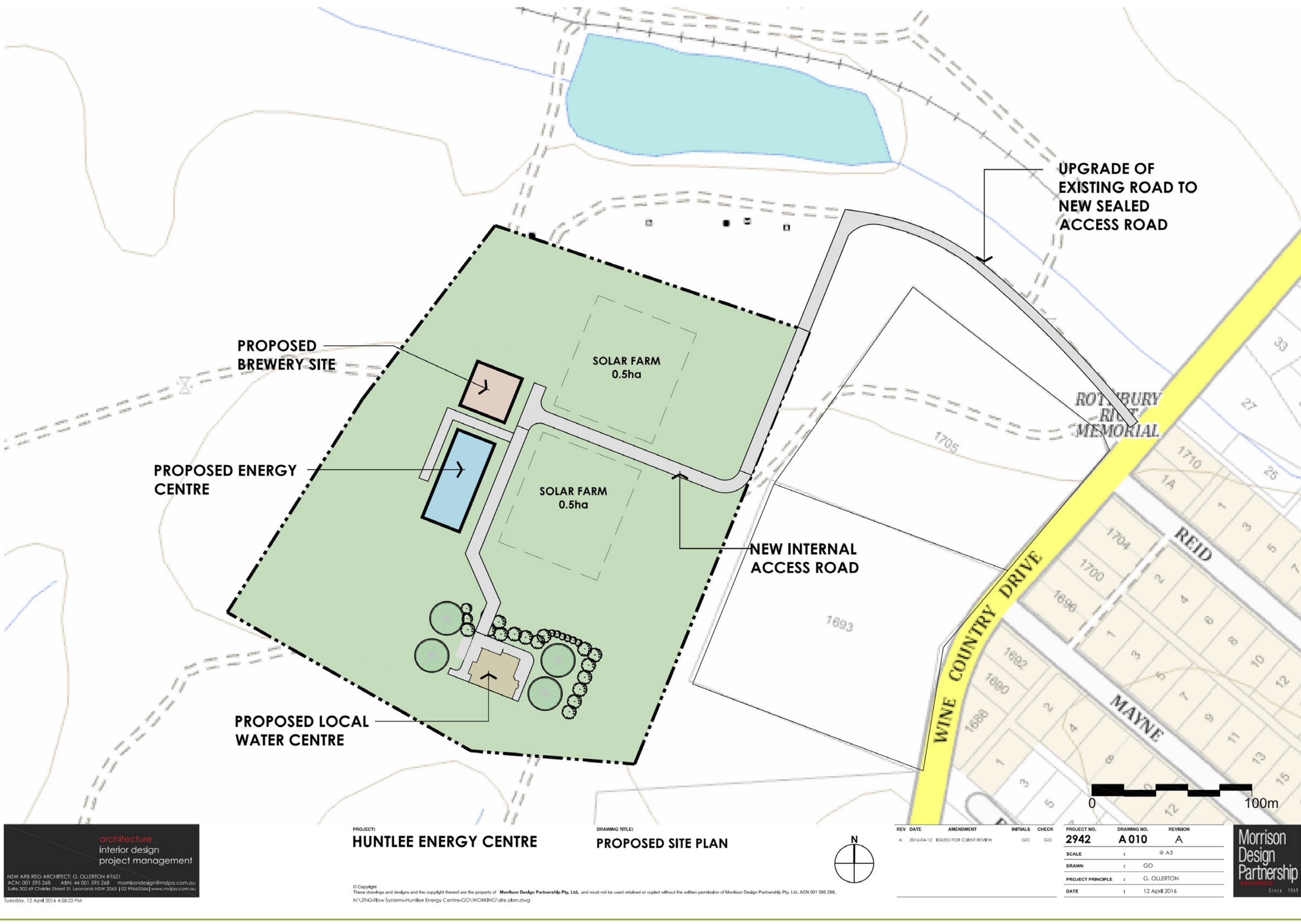
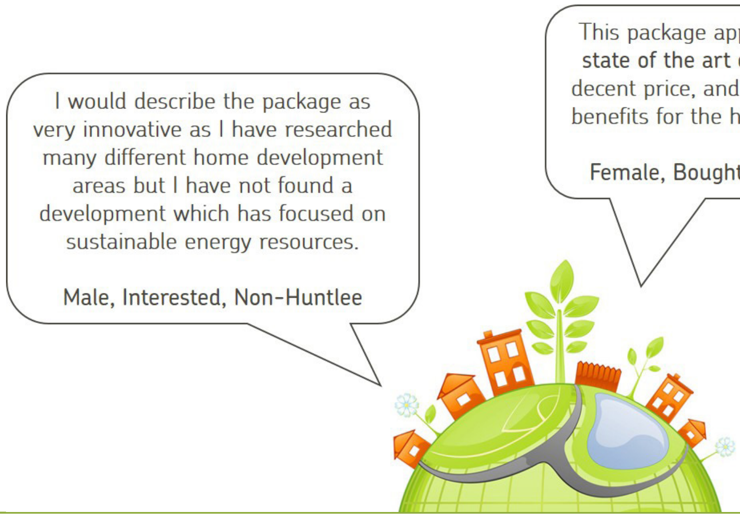


Figure 3: Huntlee Energy Centre

2.6 What we will offer customers

When modelling the financial investment case for the Huntlee Energy Utility, it was important to balance a number of competing items and concepts from a community offering perspective:

- The power needed to be more affordable than that available from outside the community. The ability not only to create lower cost energy from a Levelised Cost of Energy (LCOE) perspective, but also incorporating the total lifecycle costs of energy services to a house, including the costs of energy cost savings over time;
- It is vital, given the nature of a local distribution services operator being a monopoly, that the concept has a strong social license to operate. As outlined in (IPSOS, 2015) 87 percent of consumers support roof-top solar and only 5 percent of consumers are opposed to large scale solar. Interestingly, this report also identified that:
- To fulfil the vision of the energy utility we need to offer products that will encourage energy efficiency
- We needed to ensure that we implemented infrastructure that could manage peak demand, but that would be socially acceptable to customers
- We needed products that were easily understood by consumers
- We needed products and a supply chain that could work with the home builders in the community
- We needed to use technology that was seen as “smart” and “efficient”



The products for Huntlee were created via an iterative process with input from market research that was conducted for the project. The products that emerged were essentially based on “smart” air-conditioning and “smart” hot water systems along with community owned solar and electric vehicle charging stations.

An important innovation is that we have separated returns for the owner of the home from savings for the residents, recognising that even if home owners rents their property, it is the owner that makes decisions about the energy efficiency of their home.

Feedback from the market research indicated that simple products in the short-term was preferable. It remains the intention to introduce more products over the long-term.

Product	Description	Benefits
Solar Only	Every home will be eligible for solar which will be paid for by the utility	Home owner or occupier receives low energy pricing
Solar and Smart Hot Water	Smart Hot water is essentially controllable hot water. A series of compatible efficient hot water systems will be offered	Home owner receives annual dividends and low energy pricing
Solar and Smart Air Conditioning	Smart Air-Conditioning is controllable air-conditioning. A series of compatible energy efficient air-conditioning systems will be offered	Home owner receives annual dividends and low energy pricing
Solar and Smart Hot Water and Air-conditioning	A combination of the above	Home owner receives annual dividends(higher) and low energy pricing
Solar and Ground-Sourced Heat Pump	A heat-pump using geo-thermal head differentials to provide hot water and air-conditioning	Home owner receives annual dividends(higher) and low energy pricing
Electric Vehicle Charging to the above (can be added to any of the above packages)		Lower price electricity and higher dividend

Table 2: Huntlee energy products

Flow has created a calculator using the ARENA grant. This was aimed at clearly explaining products available to home purchasers and home builders and to also enable the purchasers to make the connection between their decisions and the local community utility.

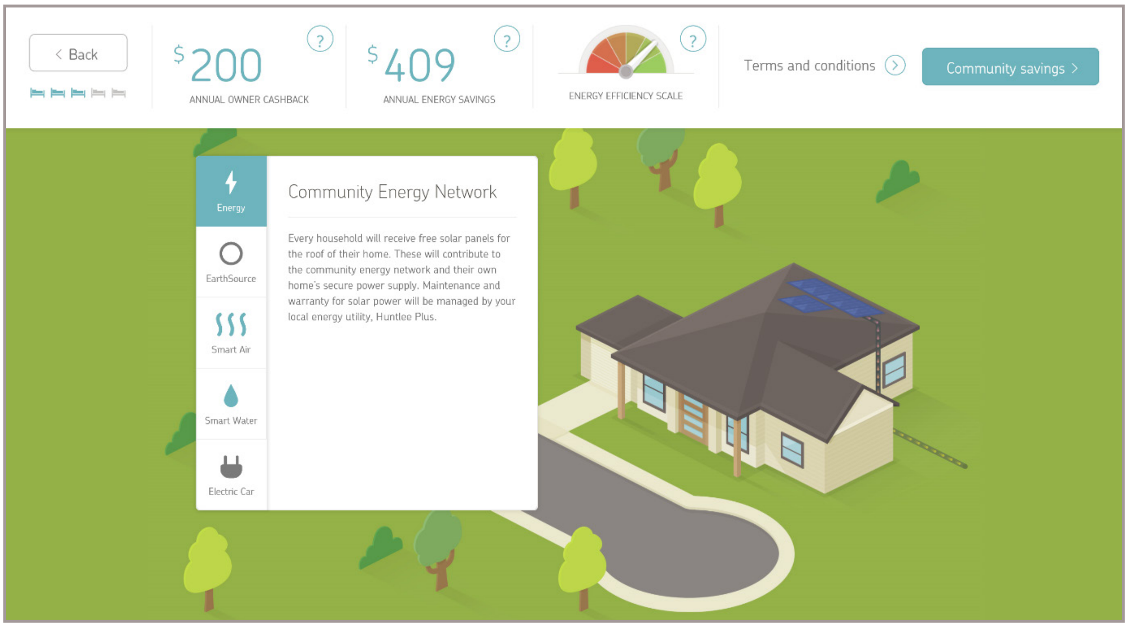


Figure 4: Huntlee energy pricing portal

We will:

- Aim to offer the best price
- Connect your property within the agreed timeframe
- Seven days notice of scheduled maintenance and engineering power disruption
- Services based on easy to understand terms and conditions
- Clear information about prices and price variations in advance
- No charge for late payment fees
- Payment management support during times of hardship or financial difficulty
- Extra care for vulnerable members of the community, through hardship protections, life support planning and assistance with securing eligible customers government rebates and concessions
- Extend to customers, all relevant consumer protections set out in the National Energy Rules, to the extent that they apply to the Off-Grid community
- Exceed or meet the services standards provided to on-grid communities by the local area distributor
- Deliver significantly lower carbon energy than the published National Electricity Market Carbon Dioxide Equivalent per Megawatt hour (CO2-e/MWh)

2.7 Safety standards

All equipment shall be designed, manufactured, installed, tested and operated in accordance with relevant Australian Standards. Where relevant Australian Standards do not exist, the equipment shall conform to relevant international standards in the following priority order: IEC, CIGRE and IEEE. In addition, all materials, equipment and work covered by this specification shall conform to the requirements of all statutory authorities having jurisdiction over the site.

In all references to standards and codes the latest edition at the time of order shall be used unless indicated otherwise. The following standards are deemed applicable to ensure the safe delivery of electricity to Huntlee consumers.

Standards:

- AS60038
- AS 61000.3.100
- AS 61000.2.2
- AS 3000
- AS 61000

In addition to the above, the design, operation and maintenance of the Microgrid shall comply with the following acts and regulations:

- Electricity Supply Act 1995 (NSW)
- Electricity Supply (General) Regulation 2014 (NSW)
- Electricity Supply (Safety and Network Management) Regulation 2014 (NSW)
- Work Health and Safety Act 2011
- Work Health and Safety Regulation 2011
- Code of Practice – Electricity Transmission and Distribution Asset Management

2.8 Network Planning

The following diagram outlines the network reticulation for the off-grid network. At a high level this is very similar to a standard Ausgrid network. This network will however have a layer of added smarts that will enable it to operate more efficiently and provide a higher level of reliability than a standard electrical network (see SECTION 4).

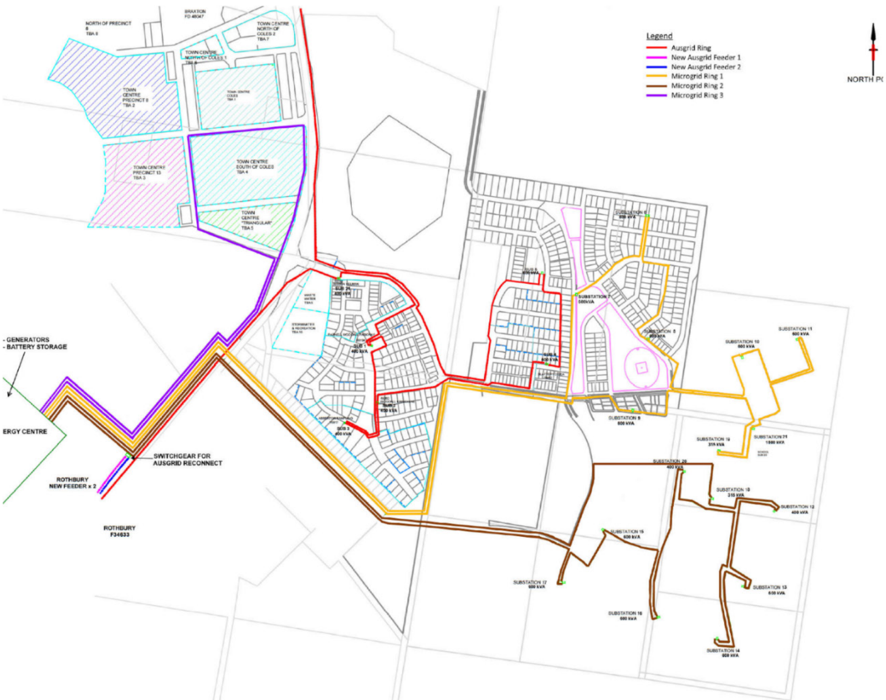


Figure 5: Microgrid reticulation network

2.81 Benchmark for assessing downtime/failure rates

The benchmarks for assessing downtime and failure rates are well established globally. BEA will comply with these standard benchmarks. Two related indices are applied when reporting reliability. The first, SAIDI, is commonly referred to as the "Reliability Index" and represents the average number of customer minutes lost by all network customers. SAIFI represents the average number of interruptions for all customers. It is important to note that based on Australian Energy Regulator (AER) guidelines, the SAIDI includes scheduled outages but excludes Major Event Days based on a Major Event Day Threshold (Tmed) calculations. Such an outage is defined as a day where the daily SAIDI value exceeds a threshold value.

