Indra Monash Smart Energy City

Lessons Learned

March 2022

Indra Monash Smart Energy City Project
LESSONS LEARNT REPORT #1

Project Details

Recipient Name and website	Indra & Monash University https://www.monash.edu/net-zero-initiative/facilities/microgrid/smart-energy-city
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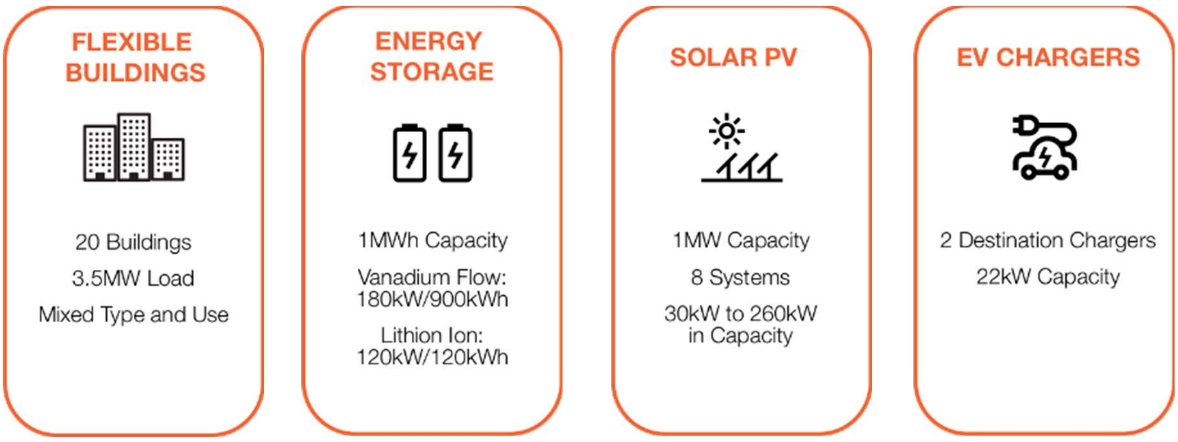
EXECUTIVE SUMMARY

The Indra Monash Smart Energy City platform is an advanced precinct-scale microgrid developed and implemented at Monash University's Clayton campus in South East Melbourne. The microgrid provides a much-needed 'test-bed' for developing solutions to the very challenges outlined above. As a real-world implementation of a microgrid on a operational campus, it provides a realistic and useful platform for critical research into technological, business and customer behavioural aspects associated with the deployment, coordination and orchestration of distributed resources.

The microgrid includes the following assets:



Key drivers for establishing the Smart Energy City include:

- Assist Monash University in achieving their Net Zero carbon emissions by 2030 commitments
- Provide the ability to better manage energy costs
- Establish a 'living lab' to enables Monash and collaboration partners to:
- Demonstrate the integration and orchestration of DER
- Develop mechanisms for transacting the value provided by DER while maintaining
- system security
- Understand the interplay between behavioural sciences and user preferences and smart
- energy management
- Increase understanding of cyber security and data governance issues and management
- strategies
- Determine the overall value represented by such a system as an input to future microgrid
- business cases

The project has received funding from ARENA's advancing renewables program.

The Indra Monash Smart Energy City Project has identified a number of key learnings over its duration, from a technical, governance, commercial and regulatory perspective.

Lesson 1 - Operational readiness, of both solutions and customers, is critical to enabling microgrid technology: The maturity of technologies has a significant correlation with the level of development effort required to make ready for integration and deployment. Further to this, the maturity of a customer/business in its approach to deploying and integrating these technologies also impacts on speed and ease of deployment. Under-estimating the effort required presents risks to project execution. Therefore, assessing technology maturity and operational and data readiness of selected solutions at the outset will enable better project design.

Lesson 2 - Data Governance is a critical enabler of smart energy management: A well-designed Data Governance Framework is a critical early-stage consideration for future projects where large and sensitive datasets are generated. Monash is working to establish a repository for research data in it's Secure e-Research Platform (Monash SeRP). This is a key initiative, particularly for sensitive data where operations will want to retain control over the Repository Management activities while researchers can readily access all the data analytical tools needed to undertake their research (including high performance computing).

Lesson 3 - Cyber Security Frameworks specific to Energy Systems are important: As energy systems continue to digitalise and increasingly consist of network- and internet-connected components, the unique Cybersecurity requirements of energy systems must be well understood and assessed. The process of developing a Cybersecurity Assessment Framework has uncovered important principles and lessons applicable to a range of future projects.

