

# SMART ENERGY CITY

INTRODUCTORY REPORT

DESIGN OVERVIEW AND  
INITIAL RESEARCH QUESTIONS  
**JULY 2019**

A partnership between

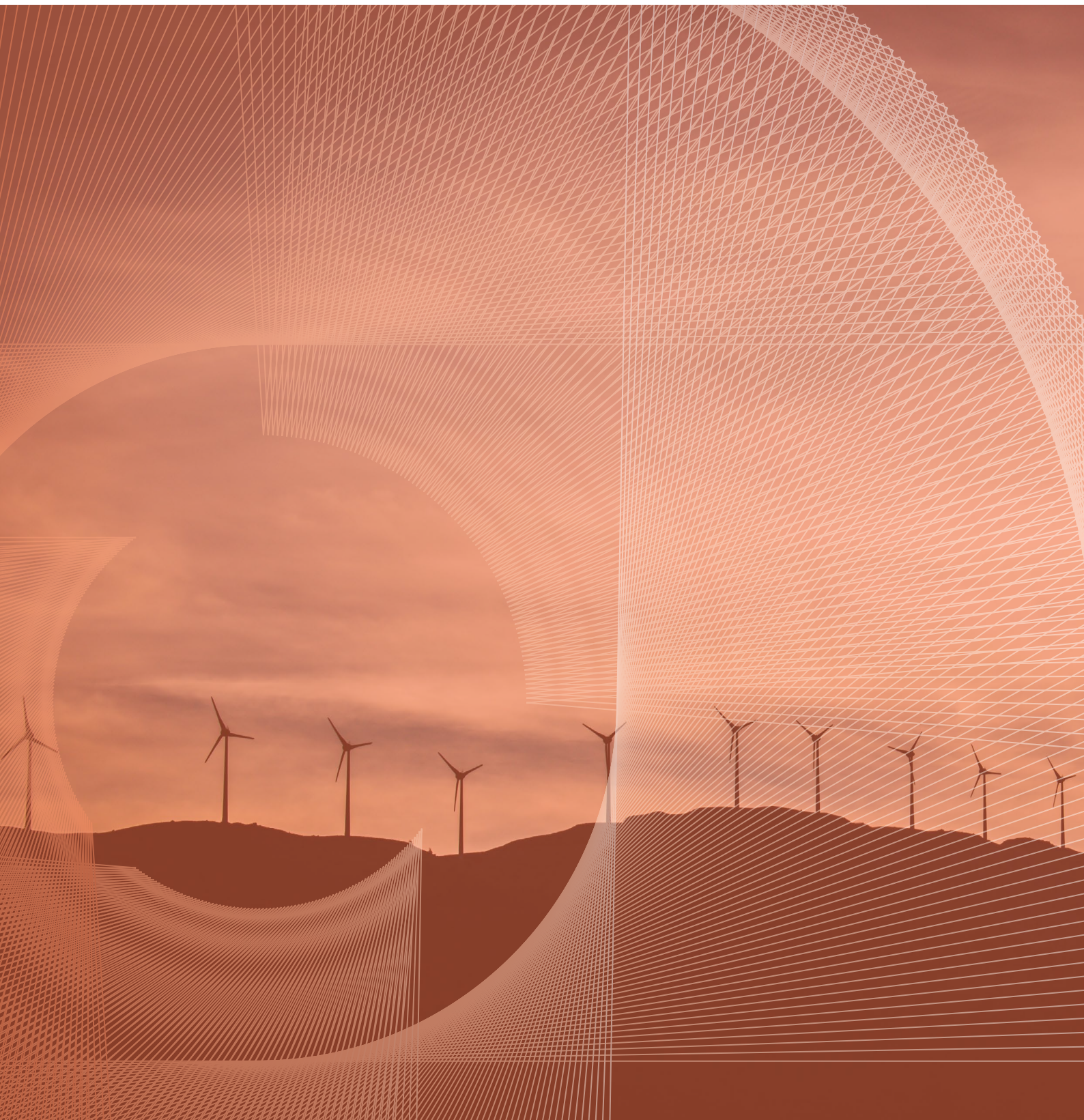


**MONASH**  
University

**indra**

# Contents

|                                                    |           |
|----------------------------------------------------|-----------|
| <b>Executive Summary</b>                           | <b>3</b>  |
| <b>About Us</b>                                    | <b>4</b>  |
| <b>Introduction</b>                                | <b>5</b>  |
| Purpose of This Report                             | 6         |
| <b>The Smart Energy City microgrid</b>             | <b>8</b>  |
| Microgrid Overview                                 | 8         |
| The Monash Microgrid                               | 10        |
| Potential Benefits of the Smart Energy City        | 11        |
| <b>The Smart Energy Framework</b>                  | <b>12</b> |
| DER Integration                                    | 13        |
| Active Grid Management                             | 14        |
| Smart Energy Management                            | 15        |
| <b>The Smart Energy City Platform</b>              | <b>16</b> |
| DER Integration: Indra Node#1 and iSPEED           | 16        |
| Active Grid Management: Indra Onesait Platform     | 17        |
| Smart Energy Management: Transactive Energy Market | 18        |
| <b>Key Areas for Investigation</b>                 | <b>20</b> |
| Microgrid Costs and Benefits                       | 20        |
| Microgrid Design, Deployment and Operation         | 20        |
| Running a Smart Energy City                        | 20        |
| <b>Next Steps and Call for Feedback</b>            | <b>21</b> |
| <b>Appendix 1: Key Stakeholder Questions</b>       | <b>23</b> |



# Executive Summary

Australian electricity markets are rapidly changing. Distributed energy resources (DER) such as rooftop solar panels are increasingly being deployed directly on electricity customers’ premises. The role of the “prosumer” is rising; a category of energy users which both generate and consume electricity using a combination of on-site renewable energy and energy storage. Practices in buying and selling electricity are rapidly evolving to service this growth in DER and prosumers. In addition, these factors are increasing the need for load management technologies and services, such as demand side response and electricity storage.

Monash University is partnering with global technology and consulting company Indra for the Smart Energy City project, supported by a \$2.9 million grant through ARENA’s Advancing Renewables Program. The Smart Energy City project will develop a grid-interactive microgrid at Monash University’s Clayton campus, which will maximise the utilisation of DER and loads in a coordinated way through Indra’s OneSait AGM technology platform and development of a Transactive Energy Market.

**The Smart Energy City project will demonstrate how a grid-interactive 100 per cent renewable-powered net zero emissions city could operate reliably, and the value it could provide to customers and the broader electricity network.**

A Smart Energy Framework has been developed as a design and implementation method for the introduction of Smart Energy Management to precinct scale microgrids. The three framework layers (DER Integration, Active Grid Management and Smart Energy Management) have been applied in the Smart Energy City project to enable Monash to manage and orchestrate the energy generation, storage and two-way power flows in the microgrid, including the interface with the broader electricity network, both from an energy and power quality perspective.