The following table is extracted from Ausgrid's Electricity Network Performance Report 2014/2015 for urban feeders. BEA proposes to match these performance benchmarks.

	YEAR	2010/11	2011/12	2012/13	2013/14	2014/15
SAIDI	ACTUAL	82.37	72.21	56.43	64.74	58.41
	TARGET	80	80	80	80	80
SAIFI	ACTUAL	0.97	0.80	0.65	0.74	0.57
	TARGET	1.20	1.20	1.20	1.20	1.20

Table 3: SAIDI and SAIFI AUSGRID performance

2.82 Microgrid Reliability Indices

For the electricity supply to lots in stages 10 to 15, the reliability performance has been calculated for both maximised and minimised network design. The table below shows the figures of SAIFI and SAIDI for maximum reliability and minimised cost designs, respectively. The minimum and maximum values are related to results obtained at respective lots, whereas the average value is calculated based on the individual results of all lots.

	MAXIMUM RELIABILITY DESIGN		MINIMISED COST DESIGN	
	SAIDI	SAIFI	SAIDI	SAIFI
Minimum Value	16.8	0.412	15.6	0.355
Average Value	20.4	0.461	95.0	0.440
Maximum Value	27.1	0.545	238.4	0.489

Table 4: SAIDI and SAIFI for alternative microgrid designs

The two scenarios are compared in detail below:

- The maximised network reliability design shows a significantly better reliability performance compared to minimised cost design. Maximised design results in similar average frequency of supply interruptions compared to minimised design. But, with respect to unavailability or SAIDI, differences are significant as for maximised design, this index is only 20 percent of the one obtained for minimised design.
- Due to the increased number of ring main units in the maximised design, the size of low voltage (LV) networks supplied by any one ring main unit is reduced. Consequently, there are less components (and customers) within an LV tripping area being affected in case of a failure. However, this advantage is at

the cost of having additional ring main units in the high voltage (HV) cable ring contributing to the fault occurrence and in the end leading to a slightly higher frequency of supply interruptions in scenarios for the maximised design.

- For the maximised reliability design, customers strongly benefit from the interconnection possibilities on the low voltage level which allows a fast re-supply of customers when isolating a faulted section of network.
- When considering the scenarios individually, it can be stated that differences between minimum and maximum values are moderate with respect to frequency of supply interruptions. Regarding unavailability, however, differences are very high for the minimised network design. The probability of supply interruptions or unavailability at the lot is about 15 times higher in the worst case.
- In the minimised cost scenario, maximum unavailability is experienced by customers at the end of the radial LV feeders as their power supply is interrupted whenever a failure on the feeder occurs and the duration of supply interruption equals to the down-time of faulty equipment unless power supply via emergency generation units is provided quickly, i.e. faster than the average duration of supply interruption (~4h).

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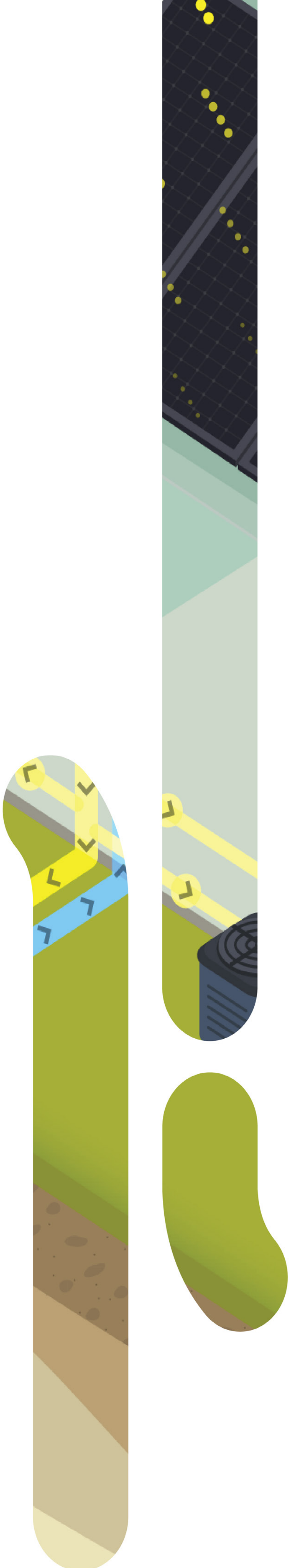
IMPACTS OF MICROGRIDS ON RENEWABLE ENERGY PENETRATION



3. IMPACTS OF MICROGRIDS ON RENEWABLE ENERGY PENETRATION

3.1 What are Microgrids and how do they relate to new land and housing developments

There is no universally accepted definition of a Microgrid as the technology is still developing. The accepted minimum or maximum size (MW) for a Microgrid will depend on its generation resource types, and storage and control possibilities (MG Institute 2014). One definition from the US department of Energy (2012) is:

'a group of interconnected loads and distributed energy resources within clearly defined electrical boundaries that acts as a single controllable entity with respect to the grid. A MG can connect and disconnect from the grid to enable it to operate in both grid- connected or island- mode'.

For ease of use when we talk about Microgrids in this document we will be referring specifically to edge of grid Microgrids. Figure 6 is Siemens conceptualisation of a Microgrid. This shows the function of a control system with respect to the grid and the various input that are required from the control system. This control relates to both the generation, storage and the physical network itself which becomes a network with greater control and self-healing properties than the wider grid.

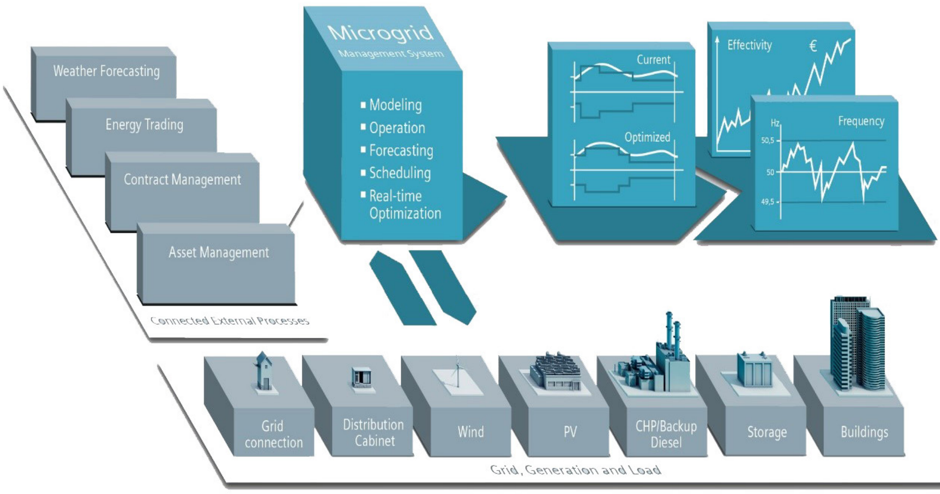


Figure 6: Siemens Microgrid Concept

Microgrids have typically been used as diesel generation substitutes for remote communities or for universities, military, commercial and industrial contexts. In the last few years it is becoming clear that Microgrids are not only beneficial to these applications, but are becoming a key part of the future grid transformation more widely. In the current Energy Networks Australia funded “transformation roadmap” Microgrids were seen as a significant part of the future of customer centric engagement[3].

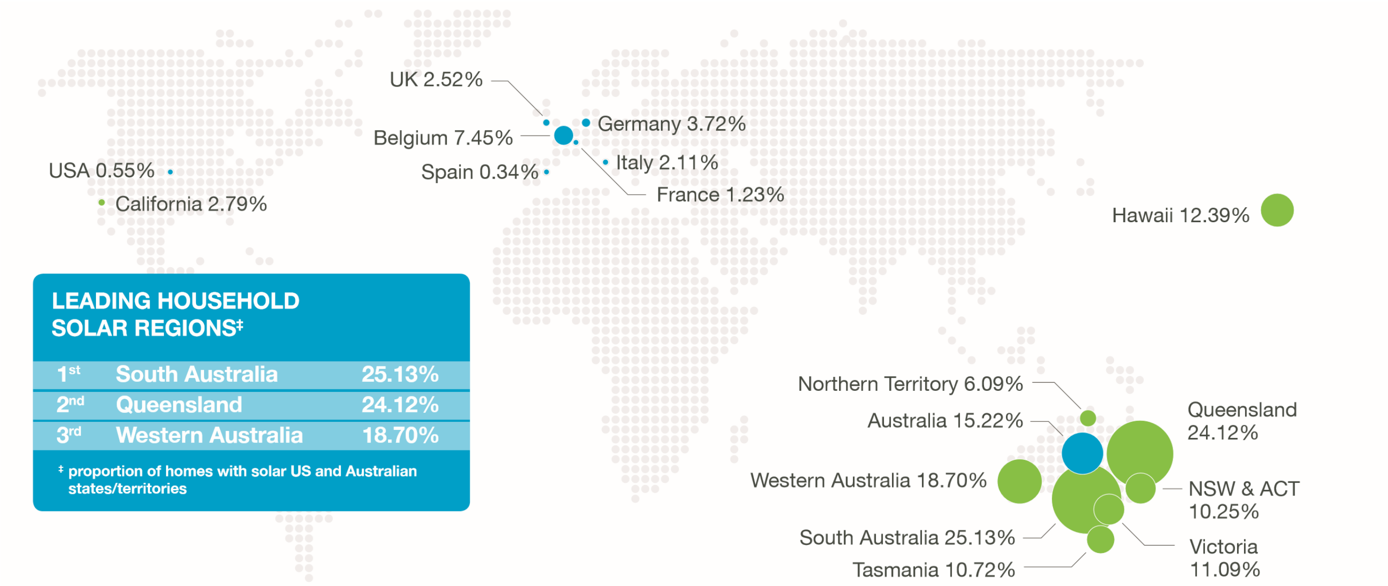
In the edge of grid context Microgrids can be used to service large numbers of mixed use communities, typically based on low to mid density of dwellings. The Microgrid itself in this environment refers to the physical network and generation assets.

3.2 Impacts on Renewable Energy Penetration in Australia

The purpose of this research is to establish whether Microgrids in the land and housing context will have a significant impact on renewable energy penetration in Australia. The method is to use the Huntlee case as an example to see the impact on that development and then to extrapolate this across Australia.

To determine the impact of Microgrids it is important to establish the baseline that we are comparing against. There are many drivers of solar penetration in land and housing developments including location, government incentives, developer preferences and the quality of the housing product (ie is it in an up-market location).

The ESSA produced a fact sheet on renewable penetration in Australia and found the penetrations of solar in each state as outlined in the following figure 7.



Australia clearly leads the world in the installation of household scale distributed solar PV. Australia has double the residential solar PV penetration rates of the next country (Belgium), and more than three times the penetration of Germany and the UK. The three leading jurisdictions in the world for rooftop solar PV are South Australia, Queensland and Western Australia ahead of Hawaii.

Figure 7: Australian rooftop solar market

3 Network Business models last accessed 25 April 2016 http://www.ena.asn.au/sites/default/files/network_business_models_accenture_report_john_bradley_final.pdf

Within new land and housing developments it is expected that the penetration would be slightly higher than in the past, although it depends on the developer drivers and the incentives at the time. There is limited research into future adoption of solar in land and housing developments.

Our research suggests that Microgrids enable higher deployment of renewables if there is a model in place that incentivises take-up of solar and thus providing an incentive to replace any government incentive scheme. More than that, by creating a local "virtual power plant" and district storage solutions, it maximises the efficiency of power use by socialising the output of panels within the community, minimising the solar spill from within the community.

In addition to the economic drivers, as our market research demonstrated there is also the buy-in that the community has to the concept that will drive additional adoption.
Finally, the nature of Microgrids means that the optimal mix of solar/battery deployment can be achieved by adding renewable energy to the mix through central solar plants even if the take up on homes is not enough. Commercial areas can also be included in the mix which leverages the larger roof space areas within the community.

3.21 Modelling the benefits

Through modelling the Huntlee Microgrid we found that the optimal solar uptake rate to make the the Microgrid economic is considered to be a 5kW rooftop array on each dwelling. Given it is not possible to know how many homes will adopt solar, we used an estimate of 2kW of solar per home to account for either smaller arrays than anticipated or lower adoption of solar panels.

To establish a BAU benchmark we used the Australian PV institute tool. Figure 9 shows the PV penetration currently in Branxton postcode being at 368 out of 2335 dwellings or 17.7 percent[4]. The total installed capacity is 1334 kW or 3.6 kW per dwelling.