Lesson 4 - The value proposition of microgrids is evolving: The value microgrids can provide continues to evolve, and access to value streams is increasing as markets for demand side flexibility increase in maturity, which will continue to enhance the commercial viability of microgrid systems in a range of settings.

Lesson 5 - The microgrid model developed is translatable outside Monash, but barriers to uptake still exist: The microgrid model developed provides further validation of suitable applications that should be targeted. Larger residential areas prone to bushfires or severe weather events, commercial offices and shopping centres, and large precincts are priority locations for microgrid implementations. A diminishing number of barriers still exist, which would benefit from further research.

KEY LEARNINGS

Lesson learnt No.1: Operational readiness, of both solutions and customers, is critical to enabling microgrid technology

Category: Technical

Objective: Demonstrate optimised system efficiency and electrical network reliability in an embedded network through interoperability of the AGM system with different software and control mechanisms.

Detail: Technology readiness and its influence on technical architecture refers to the maturity of technology in this space. The Smart Energy City project faced significant issues overcoming technology hurdles associated with the integration and maturity of solutions that resulted in significant additional development requirements and changes to the technical architecture to ensure that the project stayed true to its objectives. These issues most often presented where the project engaged early-stage nascent technology. As this is a developing field, some products were still in the development phase, which led to delays in some areas of the project as the time to further develop these was not anticipated.

Notably though, the project was able to provide the operational sandbox and research and development expertise to accelerate the growth and maturity of these technologies. An example of this is the transactive energy ledger developed in collaboration with RedGrid. This distributed ledger collaboration allowed RedGrid to test and develop the underlying Holochain technology and to progress the technology and the distributed ledger concept, enabling performance increases in the order of 100x. This fast tracked the product to become one that is operationally and commercially viable and is following the necessary steps to become open sourced. Another example that enabled efficient implementation was the development of EV Charger control with ChargeFox that allowed for future roadmap activities to be brought forward and tested in the platform.

Data readiness refers to the processes and constraints surrounding data, primarily in relation to research, needed to produce outputs that are deployable as operational technology. Leveraging access to research capabilities has allowed the Smart Energy City project to explore and make significant progress in areas of transactive markets, forecasting and optimisation. The process to enable this however was one with many learnings. A key hurdle that needed to be overcome in enabling research was data integrity and readiness. The data governance framework and process derived through this need is a key development however the ability for research to produce operational components deployable in the platform was greatly hampered.

From a customer readiness perspective, there were delays early in the project due to a lack of experience internally related to the deployment and integration of the microgrid control technology, from a capability, process and security perspective. This led to longer times for install, deployment of more equipment than was probably needed.

Implications for future projects: The above influences notwithstanding, the technical architecture allowed the Smart Energy City project to remain true to its objectives of demonstrating the value of smart energy infrastructure and orchestrate DERs to achieve an optimised economic outcome whilst maintaining reliability. The primary shift that the above influences drove was a move away from a market mechanism to a contract mechanism that retained the transactive components by incorporating users preferences or participation in a dynamic manner. This ensured that end users retained autonomy and the ability to participate in orchestration by the EMS if they chose to do so. This shift from market to contract mechanism reflected not only the influences outlined above but the pragmatic requirements to operationalise transactive energy market theoretical approaches that were analysed as part of this project.

The ability to adapt the implementation of the transactive component of the project, whilst retaining the original technical architecture, demonstrates to future projects the importance of a flexible high-level design that allows for a range of solutions to achieve project objectives.

Conclusion: The maturity of technologies has a significant correlation with the level of development effort required to make ready for integration and deployment. Further to this, the maturity of a customer/business in its approach to deploying and integrating these technologies also impacts on speed and ease of deployment. Under-estimating the effort required presents risks to project execution. Therefore, assessing technology maturity and operational and data readiness of selected solutions at the outset will enable better project design.

Lesson learnt No.2: Data Governance is a critical enabler of smart energy management

Category: Technical

Objective: Demonstrate predictive demand response for a smart embedded network through development of a precinct load forecasting model.

Demonstrate the ability of the Project's energy management system (EMS) to manage and control loads of buildings in response to demand constraints and energy market price signals in a smart embedded network.

Increase understanding of interactions between individual customers in a transactive energy market. In this case, develop a transactive energy market within the precinct with each building representing a single customer, meaning that each building may expose its particular flexibility in terms of power demand and price sensitivity.