A new market will be set up on the campus, with metering and monitoring technology that allows individual Monash departments to act as “customers” within this market. The market will enable customers to trade electricity and access revenue from market and ancillary services they provide to the broader electricity network (such as demand response and frequency and voltage control). By managing distributed energy resources, the microgrid will deliver benefits to both on-campus customers and the broader network.

**Targeted insights from the Smart Energy City project aim to support uptake of microgrids on appropriate sites around Australia by shedding light on the technological, economic and governance aspects needed to make this type of system a reality.**

This *Introductory Report* summarises the platform being developed, as well as the hypotheses, research questions and assumptions to be investigated and tested in the Smart Energy City project, which have been developed through initial meetings with a selection of project stakeholders. These questions can be grouped around the following themes:

- Microgrid costs and benefits;
- Microgrid design, deployment and operation;
- Running a Smart Energy City.

Over the course of 2019-2020, Monash and Indra will work with industry, government and consumers through a series of engagement events and roundtables to share insights from the Smart Energy City project and ensure it provides value to relevant stakeholders.

In the second half of 2020, Monash and Indra will release the second report in this two-part series. The second report will detail the findings of the Smart Energy City project, in response to the research questions presented in this *Introductory Report*. Results and recommendations in the second report will support policy makers, regulators and industry in the accelerated uptake of microgrids.

# About Us

## Monash University

Since its establishment six decades ago, Monash University has transformed at an unrivalled pace and scale. Today, our education and research are truly world class, advancing innovation to deliver benefit to communities locally, nationally and globally. For example, our leadership in health research is evidenced through our ranking as the top university in Australia for National Health and Medical Research Council awarded medical research funding. This distinction reflects the impact we make through our engagement with partners in government, industry and local and global communities.

With an annual turnover of \$2.4 billion and direct employment of over 17,000 people, Monash University is an economic and social powerhouse of Victoria. We contribute 25 per cent of Victoria’s largest export sector, international education, which equates to 5 per cent of Victoria’s total exports.

Monash University plays an active role in the communities surrounding our campuses. Over 800,000 non-student/non-staff visitors use our campus facilities each year.