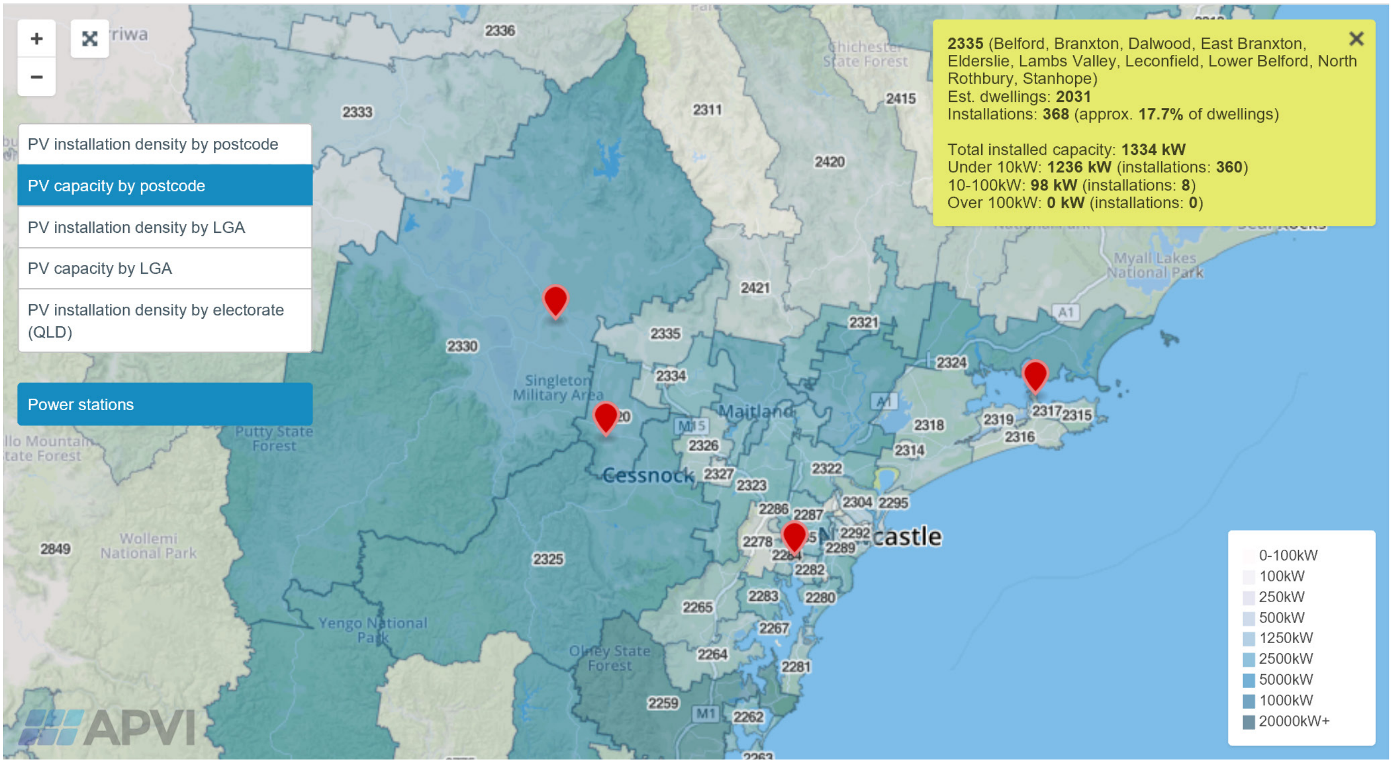


Figure 8: APVI solar map

4 http://pv-map.apvi.org.au/historical#9/-32.6879/151.4410

We created a model to understand the benefits of the Microgrid against business as usual (BAU). As outlined above the Huntlee Microgrid PV per home would be 4 kW with 100 percent penetration regardless due to the make-up of penetration from a ground-mounted PV plant on site. Given the reductions in solar prices (see table 5) an assumption was made that PV penetration in future homes would increase by 15 percent per annum.

Aspect	Huntlee BAU	Huntlee Microgrid
PV size (kW per home)	3.6	4
PV Adoption	20%	95%
Annual increase in PV penetration (outside Huntlee)	15%	N/A
Lots per annum		200
PV Output per kW	1362	1362

Table 5: PV penetation in Huntlee vs BAU

For Huntlee we are assuming in our financial model that 200 new homes would be added per annum. The graph in figure 10 outlines the net benefits of the Huntlee Microgrid against BAU, which is that by the time the community has 7500 lots it would have an additional 13 MW or 15 GWh of PV penetration.

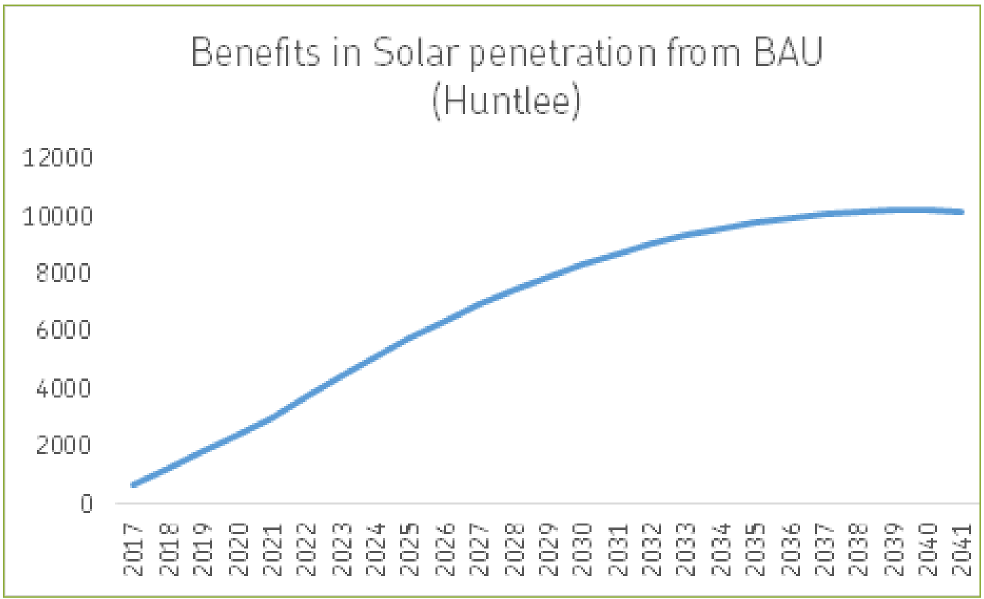


Figure 9: Benefits from solar penetration from BAU

What this did not take into consideration was the increased penetration on commercial buildings which would significantly add to this penetration.

This basic model does not relate to the value in terms of solar output. RFI Solar identified that in 10 years time it is estimated that the same size panel will produce 18 percent more power. This will significantly increase the net benefits of solar penetration in Microgrids.

It is more difficult to determine the impact of these models on the grid more widely as there are varying levels of solar uptake in each state. To determine the penetration consideration must be given to a national average, and also how many of the new homes will install solar panels within a few years of being constructed.

To estimate the figure we looked at the current penetration rates in Branxton (figure 10), and then looked at the existing household penetration.

Currently more than one in seven Australian households had installed solar PV. This is a 15 percent penetration rate across all Australian households. In NSW household penetration was 10.25 percent. In South Australia and Queensland the household penetration rate is 25 percent and 24 percent respectively. Some suburbs in greater Brisbane and Adelaide have recorded household solar PV penetration rates above 50 percent[5].

The following analysis is based on the conservative assumption that there will be up to 1,000,000 new land and housing homes in Australia in the next 25 years to 2041. If we were to aim for 15 percent of these homes to be serviced by Microgrids , then that would be approximately 6,000 new homes serviced by micro grids each year. The following assumptions are similar to those above, except there is an assumption that 25 percent of homes will be built with PV today and that there would be an incremental 20 percent more built with solar each year. The 25 percent is supported by the ENA Fact Sheet along with the Electricity transformation roadmap which estimated that around 50 percent of energy would be produced locally by 2050 (Energy Networks Australia, 2015).

Aspect	National BAU	Huntlee Microgrid
PV size (kW per home)	3.6	4
PV Adoption	25%	95%
Annual increase in PV penetration (outside Huntlee)	20%	N/A
Lots per annum		200
PV Output per kW	1362	1362

Table 6: Assumptions - national PV penetration PV in Microgrid and BAU

The result of this is around 250 MW of additional solar from now to 2041 producing 317 GWh hours per annum. This is again conservative given the improved energy output and the fact that commercial areas were not included in the analysis. Figure 10 shows the potential national net benefits of Microgrids to solar penetration.

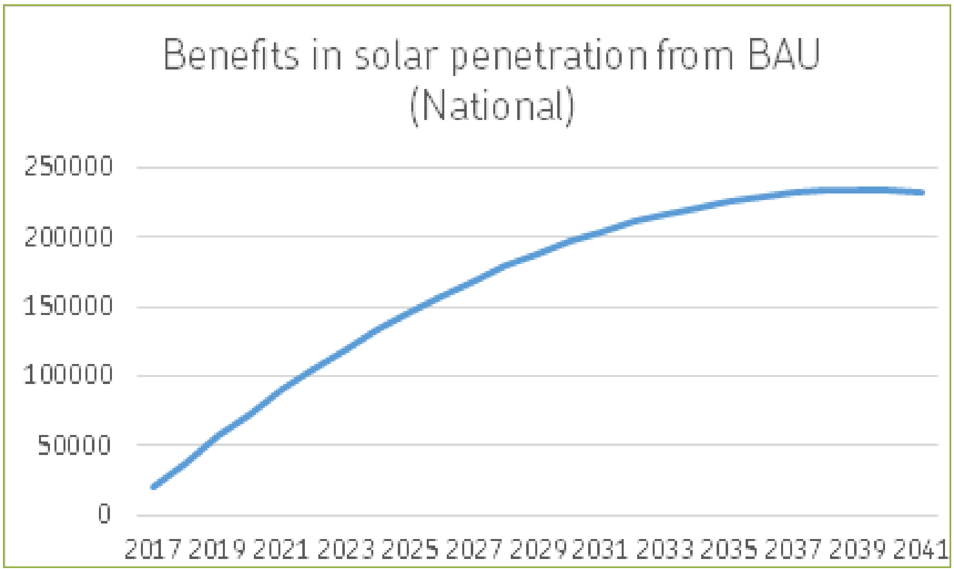


Figure 10: Potential Net Benefits of Microgrids on Solar PV Penetration

5 http://www.energycouncil.com.au/Library/PageContentFiles/14251626-ae50-48a1-8fb0-70841eae409f/ESA002_factsheet_renewables.pdf

3.3 Other social benefits of Microgrids

3.31 Benefits for Developers

This Measure is concerned with the application of Microgrids in land and housing developments. The project at the centre of the study Huntlee is a new town so by definition represents an extension of the existing grid.

Often large new developments such as Huntlee present an ideal application for Microgrids:

- Typically these areas have high headworks charges (ie charges for getting utility infrastructure to a site)
- Developers are trying to differentiate themselves with innovation and sustainable product
- The new trend towards integrated infrastructure that takes advantages of synergies between infrastructure (the energy/water nexus)
- New build does not have the legacy infrastructure of infill infrastructure
- Given these are often 30 year developments, deploying future-ready infrastructure is a critical decision at the start of a development

In the case of Huntlee, the drivers were primarily sustainability, affordability and innovation. The area is relatively well serviced given its position in the Hunter Valley, an area that has been at the centre of coal-fired generation for NSW. Even with this infrastructure the headworks charges are as high as $9 M for the life-cycle of the development.

There are many limitations in our current infrastructure delivery model that do not allow developers to deliver new homes in the best possible manner to create liveable and affordable communities. The objective of HETA was to challenge the way that land is serviced by water, energy and telecommunications infrastruture.

The developer recognised the integrated benefits of combining local energy and water infrastructure (often referred to as the water/energy nexus). By driving appropriate water cycle management higher amounts of greenspace are available via locally sourced irrigation even during sustained heat-waves. This lowers heat island effect and therefore decreases the amount of energy draw from the community. At the heart of these types of principles is the idea of area specific economic systems that enable higher productivity, sustainability and liveability for new developments. It revolves around “fit-for-purpose infrastructure” and Microgrids are at the heart of this form of servicing land.

3.32 Electricity network planning benefits

To understand the overall benefits of microgrids to electricity planning it is important to look wider than new land and housing developments. A framework for a contestable market for microgrids will be based on its overall impact on the National Energy Objective (NEO). As such it includes existing edge of grid networks and other commercial and military applications.

The National Energy Objective (NEO) is outlined in Figure 11. In various parts of this report it demonstrates that microgrids deliver benefits from the perspective of all of these criteria and more.

“promote efficient investment in, and efficient operation and use of, electricity services for the long term interests of consumers of electricity with respect to:

(a) price, quality, safety, reliability and security of supply of electricity; and

(b) the reliability, safety and security of the national electricity system”

In many quarters the approach to be successful the edge of grid model will need to demonstrate that it aligns with this objective.”

Figure 11: National Energy Objective

Figure 12 (Australian Energy Regulator, 2015) identifies that the cost to distributors for providing network services increase as they are forced to service areas of lower customer density. The place for Microgrids is the ability to service new land and housing developments which are inherently low density, in ways that reduce the cost borne by the local distributor, but reduces the overall socialised cost to the network, as that local community is served in manner that is fit-for-purpose.