Detail: As outlined in the Technical Architecture section above, the criticality of data governance became apparent through the project where research and development was stymied by data integrity issues. Some of these issues included:

- data losses
- network configuration changes
- incorrect asset installation or specifications
- lack of data definition e.g. reconciling nulls, zeros, negative integers and data losses

To address this challenge the project engaged Helix (an arm of Monash eResearch Centre) specializing in sensitive research data. Helix was engaged to adapt the Helix Data Governance Framework to the datasets being retrieved and generated by the platform. This framework has evolved to inform wider data governance requirements including data definitions, privacy issues, verification pathways and authorised access to name a few. It is clear that data governance forms an integral component of distributed energy platforms. The process and application of the data governance framework is detailed in the Net Zero - Data Governance Overview[1].

[1] https://figshare.com/s/6de1f36fdd305e058d40

Implications for future projects: A well-designed Data Governance Framework is a critical early-stage consideration for future projects where large and sensitive datasets are generated. Monash is working to establish a repository for research data in its Secure e-Research Platform (Monash SeRP). This is a key initiative, particularly for sensitive data where operations will want to retain control over the Repository Management activities while researchers can readily access all the data analytical tools needed to undertake their research (including high performance computing).

Conclusion: It is clear that data governance forms an integral component of distributed energy platforms. Specific approaches to Data Governance require specialist knowledge and should be considered and developed early in a project's lifecycle.

Lesson learnt No.3: Cyber Security Frameworks specific to Energy Systems are important

Category: Technical/Risk

Objective: Increase understanding of cyber security issues and implementing mitigation strategies for smart embedded networks.

Detail: A Cybersecurity Assessment was completed, identifying recommendations for future implementation across Monash as part of Milestone 2. A further Cybersecurity Implementation Report[2], which reviews the actions triggered by the original assessment within the organisation, was also developed. This report's primary purpose is to reflect the processes and requirements that organisations may need to implement when carrying out cybersecurity assessments. The report also serves to act as an independent assessment for operational purposes on the assessment but it's primary aim is to reflect the process post assessment and provide an insight to what may be required from an implementation perspective to other organisations. The Cybersecurity Assessment Framework (Guide and Workbook) developed in Milestone 2 has been updated with developments in the sector such as updates in the NIST SP1800-32 guidelines and will be shared as a publicly available resource.

Implications for future projects: The Cybersecurity Assessment Framework is a transferable and applicable resource for future projects considering cybersecurity requirements.

Conclusion: As energy systems continue to digitalise and increasingly consist of network- and internet-connected components, the unique Cybersecurity requirements of energy systems must be well understood and assessed. The process of developing a Cybersecurity Assessment Framework has uncovered important principles and lessons applicable to a range of future projects.

[2] https://figshare.com/s/f38fa57f39029e49103a

Lesson learnt No.4: The value proposition of microgrids is evolving

Category: Commercial

Objective: Demonstrate the multiple revenue streams that are (or can be) available for a grid-tied smart embedded network and prosumer enabled market model

Detail: At its outset, the underlying objective of the Smart Energy City project was to demonstrate the operation of a two-sided electricity market utilising the inherent flexibility of loads, and subsequently rewarding the provision of flexibility where there is commercial value in time shifting energy use.

A range of energy related value streams have been accessed or identified for the Smart Energy City project. Due to the impact of COVID related lockdowns, the detailed trialling of these services to ascertain their potential value has been limited. Further data will be collected and shared as the platform continues to operate in Monash.
However, as the project has unfolded within the context of ambitious Net Zero emissions goals, Monash has come to understand that the underpinning microgrid hardware and software platform can realise a significantly broader range of value.

The relatively low cost deployment of edge devices, coupled with the enabling software stack, releases value both to the customer, and those external to it. This value ranges from data to inform business decision making and planning, to better visibility of what is happening on the demand side, which can be utilised by distribution system operators and market operators to run the energy systems more efficiently. This data, and the underpinning control a microgrid provides, can also realise non-energy related value from the assets, including enabling predictive maintenance, and forecasting replacement timing - the increased uptake of AI in this space will only see this value increase.