Monash University will continue to forge and nurture our deep connections with government, industry and the community to achieve more.

## Indra

Indra is one of the leading global technology and consulting companies and the technological partner for core business operations of its customers world-wide. It is a world-leader in providing proprietary solutions in specific segments in Transport and Defence markets, and the leading firm in Digital Transformation Consultancy and Information Technologies in Spain and Latin America through its affiliate Minsait. Its business model is based on a comprehensive range of proprietary products, with a high-value focus and with a high innovation component. In the 2018 financial year, Indra achieved revenue of €3.104 billion, with 43,000 employees, a local presence in 46 countries and business operations in over 140 countries.

In Australia, Indra, has been operating since 2000. Today the company provides technological solutions & services to private and government agencies including Air Traffic Management Systems, Communications Solutions (Deployable Radar), CCTV Security Solutions, ETRM Consulting and Grid Management Solutions.

In partnership with Monash Indra is deploying its AGM solution as a technological platform for the Monash Smart Energy City looking mainly to collaborate with them and the industry to untangle the challenges of a renewable transition and discover possible replicable models that will benefit the industry and the public.

*This Project received funding from ARENA as part of ARENA’s Advancing Renewables Program*

# Introduction

In 2015, countries around the world, including Australia, agreed to limit global temperature rise to less than 2 degrees Celsius above pre-industrial levels to avoid the worst impacts of climate change, and to pursue efforts to further limit this to 1.5 degrees<sup>1</sup>. For developed countries like Australia, limiting temperature rise to less than 2 degrees is commonly accepted as requiring net zero greenhouse gas emissions<sup>2</sup> by 2050.

Monash is Australia’s largest university with more than 70,000 student enrolments and over 150 buildings spread across four domestic campuses. By committing to a net zero target well before 2050, Monash University is leading the way in Australia’s transition to net zero emissions.

## Monash University has committed to transitioning to net zero emissions across its Australian campuses by 2030.

Jointly developed with ClimateWorks Australia, Monash University’s strategy to achieve net zero emissions by 2030 encompasses five key pillars<sup>3</sup>:

- Energy efficiency measures
- Deployment of on-site and off-site renewable energy
- An economically viable and reliable microgrid on the Clayton campus
- Electrification of all campuses to reduce reliance on natural gas
- Addressing residual emissions through offsetting.

Monash is partnering with Indra to develop the Smart Energy City project, supported by a \$2.9 million grant through ARENA’s Advancing Renewables Program. Indra is contributing its vast experience implementing electrical management systems and its internet of things technology platform to automatically balance generation, operation and demand, reducing costs and improving the reliability of the electrical system.

## The Smart Energy City project will develop a microgrid at Monash University’s Clayton campus.

A Smart Energy Framework has been developed as a design and implementation method for the introduction of Smart Energy Management to precinct scale microgrids. The three framework layers (DER Integration, Active Grid Management and Smart Energy Management) have been applied in the Smart Energy City project to enable Monash to manage and orchestrate the energy generation, storage and two-way power flows in the microgrid, including the interface with the broader electricity network, both from an energy and power quality perspective.

Using this framework, the microgrid being developed by Monash and Indra is an interconnected electricity network that will maximise the utilisation of DER and loads in a coordinated way through Indra’s Node#1 edge computing devices and OneSait AGM technology platform, plus a Transactive Energy Market (TEM) which is being developed by Monash researchers and developers. The Smart Energy City project aims to demonstrate how a grid-tied 100 per cent renewable-powered net zero city could operate reliably, and outline the value it could provide to both customers and the broader electricity network.

1. The Paris Agreement: <https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement>  
2. Defined by the Intergovernmental Panel on Climate Change as balancing human-caused emissions of greenhouse gases with deliberate human-caused removals of greenhouse gases from the atmosphere. For further details, see Glossary in the Special Report - Global Warming of 1.5°C: <https://www.ipcc.ch/sr15/>  
3. <https://www.monash.edu/net-zero-initiative>

# Purpose of This Report

This *Introductory Report* provides an overview of the Smart Energy City platform and summarises the design framework and key areas of stakeholder interest which Monash and Indra plan to investigate and test in the microgrid through the project. Outcomes will be captured and shared by Monash and Indra over the course of the project throughout 2019-2020. This process is designed to support policy makers, regulators and industry (including organisations interested in establishing their own microgrids) in the accelerated uptake and effective implementation of microgrids.

The process for investigating the Monash Microgrid is intended to be dynamic and adaptable as technology evolves and the policy and regulatory context shifts. Stakeholders are encouraged to suggest additional hypotheses, questions and assumptions that might be useful to test as the Smart Energy City project progresses.