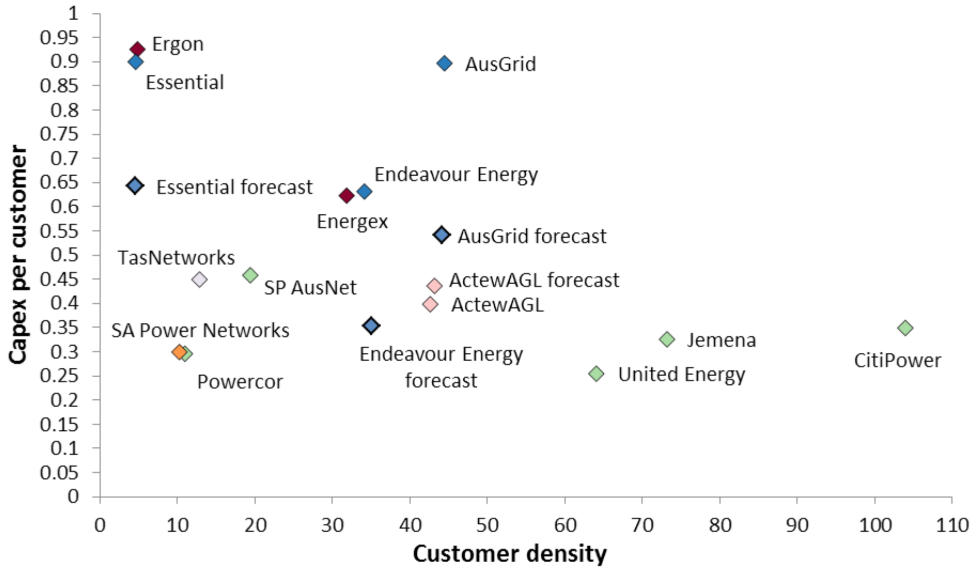


Figure 12: National CAPEX per customer against customer density AER

A reference for the types of savings that could be achieved was presented in Thorpe, 2015 also outlined that there is 100,000 km of network that could currently be classed as edge of grid. They stated that if "a ten percent saving in only ten per cent of these lines were available for a Microgrid, the saving would be of the order of $50M, far outweighing the likely cost of regulatory and policy changes needed to facilitate the option."

In another report created by AECOM for ARENA another key market that (AECOM, 2014) identified is mines and communities being run on diesel generators:

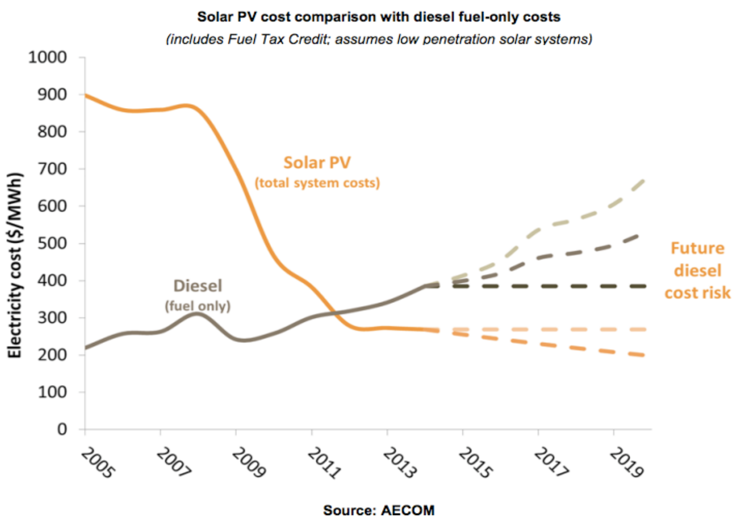


Figure 13: PV cost curve vs diesel cost curve

"over 1.2GW of diesel generation capacity installed in off-grid Australia which supplies electricity to mines and communities at a cost of $240-450/MWh in fuel only (excluding capital costs). These costs are expected to rise over time and are vulnerable to price shock events or supply chain interruptions in international markets."

3.33 Economic Value Streams

The economic value streams created by Microgrids are primarily derived from the value-capture of lower or nil (if off-grid) transmission use of system (TUOS) and distribution use of system (DOUS) fees, along with any fees associated with network losses given that the Microgrid uses 100 percent locally generated energy. The other value capture comes from greater ability to manage the critical peak within the community, creating a flatter demand curve – the holy grail of energy management.

In a well-regulated market, grid-connected Microgrids can also deliver benefits back to the grid through a transactive market for ancillary services. By aggregating loads and providing localised control, they have the potential to improve voltage profiles and postpone network upgrades (where thermal limits are key factor), control support, congestion management, reduced grid losses, improved power quality and provide black-start and grid-forming operation.

Value streams can also be achieved through improving price elasticity of the wider market as Microgrids reduce reliance on peaking plants with their ability to island at peak demand events.

To give one example, Dunstan et al (2011c, pp. 65-8) suggested that in the period to 2020 there is the potential for Distributed Generation (DG) to provide over 4000 MW of peak power at a lower cost than expanding centralised supply capacity. This represents about 10 per cent of peak power requirements.

The other economic value stream is created through deferral of infrastructure upgrades in the network. There are currently regulatory frameworks to capture this value such as the non-network options regimes that have been created by the AER.

All these value-capture streams can then be used to pay for the infrastructure, deliver an economic return to an investor in the infrastructure and then be used to deliver dividends to a community.

3.34 Power quality and reliability – a comparison with the Ausgrid Network

Microgrids can deliver not only higher levels of power quality and reliability but are also able to create various tiers of quality and reliability in a way that is fit for purpose. In the case of Huntlee, decisions can be made in the long term (once the community is more comfortable and engaged in the utility) as to whether compromises can be made on quality for some applications to drive prices down in the long term.

To understand the reliability of the Microgrid we created a comparison to the Ausgrid network. It is important to note that this network design and associated reliability assessment was done for 300 lots only. These numbers rely on scale and as we model a larger number of lots, the figures improve. Ausgrid's numbers are calculated on a full scale utility network and therefore yield a better result.

According to Ausgrid's Electricity Network Performance Report 2014/15, the urban feeder performance (normalized) trend comes to:

- 0.746 1/a actual SAIFI (average value based on the years 2010-2015) – target: 1.2 1/a
- 66.83 min/a actual SAIDI (average value based on the years 2010-2015) – target: 80 min/a

Given these assumptions, the calculated average frequency of supply interruptions for the Huntlee Microgrid is almost half of the actual SAIFI value for both scenarios. This relation is expected to still be valid when the generation units (Diesel generators and PV plants) are considered in addition.

With respect to unavailability performance, the values calculated for a minimised investment scenarios are exceeding both actual and target SAIDI. For the maximised scenario, calculated values are about 1/3 of the actual SAIDI and 1/4 of the target SAIDI. It is expected that if the minimised cost scenario is chosen, the actual SAIDI of Huntlee Microgrid would be closer to the range of the Ausgrid SAIDI mentioned above. The actual SAIDI is expected to be significantly better than Ausgrid's performance trend if one of the maximised scenarios is realised.

There is one good reason why Microgrids are currently primarily used by Military, Universities, schools and hospitals, they all demand reliability that is not provided by the wider grid.

An example of this resilience is that Hurricane Sandy cut power to 8.5 million people, including one million without power for a week and 60 percent of diesel generators failed for critical facilities. At the same time a 5 MW cogeneration plant and 5.3 MW solar Microgrid kept Princeton university live throughout. At the same time Oaks Hospital on Long Island was able to disconnect and operate for fifteen days using 1.25 MW CHP and 47 Kilowatts of solar.

In terms of Huntlee this resilience is further extended by the local water centre which will enable local generation of water from sewer for use in toilet flushing, clothes washing and irrigation.

3.35 Unlock housing supply and assist delivering the vision of developers

When developers look at new land, they have to consider the cost of servicing the land for essential services such as transport, water and energy. The Huntlee development was relatively well serviced from an electricity perspective however the infrastructure was still going to cost Approximately $6.6M net present cost in lead-in infrastructure costs in a business as usual basis. The local providers of power had a very uniform regulated process for engaging with the developer which means that they were not able to explore options such as the Microgrid.

FIGURE 1: HUNTER CITY'S DISTRICTS

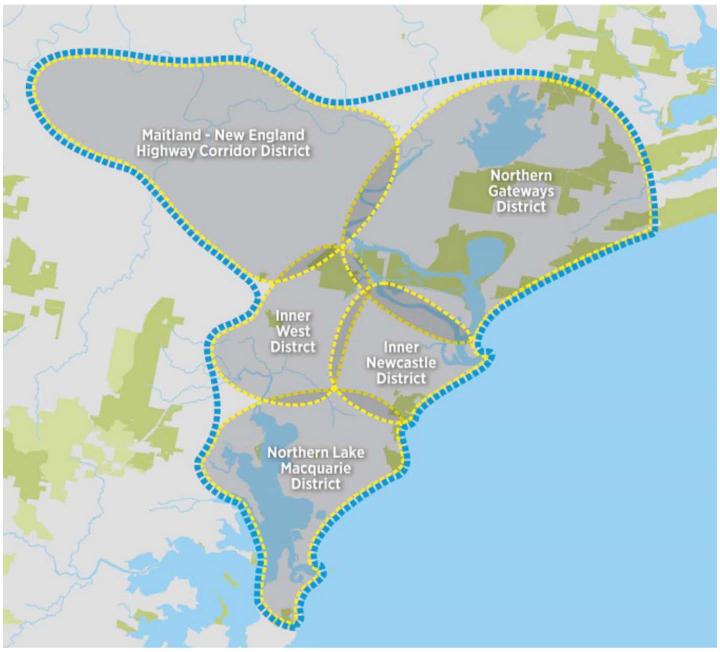


Figure 14: Hunter Regional Plan

In many cases around Australia development sites are not moving forward in prime locations because they cannot be serviced in an affordable and timely way. In the Hunter itself there is a demand for 60,000 new dwellings to 2036 (Hunter Planning, 2015)

The South East Queensland, SEQ, 2009-31 Regional Plan for priority development areas (PDAs) allocates 754 000, additional dwellings needed to accommodate the population growth in the south east region.

Another example is the NSW Government established the North West and South West Priority Growth Areas in 2005 to sustainably plan Sydney's growth on its urban edge. Over the next 25-30 years, the Priority Growth Areas will become new communities for up to 500,000 people with 181,000 homes

All of these developments will require significant infrastructure investment in the area. Typically investment needs to be staged in a way that allows for the extension of exising infrastructure, rather than allowing for "out of sequence" developments to occur. This stifles new developments which may be ideal for development, but remote from existing trunk infrastructure lines.

In land and housing developments, developers typically build infrastructure to the standards dictated by the local franchised distributor and then once that infrastructure has been verified they dedicate it to the network operator. For many years developers have tried to look at more innovative ways to reduce electrical infrastructure required, or defer the cost of the electrical infrastructure or ways to innovate within the current parameters. Microgrids deliver on these ambitions and will unlock development sooner and deliver a more innovative approach.

3.36 A manageable migration to future technology stack

Many of the same frustrations that are driving people to embrace Microgrids are similar to the frustrations that are driving people to buy battery and solar for home use even before they are economic. A thirst for sustainable and resilient supply with genuine sense of ownership is empowering for consumers.

The reality for the wider network and regulators is that if individuals start to defect from the grid to fulfil these desires it will be a far less manageable outcome than embracing the concept of Microgrids for applications such as Huntlee.

3.37 Potential for export growth market

At a time where Australia is seeking areas of competitive advantage to replace our mining industry, Microgrids present a natural area of competitive advantage. Australia has a 12 percent share of the world's Microgrid projects. Most of these projects are located in Western Australia where the MGs are isolated (Cornforth 2011).

Since 2011, there has been a rapid growth of mircrogrids globally. It is estimated that the Microgrid market will grow at a compound annual growth rate (CAGR) of 17 percent from 2012- 2022 to achieve a total installed capacity of 15 GW by 2022 (Smart Grid Australia 2013). The global Microgrid market stood at US $9.8 billion in 2013 and is expected to reach US $35.1 billion by 2020, according to a report from Transparency Market Research (Transparency Research, 2014) The report predicts Europe and Asia Pacific will expand Microgrid use in the coming years thanks to energy restructuring and supportive regulatory policies.

Perhaps the leading Microgrid initiative globally is being rolled out as part of New York State's "Reforming the Energy Vision " (REV). The goal of this vision is to drive regulatory changes to support reliable, resilient and affordable infrastructure. Microgrids are a feature of this development. The state established a US$40M competition for Microgrids, the outcome was 83 projects which were awarded US$100,000 to undertake feasibility studies.

Meanwhile, Connecticut is offering $30M in Microgrid funding. The Department of Energy and Environmental Protection (DEEP) issued the request for proposals (RFP) in November 2015 and started accepting proposals in December on a rolling basis. The state has already funded 11 Microgrids from two earlier project solicitations. This year could also bring pro-Microgrid legislation in Illinois and regulators in Pennsylvania have approved $100M in spending by PECO Energy on Microgrids. In Maryland, Baltimore Gas & Electric has launched a plan that could bring public purpose Microgrids across the central part of the state. Hawaii and Alaska continue to be meccas for Microgrid development.

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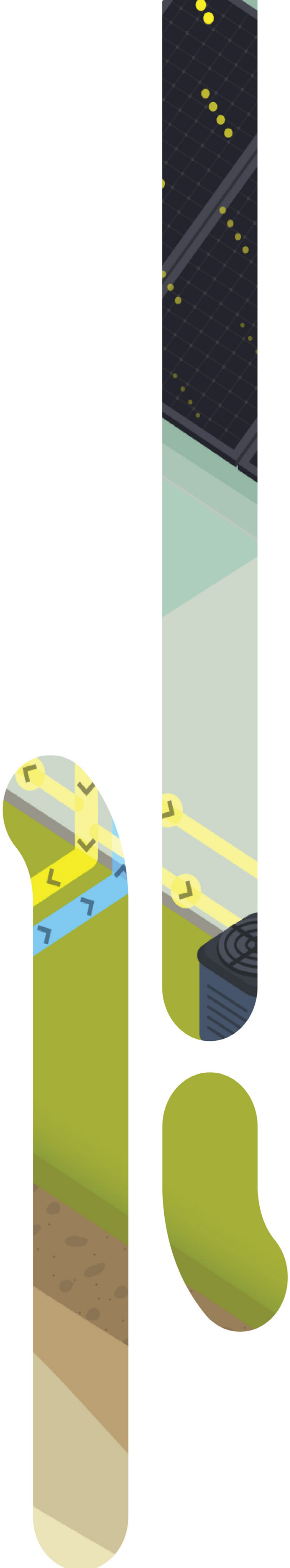
ECONOMIC REVIEW OF EDGE OF GRID MICROGRIDS



4. ECONOMIC REVIEW OF EDGE OF GRID MICROGRIDS

4.1 Key Assumptions

Before commencing what was quite an extensive and iterative modelling exercise, it was important to establish key assumptions to create a foundation of input parameters and place some boundaries around levels of detail and granularity, which would otherwise make this task almost impossible.