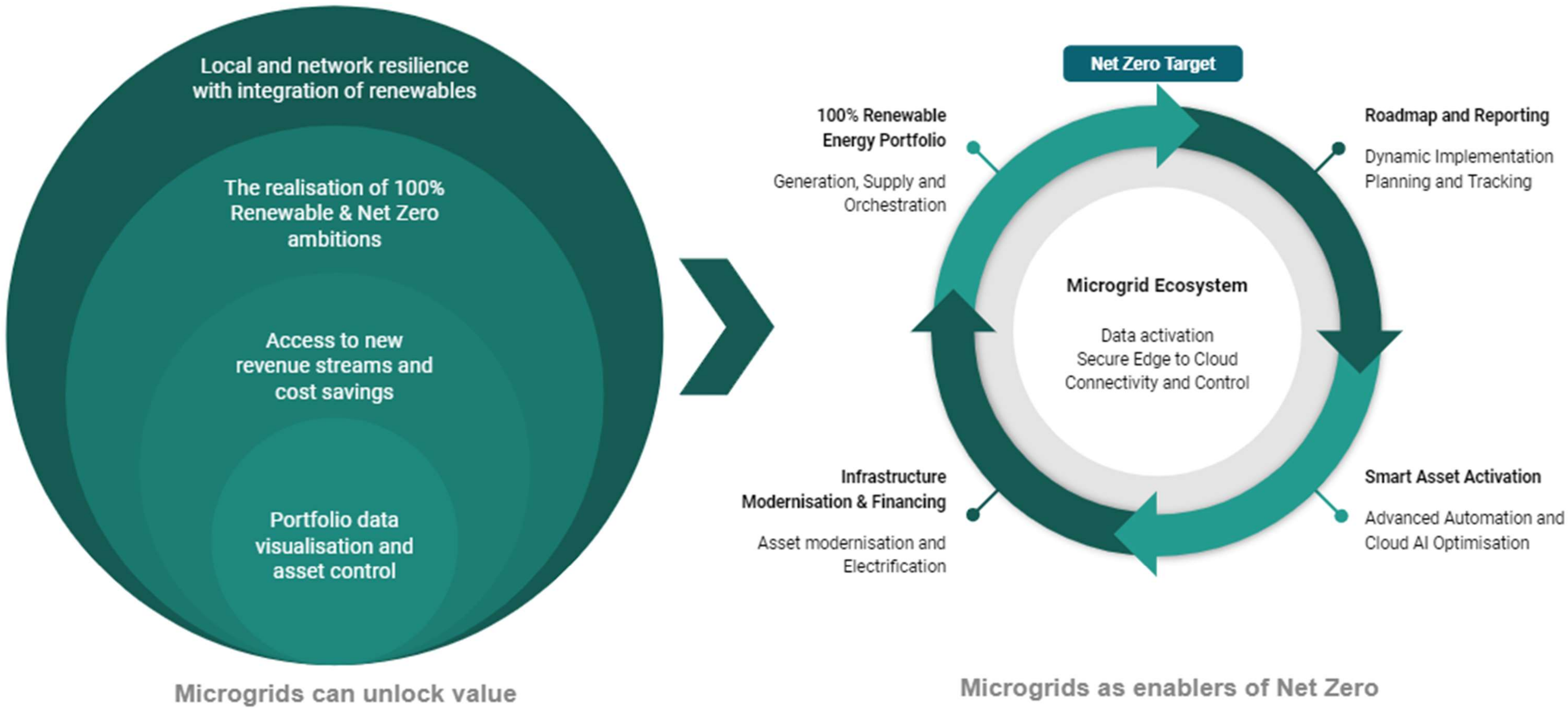


Figure 1: The value the microgrid technology stack can unlock are evolving to a broader enabler of Net Zero and business and system operation

Deployment costs are low, but asset integration is still a challenge

Costs for realising this value relate to a number of key elements.

- Device purchase and install
- Integration with assets
- Software costs
- Optimisation development and deployment
- Project management and operation costs

Whilst the hardware and software costs are relatively low, and more products, vendors and service offerings are coming onto the market increasing consumer choice, the costs of integration with brown field assets can still provide a challenge. Through the Smart Energy City project, significant investment was made to enable flexibility within a range of commercial buildings, and existing DER. The unknowns and sometimes inconsistent control systems which are already deployed, can prove to be challenging and cost inhibitive to integrate into a microgrid system. However, emerging AI based solutions, can help reduce time and cost for this integration, and increase flexibility available. Further advancements in this space bode well for greater returns from the upfront or microgrid as a service offerings.