Using Huntlee as the case study and being a residential property development, there are a number of parameters that are determined by plans and physical constraints. Working with the developer, LWP, some assumptions were set around the dwellings.

- Lot Configuration
- Lot Uptake
- Roof Orientations
- Technology Choices for Major Consumers
- Air-Conditioning - Reverse Cycle
- Hot Water Systems - Electric

The next set of assumptions were around the energy generation assets. It was assumed that the mix will consist of solar PV arrays, battery storage, gas generators (co/tri-gen) and backup diesel generators.

Solar PV and Batteries

- Solar Penetration - Residential
- Solar Penetration - Commercial
- PV Array Capital Cost (Installed)
- Battery Capital Cost

Generators

- Gas Generator Capital Cost
- Gas Generators Maintenance Cost
- Gas Price - Commodity
- Gas Price – Fixed Monthly Charge
- Diesel Generator Capital Cost
- Diesel Generator Maintenance Cost
- Diesel Price

Because the Huntlee project spans over 30 years, it is important to consider the effects of escalators on costs. Most of these are common factors that are readily available and can be predicted with a reasonable level of certainty, such as inflation and wage price indexation.

There are however a few key sensitivities and dynamics that have significant impacts on the modelling and rely on advanced forecasting to predict. The critical factors for this exercise were determined to be battery capital costs, solar PV costs and gas prices.

4.11 Batteries

Firstly, we conducted some research on battery costs to understand what industry and experts are predicting. The following curve was constructed based on lithium ion prices which were sourced from a joint study between Melbourne University and IBM Research Australia. The starting price was based on advice from our technology partner Siemens, who are a major player in the utility scale storage business with their Siestorage solution.

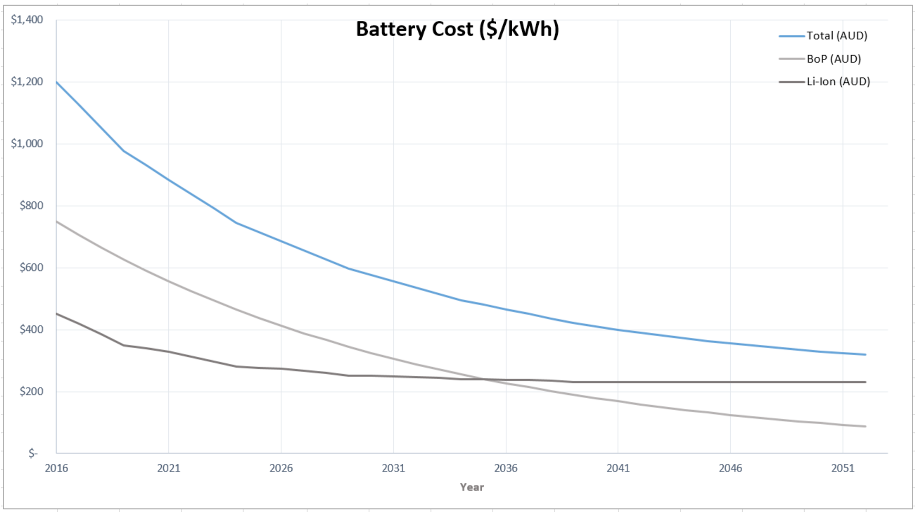


Figure 15: Battery Cost Curve

The results of the University of Melbourne study are also shown in the graph below. An average of these figures was taken to construct the escalator for our modelling. It was assumed that the cost of Lithium Ion used for centralised utility grade energy storage would be strongly correlated to the automotive market.

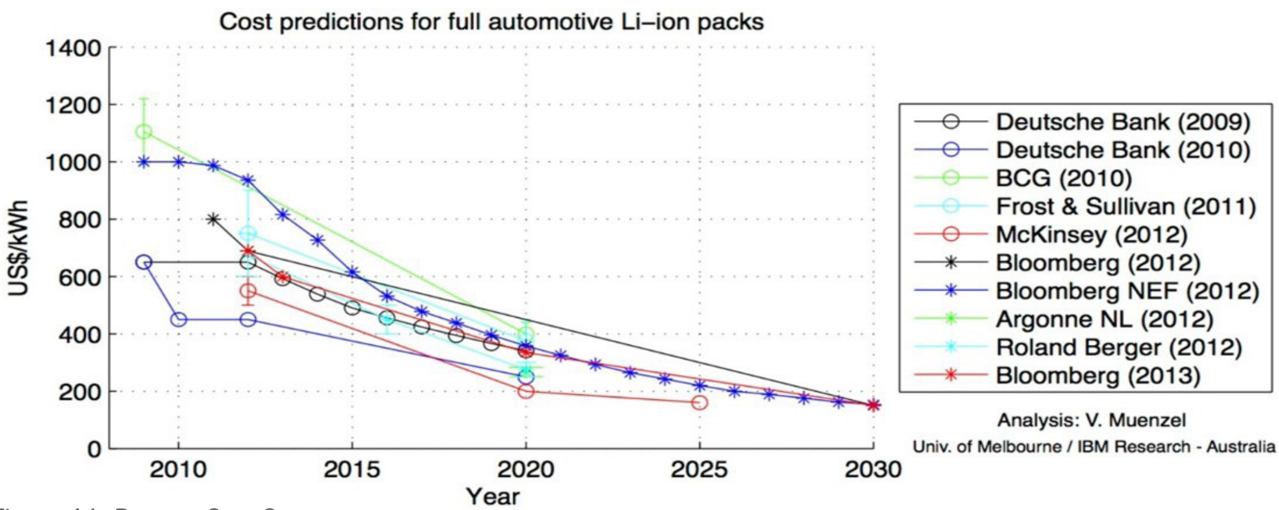


Figure 16: Battery Cost Curve

To determine the total cost of battery systems, the Balance of Plant (BoP), such as inverters and switchgear, was forecast to depreciate at a rate of 5.8 percent annually. This depreciation rate is based on CAGR of solar BoP from 2008 to 2014. This cost was then added to the cost of lithium-ion.

4.12 Gas

Due to the developments in Liquefied Natural Gas in Australia (LNG), gas prices have become harder to forecast as they are now affected by global markets. Gas generators will initially serve up to 70 percent of the total load in the Huntlee Microgrid, therefore the project will be very sensitive to gas price. As the cost of batteries comes down, it is anticipated that gas generation will only account for 45 percent of the generation mix, hence reducing the sensitivity to gas price.

The following chart was used to forecast gas prices. It was obtained from Frontier Economics' 2015[6] assessment of the Australian gas market.

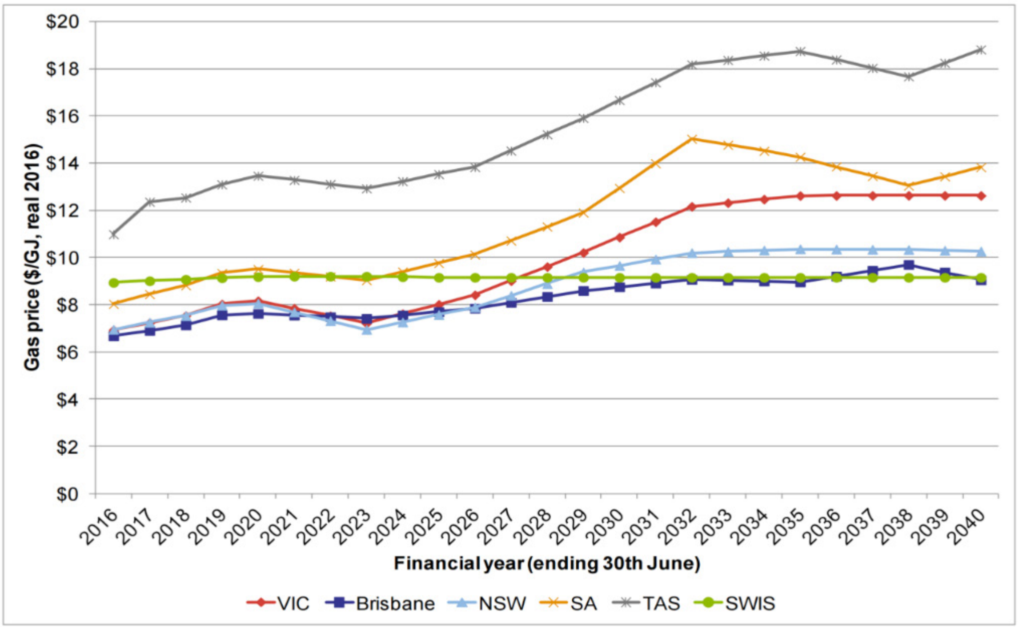


Figure 17: Gas Price Curves

This forecast has factored in demand for gas, international LNG prices, foreign exchange rates and underlying resource costs associated with gas extraction and transport.

4.13 Solar

Using a number of sources such as the 2015 PV Market Outlook by Bloomberg New Energy Finance and reports by the U.S. based National Renewable Energy Laboratory, we constructed the following cost forecast for PV panels.

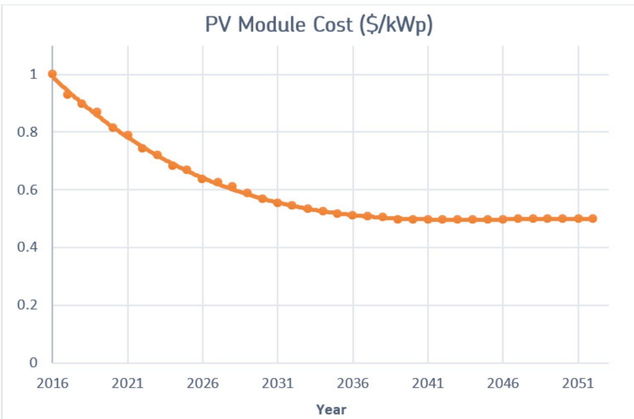


Figure 18: PV module cost curve

6 http://aemc.gov.au/getattachment/c0d9afe1-d082-471e-ba89-c36b342838a3/Frontier-Economics-%E2%80%93-2015-Residential-Electricity.aspx

4.14 Other

A summary of some of the other key escalation assumptions is provided below.

Description	Value	Source
CPI	2.5%	RBA Target
Gas and Diesel Generator CAPEX	2.5%	CPI
Network CAPEX	2.5%	CPI
Metering, Telemetry and Controls	2.5%	CPI
Wage Price Index	3.5%	Australian Bureau of Statistics

Table 7: Inflators

4.2 The Modelling Process

Having established the modelling assumptions, an extensive modelling process was conducted to establish the optimal generation mix, equipment staging and financials.

4.21 Establishing the Load

We partnered with Kinesis to establish load curves for the dwelling types that are expected in the Microgrid. These load curves factored in aspects such as temperature, insulation, occupancy and types of appliances. Then working with the developer, the proportion of each dwelling type in the development was established.

This data was then fed into an aggregator, which produced an electrical load curve at hourly intervals for each year. For example, for the year 2018, when the development reaches 400 dwellings, the load curve looks like:

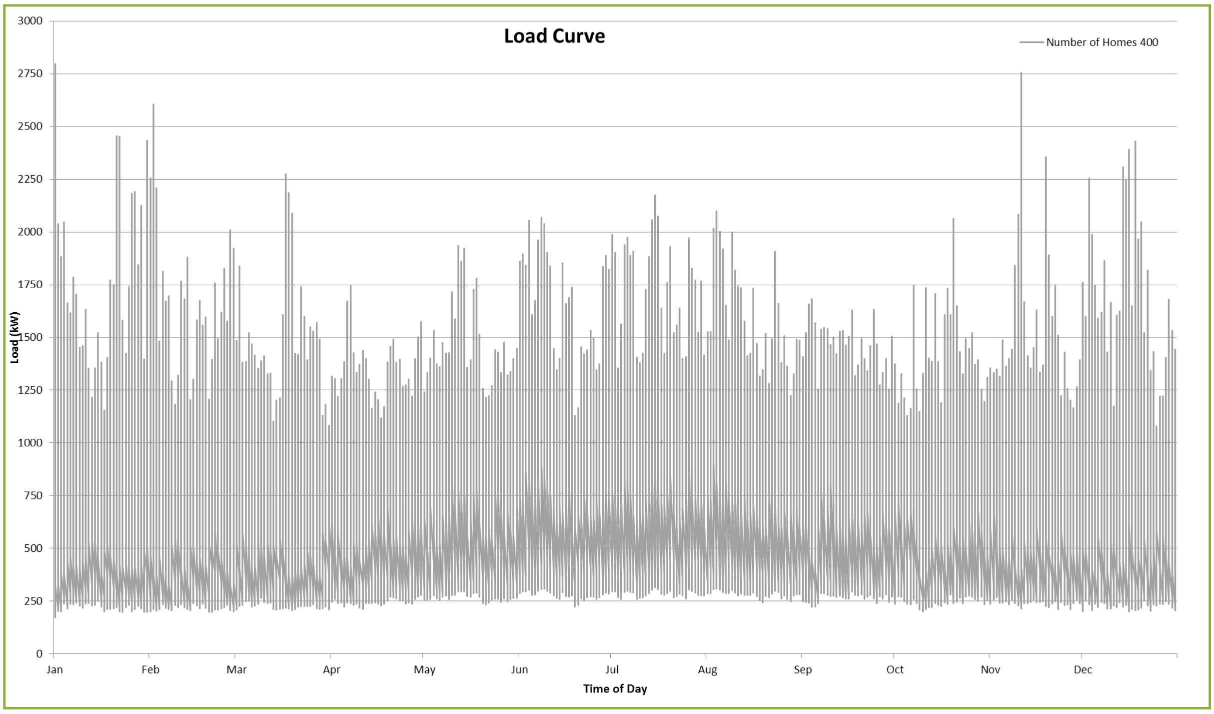


Figure 19: Huntlee forecasted load curves

4.22 Optimal Generation Mix

All of the information above was then fed into HOMER Pro modelling software in order to determine an optimal generation mix to service the load. Key outputs were then extracted and entered into BEA's financial model.

These numbers were key inputs to the financial model because they drove the operational costs of the system and fed into emissions calculations.

4.23 What about grid defection?

Energy Networks Australia (ENA) estimated that off-grid parity would occur in 2030 at a home level (Energy Networks Australia, 2015). It is anticipated that government policy would still enforce some network fee availability charge to apply at this point.

Our model assumes up to 35 percent of homes install their own solar panels, but that only 5 percent of homes completely defect from the grid.

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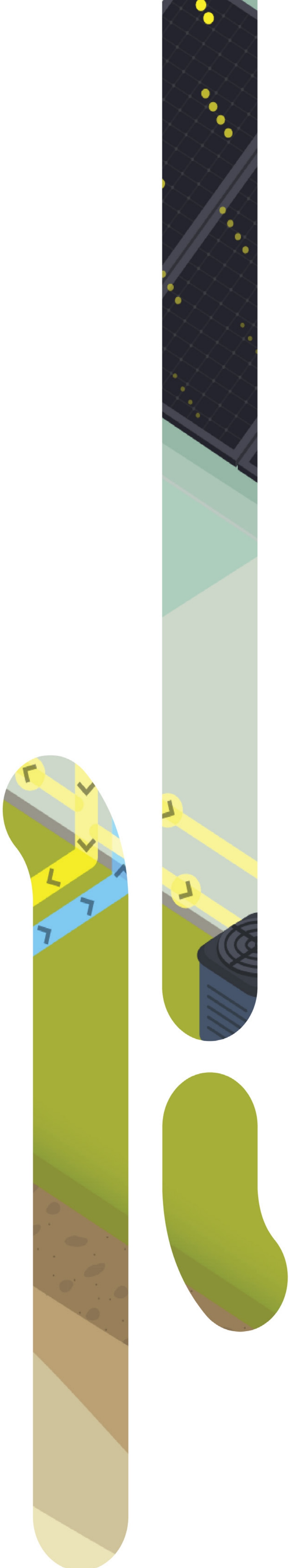
TECHNOLOGY ASSESSMENT



5. TECHNOLOGY ASSESSMENT

5.1 Control Systems

At the heart of the Microgrid, and what differentiates them from other renewable deployments is the sophisticated control system. Microgrids are able to exceed the performance of macrogrids due to the high level of visibility into system parameters through advanced telemetry. They are also highly automated by using control systems that can act quickly and with minimal operator intervention.

A microgrid consists of a number of distributed generation sources, energy storage devices and loads. Within this system there are various complex dynamics that must remain balanced in order to maintain a healthy network. These include real and reactive power flows, voltage regulation, frequency regulation and fault detection.

Distributed generation sources such as synchronous generators and inverters are capable of locally controlling their output via droop control algorithms in order to share power and regulate the voltage and frequency of the network. These localised control strategies are promising in enabling multiple units to be connected in parallel with minimal interfacing and communications requirements.

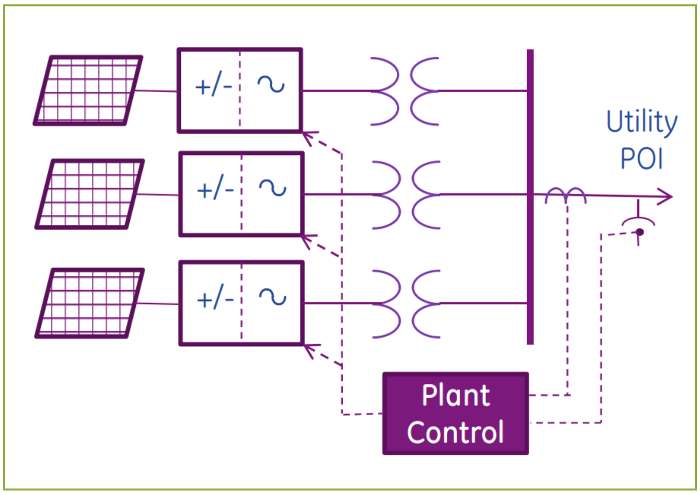


Figure 20: Cetralised PV control System (Source: http://www.uwig.org/mauisolar/Walling_Self-Mitigating_PV_Plants.pdf)

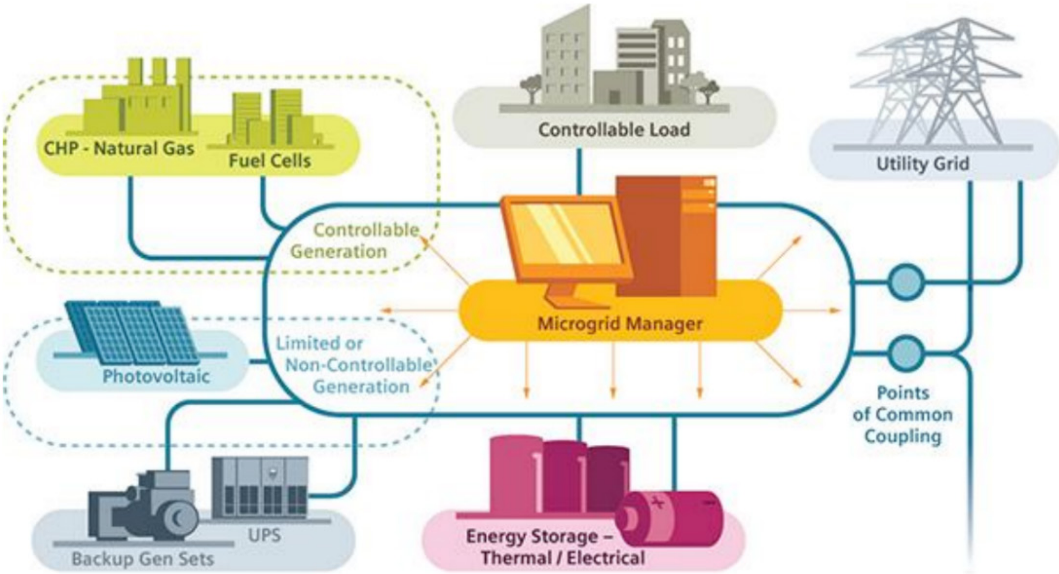


Figure 21: Microgrid management concept

The Microgrid Management System (MGMS) is capable of operating the system in a proactive manner using historical data and weather feeds. It does so by pre-emptively starting up generators in anticipation of a peak due to anticipated hot weather based on the time of day or other historical information.

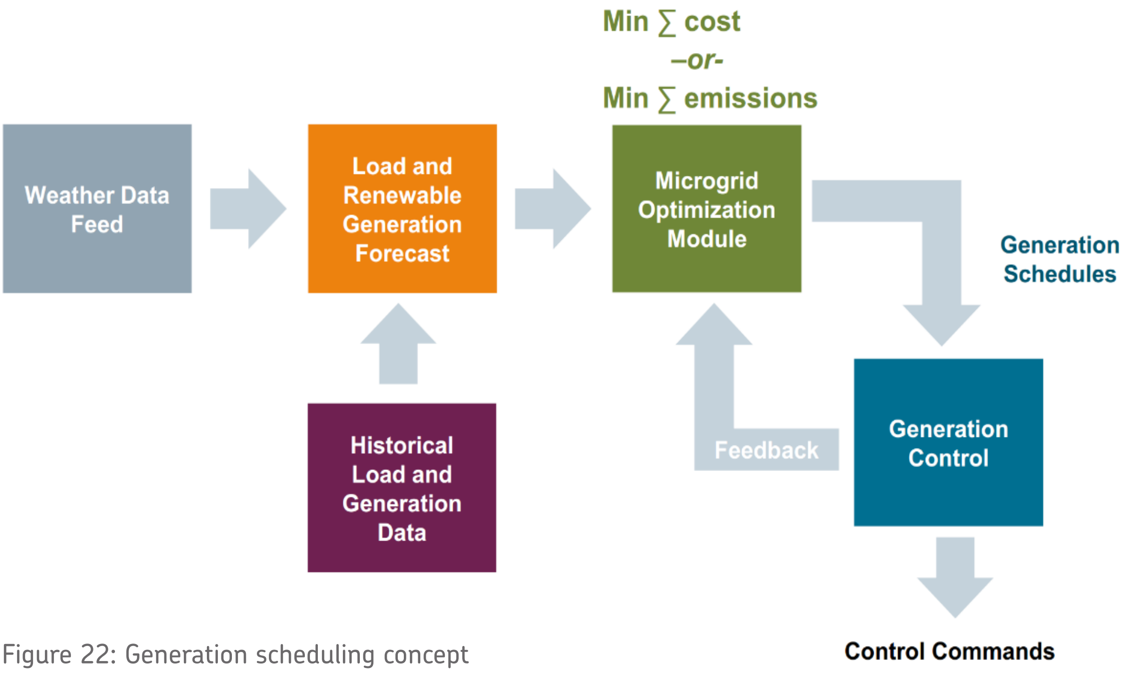


Figure 22: Generation scheduling concept

The MGMS pulls all of the components of a Microgrid into one central place and in doing so allows an operator to monitor the whole system from one location and make any adjustments to control strategies if necessary.

5.11 Huntlee Microgrid Manager (HMM)

The HMM is the system-level control software necessary to serve the needs of the Huntlee Microgrid. The MGMS will talk to multiple sub systems via DNP3 and / or MODBUS all over Ethernet. The Subsystems will be:

- Conventional Generation Control
- Battery Storage System
- Solar Generation
- Home Energy Management Systems
- Generator + Distribution Substation
- Weather Systems
- Sky Cameras

The overall function of the HMM will be the optimal coordination of dispatchable generation (gas and diesel generators), renewable generation (PV), energy storage (large centralised battery), and in some cases residential load (via aggregated Home Energy Management System (HEMS)).

In order to do this, the HMM will need to forecast the load and PV output of the Microgrid, then optimally schedule the energy storage and gas generators to minimise production costs while ensuring frequency and voltage stability.

The HMM must also manage a set of defined conditions or contingencies to uphold reliability in unfavourable conditions. These conditions include the unforeseen tripping off of a generator, excess generation due to PV output being greater than system load, transferring load from gas generators to the diesel generators when necessary and managing any emergency reconnection to the larger AusGrid network.

5.12 Control Strategy

The automation system is responsible for the optimal operation and reliable control of the hybrid power plant. The main functions of the automation system are:

- Automatic mode for normal operation requiring operator intervention only for unusual or critical events
- Management of power quality relevant factors which at a minimum include operating reserve, frequency and voltage control, short circuit current availability, redundancy condition requirements
- The economic optimization of energy production over the lifetime of the plant
- Local operation and control interfaces
- Local engineering and maintenance interfaces
- Event logging including faults, alarms and selected events
- Web-based monitoring to allow remote evaluation of plant performance and status (e.g. for management)
- Remote access to allow technical support for planned and corrective maintenance

The Hybrid Plant Optimizer (HPO) optimizes the operation of all generation units. Depending on the process plant operation, a load forecast can be implemented. The State of Charge (SoC) of the Energy Storage System (ESS) and the volatility of the renewable sources such as wind[7] and PV are predicted and managed. Functions are also implemented that ensure the generator start/stop and minimum operating limits are not exceeded. This control is to be optimized over 24 hours. When the ESS is full this may lead to curtailment of the renewable systems.

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7 N.B. This functionality will not be utilised at Huntlee as there is insufficient wind resource.

The Hybrid Plant Controller (HPC) manages the dispatch of different generators (gensets, wind, PV and storage). This includes ensuring various redundancy conditions (if required), sufficient operating reserve for load and the renewable systems, availability of grid forming units and that minimum short circuit current requirements are met at all times. In addition, the HPC provides a local Human Machine Interface (HMI) and monitoring of the hybrid system on a web-based internet portal. This allows world-wide remote access on a secure platform to up-to-date information on the plant performance and status.

The volatility of renewable resources, in this case PV systems, means that extra operating reserve must also be provided in addition to the operation reserve for the load. A cloud movement can cause the PV generation to decrease by 85 percent in less than a minute. The cloud tracking system uses cameras to take sky images and uses proprietary algorithms based on flow tracking, segmentation and back propagation modules to predict the volatility of the renewable energy source over a 1 - 15 minute period. This time is more than sufficient to identify critical events and ensure that additional gensets are started and ready to provide generation before they are needed. This control strategy ensures that the load is optimally supplied at all times while avoiding unnecessary starts of the generators and maximizing their lifetime and plant operation.

Security

The ongoing convergence of a number of trends over the past several years has led to a continuous elevation of the importance of cyber security. The security-related features of the control system are based on international standards such as NERC CIP, ISO/IEC 15408 (Common Criteria), ISO/IEC 27002:2005, and BDEW.

5.13 Communications Infrastructure

All of these smart technologies require a communications network that can transport large amounts of data, quickly. The best fitting solution is to use a fibre optic network which as an added benefit to the community can then also be used for meter data and other services such as community Closed Circuit Television (CCTV) and local television stations.

The communications infrastructure for a smart network is detailed and extensive- this is particularly the case for the Huntlee utility. It is beyond the scope of this report to address communications infrastructure, however this study identifies communications for off-grid communities as an essential and changing area that needs coordination, investment and alternative solutions.