Energy related value streams are becoming the norm

Over the life of the Smart Energy City project, the energy related value streams available to customers have become more accessible. The range of retailers and aggregators providing flexibility related products is increasing, and the advent of the Wholesale Demand Response mechanism will only increase this. Whilst a market for network services is still nascent, the increased focus in this area is likely to see readily accessible value streams become available to a broadening customer base in the near future. Likewise, Peer to Pool trading, either via VPPs or other means, is beginning to take hold, meaning that further revenue streams for consumers with flexibility enabled will continue to emerge.

Table 1: Energy related value streams

Service	Description	Status at Monash
Peak demand management	Aim to reduce annual and summer peak demand charges from United Energy	Existing contract in place
Demand Response - DR contract	Financial reward for reducing demand when wholesale price above threshold via contract with retailer	Contract in place
Network services - export limitations	Mange DER to prevent exporting during times of low load/high onsite generation and breach of Connection Agreement	Contract in place
Contingency FCAS	Provide FCAS services to AEMO or aggregator by ramping up/down load	Contract options being explored
Demand Response - Partial self firming against PPA	Better match consumption to generation profile if moving to (more) spot exposed procurement model	PPA contract in place, assimilation to partially sleeved energy procurement under development
Network services - voltage	Manage local (on our embedded network) or within local distribution network voltage fluctuations	Simulation only
Peer to pool trading	Sale of excess solar or flex to other customers on the microgrid	Simulation only

Demand side flexibility as an enabler of real time net zero

With the advent of large scale, near zero generating cost wind and solar, energy markets are rapidly changing, providing opportunities to both decarbonise energy supply and reduce energy costs through the development of a renewable energy portfolio and the coordination of generation with energy demand. Microgrid technology enables both the access to the underpinning data to shape renewable PPAs with a high coincidence, and optimise demand side flexibility to both reduce energy costs and carbon emissions.

Monash is working towards a model where electricity demand is matched with green electricity supply on an hourly base. The matching is realised by combining solar PV, wind energy, and battery energy storage at the supply side with flexibility on the demand side. As there is a direct link between the hourly production and consumption of energy, the real-time net zero approach can scale up to a system-wide level. Analysis undertaken by ENGIE Impact for Monash's Clayton campus has shown that this approach can substantially reduce a customers exposure to energy and carbon pricing. It can reduce LCOE over BAU whilst delivering significant emissions reductions.