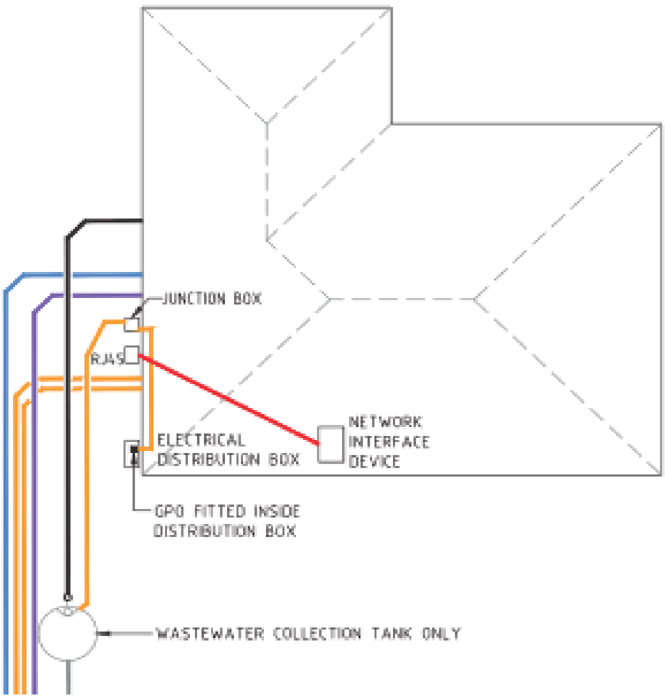

Figure 23: Converged metering and telemetry network Huntlee

5.2 Home Energy Solutions

The proving study involved review of the market for home energy solutions. These included Solar PV, inverters, hot water systems (electric, gas, heat pumps), and multi-purpose geothermal heat pumps (which can be used for air-conditioning and hot water).

To evaluate the various options a functional requirement list was created that set out the key criteria to enable comparison as far as possible. These were based broadly on technical, commercial and aesthetic criteria.

- CAPEX
- Reliability
- Operating costs
- Warranty availabilities
- Expected life
- Performance criteria (differs for each)
- Carbon Efficiency
- Risks
- Aesthetics
- Simplicity – installation, metering, operations
- Demand management capabilities
- Performance under target climate
- Value added functionality

This exercise had a number of purposes. Firstly, it enabled the evaluation of complete "Home Energy Solutions" that could be promoted to Huntlee residents and then to compare them to business as usual approaches. Secondly it enabled an understanding of the impact of these solutions for the overal Microgrid performance from a demand management standpoint. Thirdly, this exerise created a baseline for understanding whether the local utility could fund anything beyond just the solar panels.

In addition to these considerations, we had to consistently evaluate whether the offerings we were articulating would be attractive as packages for end residents, and furthermore would be accepted by home builders as part of the package they would accept when delivering their standard home designs.

These solutions were then considered from an end customer perspective and "bundles" were created for the market research. Through the process of market research and the finalisation of the modelling exercise it was found that there is not sufficient benefit in influencing the specific home energy systems that are purchased by a customer when you have control of an entire Microgrid. The key objective is about control and ensuring that systems installed in the Microgrid had compatibility with selected control system approaches.

The main challenge to any form of specified systems is the supply chain with home builders. It is anticipated that the relationship with home builders will be further developed as the Huntlee Microgrid is implemented over the coming 3-5 years.

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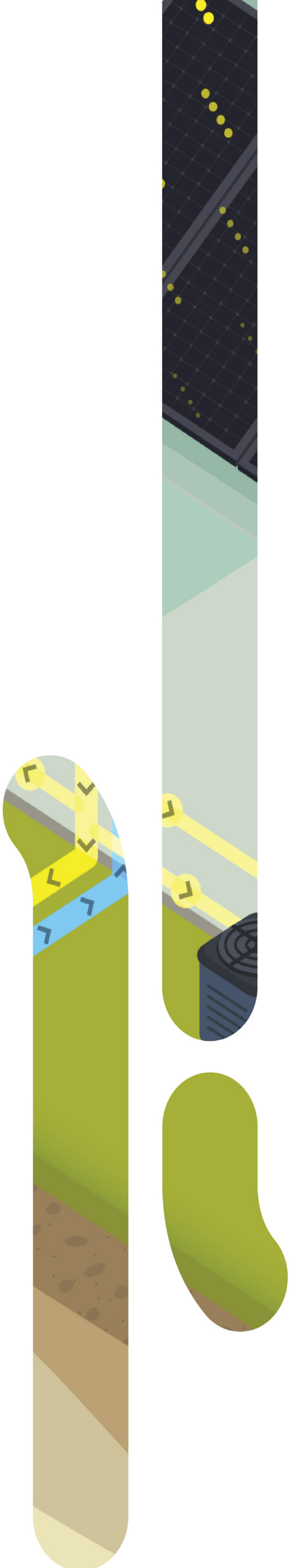


LESSONS LEARNT

6. LESSONS LEARNT

As mentioned, the Huntlee Energy project started in 2013 with the formation of the HETA alliance. During that period there have been many lessons learnt. Along with solar, batteries and gas generation, significant research was conducted into energy efficiency, biomass supply chains and thermal networks. The project has also explored many alternative ownership models for integrated utilities and the synergies between utilities.

This section will address in more detail the key learnings around stakeholder engagement and understanding of the current regulator position with respect to Microgrids in Australia.

6.1 Market Acceptance

6.11 Council requirements

BEA and LWP met with Cessnock City Council on the 25th of October 2015 to present "innovative energy supply options" for the Huntlee development. The meeting was facilitated by Council's Director of Planning and Environment, Gareth Curtis.

Cessnock City Council indicated strong support for the Huntlee Energy concept during the meeting. Whilst decisively positive, the council did raise the potential issue of purchasing non-contestable energy supplies from Huntlee Energy Retail.

Irrespective of this requirement, the advice from Baker and Mckenzie suggests that the council would not be denied access from Ausgrid for services, and they could therefore contest our services. They would simply need to pay for Ausgrid lead-in works to their facilities.

6.12 Home Builder requirements

It is beyond the scope of this project to conduct extensive research into the home builder market in Australia. Home builders are a critical link in the development supply chain. Some major developers both sub-divide land and physically build the homes. In many other developments, the developer sub-divides and services land and allows builders to then sell packages to home purchasers.

Huntlee is the latter scenario and this creates some complexity for implementing home energy solutions. Our initial engagement with home builders indicated that deep engagement with them for the purpose of customisation of home energy solutions would be a fairly extensive exercise. This engagement process will be launched as the first homes are implemented. In addition an “innovation home” will be constructed and used as a means of demonstrating best practice to builders.

Through the modelling it became clear that the benefits of tailored home energy solutions did not outweigh the costs of compelling homebuilders to participate in the scheme at this stage.

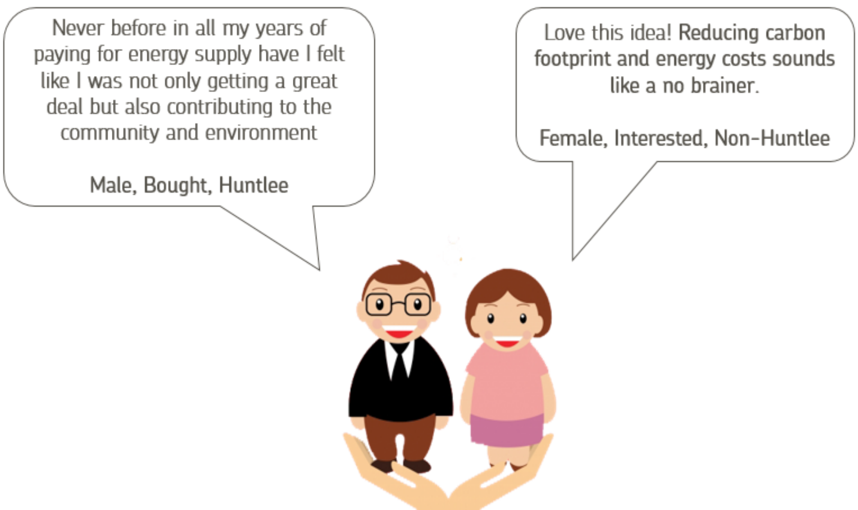
6.13 Customer requirements

The viewpoint of the customer within Huntlee was tested in a comprehensive market research exercise conducted by the Behavioural Architects. The goal of this exercise was not only to understand the potential reactions to aspects of the products, but also to find a path to create a “behavioural objective” which is to maximise the value that new home buyers see in the Huntlee Energy Utility concept and products.

The Behavioural Architects’ method relies on psychology and how to promote change, which is appropriate given the ground breaking nature and ambition of the products and project being developed with the support of LWP and the ARENA grant. They explored people’s behaviour and what their anchors are for making decisions on their energy provider and their household products.

Flow Systems wanted to carry out research to help define the thresholds and boundaries around market acceptance of energy products at Huntlee, and to specifically understand:

- Attitudes to sustainability and the Huntlee concept
- The attractiveness of the different packages at Huntlee
- Consumer price sensitivity



The key underlying question was: How do we get home buyers to purchase an energy package at Huntlee and be satisfied with their choice?

As a Behavioural Change research exercise it is important the research was conducted as close to the real world as possible. For this reason we ran a self-ethnographic exploration of each respondent's behaviour over the course of 5 days.

All respondents were either Huntlee landowners, interested in Huntlee land or buyers in other developments so we were able to get close to the real decision on the energy packages by putting them in the context of their current situation and the choices they will have to make.

Some of the key outcomes were:

- Customers were generally very positive about the concept
- Customers were attracted to the inherent sense of efficiency
- Price was the key motivator of acceptance
- Customers liked the co-operative structure with dividends. They associated it closely with the overall community concept of Huntlee
- Customers liked the innovation and associated it with a higher quality development Most concerns were due to mis-interpreting the packages and can be resolved through final packaging
- People were comfortable with the service level guarantees we are proposing
- People liked the fact that they don't have to maintain their equipment
- Interestingly, people did not question the concept and not a single respondent wanted to opt-out of the concept

That sounds like a good concept and it is good to know that you get dividends at the end of the year. I would want the rates of energy to be competitive to the larger companies as well.

Female, Interested, Huntlee

Sounds good and who doesn't like dividends!

Male, Bought, Huntlee

The good thing about Huntlee is that it is a community focussed development which puts the power (sorry about the pun) in the hands of the residents rather than large corporate suppliers.

Male, Interested, Non-Huntlee

I love how it's our own communities supply

Female, Bought, Huntlee

6.2 Technical Lessons

6.21 Complexity of metering and telemetry

The ability to install smart meters and telemetry as well as set up the smart grid communications is a considerable challenge. The reason for this is that the NBN is the ideal carriage for utility communications however, to date this has been constructed as a closed network which cannot carry metering and communications for utilities. This means that to create a "smart" local Microgrid network a proprietary dedicated network would need to be installed with all the complexity of trenching arrangements and approvals required.

6.22 Limitation of modelling tools

During the modelling process, BEA evaluated two software packages, HOMER Pro and Siemens' SIMPSON. It was found that these tools are still very labour intensive, requiring a large amount of human input.
A development like Huntlee grows over 20 to 30 years. Over this time the load increases, prices change and new technologies are released. Having to model each year independently, entering data, making assessments and then extracting output data is very complex and time intensive.

A modelling tool needs to be developed that can automate the process of modelling a Microgrid for a real development like Huntlee. This model would ideally be able to accept escalators for pricing and load, and take into consideration any constraints such as physical space and other key parameters. It would then run the modelling year by year.

This would also solve an issue in tools such as HOMER Pro, whereby assets that were installed in previous years would already be included in future years, rather than having to be added and costs set to zero.

6.3 Regulatory Lessons

The High Level position that had been reached is that Huntlee Energy Utility is in a position where we can deliver services within the regulatory guidelines in an offgrid context. The process of arriving at this involved significant legal advice from Baker and Mckenzie and then the presentation of this advice to government and industry (including existing distributors in NSW and QLD) for feedback.

The key learnings from this process was that:

- There is a recognition that Microgrids will be a major market in the near future and will need more formal regulation. This project is being seen as a test-case;
- The application process that is most aligned with this concept currently is through the "embedded network" market. This market enables grid-connected multi-dwelling sites to become a commercial customer with respect to the wider energy market. In this application process there are deemed exemptions, registerable exemptions or individual exemptions . Feedback from the regulators was the Huntlee does not fit into either the deemed or registerable exemptions.
- The process of applying for an individual exemption would , in our view be as long as starting the engagement for regulatory change. The reason for this is that it would require public consultation and consideration by the AER board.
- We also found that it would be possible to get a "derogation" from the state government to operate, however again this would take significant regulatory engagement

The current outcome from this is that we will:

- Launch Huntlee as an off-grid community, in line with all advice from AER regarding our ability to operate the grid in this context
- Continue to engage with Ausgrid as the local distributor
- Continue the process of submissions to guide regulation in this space in concert with Ergon and other interested parties including Energy Networks Australia (ENA)

The more detailed analysis of our position is outlined below. The process included both off-grid and partially connected embedded network models, which ultimately we believe should both be regulated and accessible in a competitive context.

Other key learnings are outlined below:

	Off-grid	Grid-connected Embedded Network Model
Generation	Unregulated	PV exempt Co-Gen needs exemption
Retail	Unregulated	No deemed or registerable exemption. Requires individual exemption, however no existing classes Need a retail license
Network	Unregulated	No “deemed” or “registerable” exemption. requires an “individual exemption” – unlikely to fit existing classes, Exemption from requirement for distribution license under NSW ESA

	Off-grid	Grid-connected Embedded Network Model
ACCC/ACL	Consumer law and ACCC applies including EWON	Consumer law and ACCC applies including EWON
Customer contracts and pricing	Unregulated	Retail under NREL and NERR (If under retail authorisation) Distribution – basic obligations. If Distribution registration then obligations to connect.
Operators of Last resort	Generator, retailer and network of last resort - contractual	Generator – contractual Retailer of last resort – regulated Distributor – ambiguous – Under ESA IPART will be obligated to step-in

6.4 Commercial Lessons

6.41 Economics

A key aspect of this report is an analysis of whether this is financeable, and not what the current gaps are. Whilst the model showed a positive result, there were so many variables of high sensitivity that the project is not financeable without some government support at this stage.