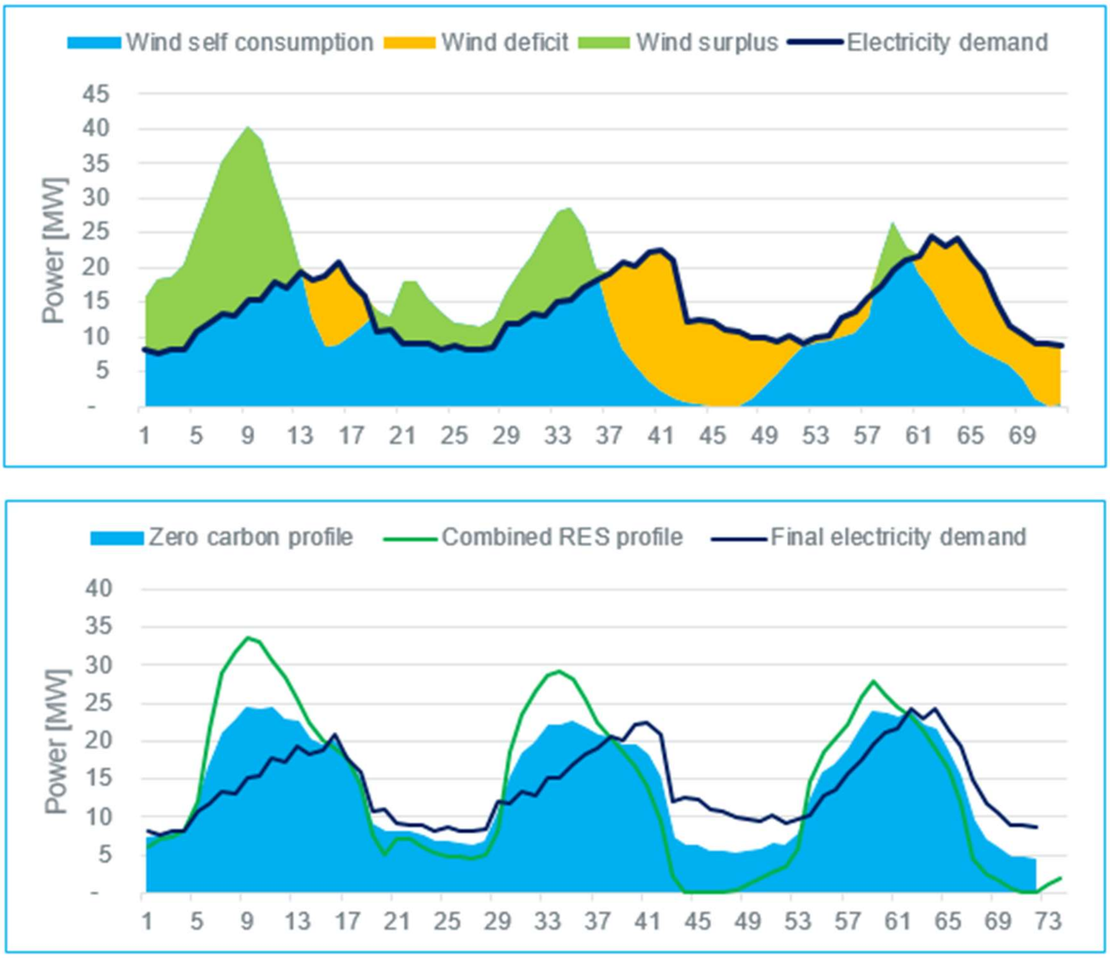


Figure 2: Microgrids can enable the value in the shift from Annual Net Zero (top) to Real Time Net Zero (bottom)

Implications for future projects: The increase in and increasing access to microgrid value streams means that future projects should be able to build a more compelling business case. As barriers to integration reduce, and deployment costs reduce, this should see a larger uptake in microgrid systems from a commercial perspective (see below re non-commercial barriers which still exist).

Conclusion: The value microgrids can provide continues to evolve, and access to value streams is increasing as markets for demand side flexibility increase in maturity, which will continue to enhance the commercial viability of microgrid systems in a range of settings.

Lesson learnt No.5: The microgrid model developed is translatable outside Monash, but barriers to uptake still exist

Category: Commercial/Regulatory

Objective: Demonstrate the multiple revenue streams that are (or can be) available for a grid-tied smart embedded network and prosumer enabled market model.

Detail: Through work undertaken for the Microgrid Electricity Market Operator project, and through continued engagement as part of the Smart Energy City project, Monash has evaluated the various applications outside of the Clayton Campus setting for microgrids and although there are many locations that suit an advanced energy precinct, there are a number of priority locations:

- Residential and small customer opportunities are more difficult because of the large number of parties involved, modest load and more stringent consumer protection frameworks. Focus should be on larger residential precincts or regions which are prone to bushfires or severe weather events where microgrids can support resilience outcomes.
- Commercial offices and shopping centres are a potential market due to proven private network models, albeit at limited scale. Implementation of load flexibility requires strong cooperation with both the owner and major tenants. Adoption of various DER technologies such as EV and batteries will enable greater utilisation and efficiency of the microgrid.
- Large precincts provide greater scale and reduced complexity making them the most attractive class to target. The larger demand/consumption in this class supports the microgrid model, provides infrastructure economies of scale and streamlines the negotiation and transaction costs.
- New/existing developments have significant benefits and drawbacks. Brownfield projects can commence immediately with known counterparties. Greenfield projects allow greater design flexibility for supply infrastructure.

Despite the opportunity for microgrids, there still exists a number of barriers, including:

- Regulatory Barriers: Regulatory barriers have prevented networks from considering microgrid and Stand Alone Power Systems (SAPS).
- Asset Management: Timing of grid infrastructure replacement significantly affects the business case for a network to transition a high cost to serve.
- Network Visibility: Lack of network's visibility of cost of supply to the customers.
- Microgrid Cost & Complexity: Complexity of control systems and cost of batteries will affect microgrid viability until costs begin to decline.
- Tariffs: Uniform Network Tariffs provide a disincentive to energy users to transition to self generation in high cost to serve locations.

Implications for future projects: Where suited, microgrids will continue to emerge as a technically and economically compelling solution. While the barriers to their application are reducing, future projects should target those that remain, such as network visibility, cost and complexity, and tariff reform, as described above.

Conclusion: The microgrid model developed provides further validation of suitable applications that should be targeted. Larger residential areas prone to bushfires or severe weather events, commercial offices and shopping centres, and large precincts are priority locations for microgrid implementations. A diminishing number of barriers still exist, which would benefit from further research.