To open up a wider competitive market, the key is the successful implementation of the Huntlee Project. This first project is carrying a significant risk that will be not be required in future projects, mainly with respect to contracual guarantees that will be provided to LWP and the community.

The other key driver is the cost curve for solar and batteries. By year 2025 it became cheaper to add solar and batteries rather than gas and diesel generation. This was a critical point as it not only reduces the levelised cost of energy, but reduces all the gas price volatility risk. At this point key prices had reached:

- Gas: 106% of base
- Gas Generator CAPEX: 125% of base
- PV CAPEX: 67% of base
- Battery CAPEX: 49% of base
- Battery BoP CAPEX: 58% of bases

6.42 Appropriate Commercial models

As described earlier, there are many benefits of Microgrids along with challenges in the existing network, such as increased distributed generation, that are leading to the propogation of Microgrids. Demand is also being created by the development of new business models.

Retailers are recognising that they could own a portfolio of Microgrids that collectively participate in the wholesale market. Distribution services operators are seeing opportunity to own the network and distributed generation and manage the schedule internally as well as trading between the Microgrid and the market (often called a DSO monopoly), (Hatziargyriou, 2009). There may be a liberalised local market where a variety of stakeholders participate in the local market for retail services and distributed generation sales with a centralised Microgrid controller managing load balance, import and export. Finally, where retail prices are high, consumers may choose to own their DG and minimise interaction with the grid to lower connection charges.

Energy Networks Australia has outlined that the future regulatory framework should promote innovation, contestability and fit-for purpose regulation. The current distribution monopoly model with regulated returns is ultimately not conducive to these outcomes.

Current distribution monopolies have confused incentives around innovations such as Microgrids. The complexity of regulated asset base business is that you may be incentivised to invest capital and gain access to operational funds which is then socialised across a network which has a wide variety of locational attributes. At the same time the massive franchise areas of these monopolies means that great efficiencies are seen from standardising on particular network infrastructure so as to minimise long term maintenance costs. This is not, however, conducive to the Microgrid concept which is fit-for-purpose.

Microgrids are higher risk and involve investments in generation at a localised level. This risk profile is not appropriate for regulated assets. The requirement and opportunity of Microgrids are the integrated investment in local generation and innovative retail and/or network services. In the current market there is no opportunity for a market player to deliver these services.

In an edge of grid Microgrid such as Huntlee, the concept is that there are many end customers who can benefit from aggregation of localised equipment.

To capture this value, LWP looked at a number of approaches. Initially the project invited the local distribution company to participate. It was difficult for them to participate at the time as they were invested in other innovation programs and there are no alternative connection arrangements and engagements. After that point a consortium of players investigated ways to empower the local community to become the owner of the Microgrid.

Eventually it became clear that while a Microgrid would deliver huge benefits for the community, it would not be prudent to create such complex asset for a local community. It became clear that the best model was a hybrid of privately designed, owned and operated, with a governance structure that was established by the developer for the benefit of the community.

(Kema, 2014) talks about four models:

- A distribution model
- A single user Microgrid
- A hybrid Microgrid
- A multi-user Microgrid

For Huntlee single user is not possible due to the nature of a residential development. A distribution model is not possible in Australia due to the regulatory environment as outlined above. The hybrid model involves a distributor owning the distribution but multiple users owning the generation. This approach is more appropriate for large scale customers interfacing with each other such as a campus connecting to a commercial building.

The multi-user model allows a business entity to own the infrastructure for distribution to multiple users. The benefit of this model is that it allows access to private capital which will drive wider adoption and greater innovation. There will typically be higher productivity (ie benefits of trade) due to the greater diversity of load. It also enables an entity with the requisite capability to trade with the wider grid, something that individual players would be unable to achieve.

The current model of the Huntlee Microgrid is for an independent distribution network operator to be established (BEA) who is the owner of the network, owner of the local generation and retailer to customers. Additionally there is a local entity established which has some level of governance in terms of rights and dividends from the Microgrid.

Under the current regulatory settings this is clearly the choice that provides the greatest outcome for all stakeholders. With grid-connected Microgrids a move towards retail contestability could be an ideal outcome, however would require Microgrids of reasonable scale and a market where it was possible for local generators to participate in the market (ie the local DSO would need to be recognised as a generator so that local power can be sold by other retailers).

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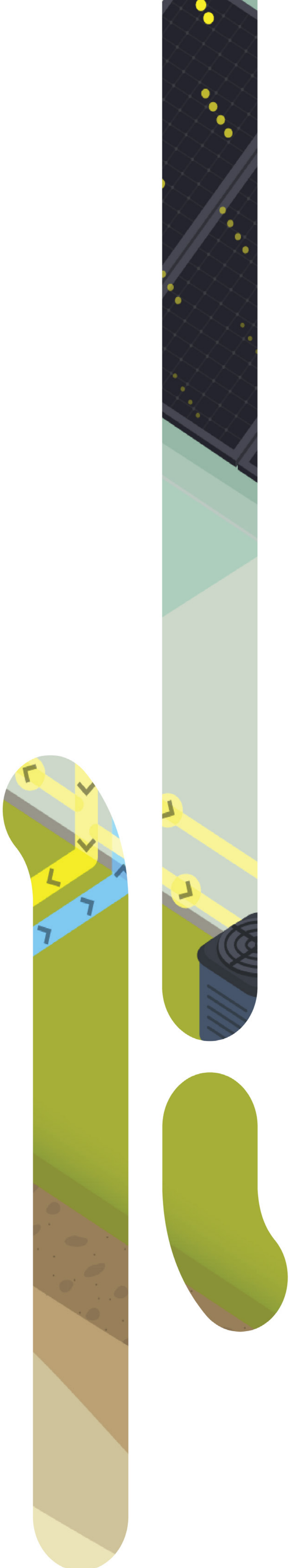
RESOLVING THE BARRIERS TO EDGE-OF-GRID MICROGRIDS IN AUSTRALIA



7. RESOLVING THE BARRIERS TO EDGE-OF-GRID MICROGRIDS IN AUSTRALIA

To be successful, Microgrids must meet a number of key criteria:

- They must be commercially viable for private sector and/or government
- Supported by a regulatory position
- They be acknowledged by regulators to deliver on the "National Energy Objective" and therefore implicitly have a social license to operate
- They must be technically possible
- Supported by a sustainable and competitive market place

Most of these barriers can be managed through the implementation of a live project such as Huntlee. The key barriers that need resolution in the short term are regulatory barriers which will enhance the benefits that can be accrued from these Microgrids.

7.1 Regulatory Barriers

7.11 Regulatory Recognition of Microgrids

It was important when doing the feasibility for this project that Flow investigated both grid-connected and off-grid scenarios to understand which scenario would optimise the outcome for the community.

The summary position of Baker McKenzie's advice and discussions with regulators was that (as outlined in the lessons learnt section), it is possible to run a Microgrid off-grid as an unregulated entity, so long as you have the capacity to meet the obligations of customers by giving them contractual comfort.

As soon as you become part of the wider grid or NEM which is the network that Huntlee co-joins, there is no clear regulatory framework for Microgrids. In particular the regulation of distribution networks does not seem to accommodate the concept and there is little regulatory direction for retailing and generation within a locally owned Microgrid.

To operate a local Microgrid at this scale the AER advised that Huntlee Energy Utility would be required to hold a distributor registration under the National Electricity Law (NEL) or be exempt in respect of its operation of the Huntlee distribution network. The AER considers:

- BEA would not be eligible for any deemed or registrable distribution exemption, due to the scale of the project;
- Although an individual exemption could be sought, the application would require significant time and resources to prepare and processing the application would take significant time;
- To grant an individual exemption in respect of a project the scale of the Huntlee Energy Utility would amount to a policy decision that the AER may not be willing to make in the absence of any higher level policy direction.

Seeking an individual exemption application would therefore be a relatively lengthy process.

Alternative approaches include:

- Seeking from the NSW Government a derogation for BEA from the requirement under the NEL to be registered as a distributor in respect of the Huntlee Network; or
- Engaging with the AER to pursue amendment of the Distribution Exemption Guidelines to include a deemed or registrable distribution exemption for entities like BEA in operating distribution networks like that at Huntlee.

7.12 Recommended approach to resolve this barrier

BEA's preferred approach to resolving this barrier is to start Huntlee as an off-grid network with a view to self-regulating in compliance with all relevant retail, network and generation rules and then working with the AEMC and AER to bring about either rule changes or new legislation.

There is good precedent and frameworks already in place in Australian Energy Law to support the recognition of Microgrids. This is a combination of rules around exempt retail and distribution networks combined with standard energy laws relating to the distribution and retail of electricity. These laws essentially would allow Microgrids to be treated as a single entity with respect to the grid, but allow for contestability for retail customers with customers having meters that are registered with the network. This reflects the drivers of 'power of choice' regulations.

BEA considers that the regulations under which the market in the United Kingdom operates which has a class of operators categorised as Independent Distribution Network Operators (or IDNO's) is an ideal starting point for a framework as it has solved many of the regulatory gaps that exist in our current legislation.

IDNO's develop, operate and maintain local electricity distribution networks. IDNO networks are directly connected to the Distribution Network Operator (DNO) networks or indirectly to the DNO via another IDNO[8]. This model identifies conditions for which all DNO's will need to be accountable, and then specifies those for which an IDNO are exempt.

Some of the key regulatory issues that this legislation resolves are:

- Interconnection rules
- Standby charges
- Pricing and tarriff structures
- Financial ring-fencing
- Boundary equipment
- Last resort supply
- Obligations to supply
- Powers for compulsory purchase of land
- Power to undertake street works
- Credit cover
- Operator of last resort

8 https://www.ofgem.gov.uk/electricity/distribution-networks/connections-and-competition/independent-distribution-network-operators

This regulation was not, however created specifically for Microgrids and as such the regulator would necessarily need to look at issues such as:

- Recognising the environmental benefit of Microgrid's
- Recognising the network benefits derived from Microgrids when establishing funding for non-network options
- Formalising obligation to serve regulations within the Microgrid
- General application of National Electricity Retail Law
- Net metering requirements for power co-mingled between the Microgrid and from the macrogrid
- Recognition of the resilience benefits that are delivered by Microgrids when establishing funding for networks
- Standard form contracts for customers

These are just some of the areas that are covered and there are existing regulations which are effective starting points. For example the existing regulated connection process for new land and housing developments (outlined below) is a suitable starting point for a process of connection of a Microgrid.

To have a functioning competitive market, technical standards must be implemented to support common interfaces and communications. These standards must be open enough to allow a variety of business models and end user flexibility. Engineering specifications (such as IEEE 1547), the communications requirements, information exchange and monitoring, control and telemetry requirements are critical. (California Public Utilities Commission , 2014)

7.2 Solving barriers through implementing the Huntlee Microgrid

Many of the other barriers that exist can be over-come through the successful implementation of the Huntlee Microgrid. Such barriers include:

- Developer acceptance of Microgrid models. Acceptance will come through the ability for developers to see live and successful models
- Financeable models- a test case will validate the financial model constructed by Huntlee
- Commercial models will evolve from the implementation of a live model
- Customer acceptance – being able to point to an existing reference site will be the best way to overcome any customer issues.
- Batteries/solar pricing – having large scale project will engender confidence in local suppliers who will be willing to offer volume discount term pricing, manufacture locally.
- Metering of converged networks – a significant challenge in this project is the ability to meter a smart network when the NBN is a closed local network. This should be resolved as soon as possible with local essential services being able to utilise the local broadband service to avoid the unnecessary duplication of telemetry services that occurs today.

Bibliography

AECOM. (2014). Australia's Off-Grid Clean Energy Market Research Paper . SYdney: Australian Renwable Energy Agency.

Australian Energy Regulator. (2015). Final Decision Ausgrid distribution determination 2015-2019 Schedule 6. Sydney: AER.

California Public Utilities Commission . (2014). Microgrids: A Regulatory Perspective. Sanfransisco: California Public Utilities Commission .

Energy Networks Australia. (2015). Electricity Network Transformation Roadmap. Sydney: ENA.

Hatziargyriou, N. (2009). Advanced Architectures and Control Concepts for More Microgrids. Greece: European Commission .

IPSOS. (2015). Establishing social license to operate large scale solar facilities in Australia : insights from social research. Canberra: ARENA.

Kema. (2014). Microgrids - Benefits, models, barriers, and suggested policy initiatives for the Commonwealth of Massaschusetts. Massachusetts : Massachusetts Clean Energy Centre.

King, D. (2005). The regulatory environment for interconnected electric power micro-grids: insights from state regulatory officials. CEIC-05.

Marnay, C. (2008). Policy Making for Microgrids. IEEE Power and Energy Magazine, 66-85.

Martins, V. (2011). Active Distribution Network Integrated Planning Incorporating Distributed Generation and Load Response Uncertainties . IEEE TRANSACTIONS ON POWER SYSTEMS, VOL. 26, NO. 4, NOVEMBER 2011 , 2164.

More Microgrids Project. (2009). Advanced Architecture and control concepts. Greece: European Commission.

Navigant. (2015). Community Microgrid - Case Study and Analysis report. Burlington: New York State Smart Grid Consortium.

OfGem. (2005). Regulation of Independent Electricity Distribution Network Operators . London.

Planning, D. o. (2015). Draft plan for growing Hunter City. Newcastle: Department of Planning.

Thorpe, G. (2015). Assessment of edge of grid regulatory and policy framework. Sydney: ESSA.

Transparency Research. (2014). Microgrid Market - Global Industry Analysis, Size, Share, Growth, Trends, and Forecast 2014 - 2020. Toronto: Transparency research.