Additional suggestions for the Smart Energy City project at Monash University can be directed in writing to: [netzero@monash.edu](mailto:netzero@monash.edu)

This Introductory Report is the first report in a two-part report series. A second companion report will be released in October 2020 that presents the findings from the Smart Energy City project.



# The Smart Energy City Microgrid

Australian electricity markets are rapidly changing. DER such as rooftop solar panels are increasingly being deployed directly on electricity customers' premises. The role of the “prosumer” is rising - a category of energy users including households and businesses which both generate and consume electricity using a combination of on-site renewable energy and energy storage, and can provide flexibility (the ability to increase or decrease consumption at a point in time) and voltage and frequency services.

Practices in buying and selling electricity are rapidly evolving to service growth in DER and prosumers.

Coordinated and controlled use of DER, in combination with load management technologies and services such as demand side response and electricity storage, can provide substantial benefits for the stability of the broader network. However, current electricity markets have been set up primarily for one-way electricity transfer from large commercial generators to consumers with limited DER. This arrangement currently limits opportunities for prosumers to offer the benefits of DER to broader electricity markets and networks, or to be rewarded for providing these benefits.

The Smart Energy City project will demonstrate solutions for controlling and optimising DER within a large precinct behind a single connection point. The project aims to demonstrate the value and benefits to customers of new business models and revenue opportunities, the opportunities to improve the resilience of the electricity network and to reduce the need for network infrastructure investment. The Smart Energy City project also aims to demonstrate the scalability and replicability of the installed systems, to support significant uptake of zero-emissions DER across the broader network.

## Microgrid Overview

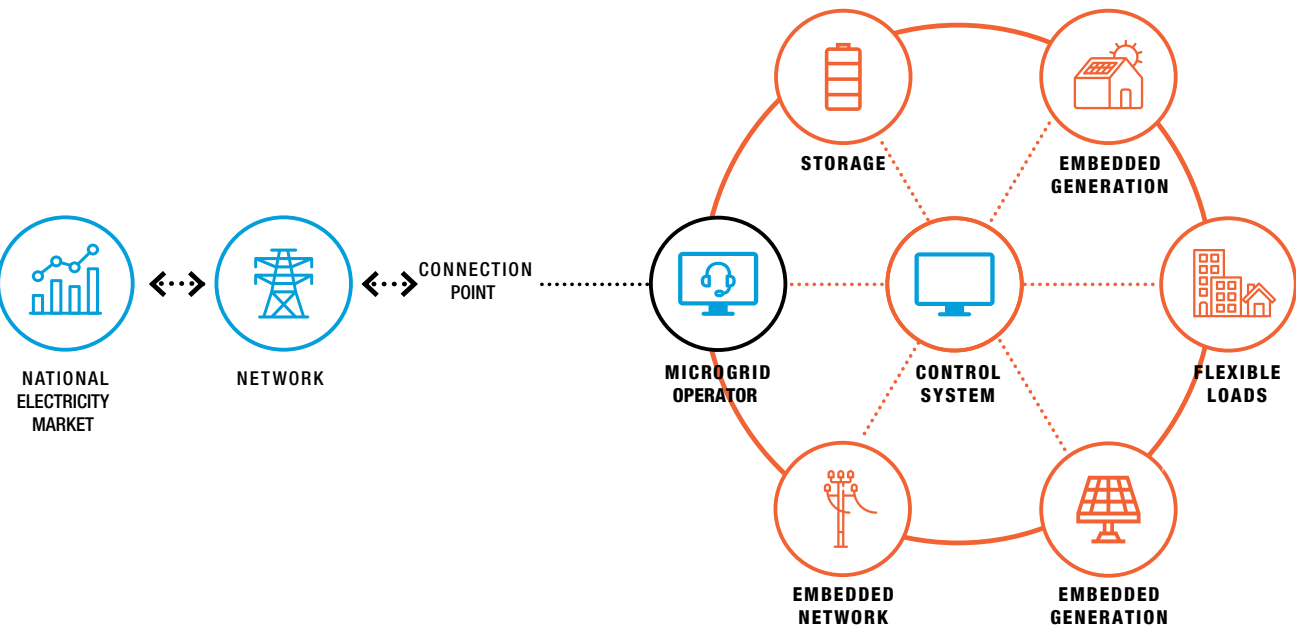
A microgrid has become a generic term that describes many different types of aggregated energy systems. For the purposes of this project, a working definition of a microgrid has been developed:

*A system for managing and controlling the electricity supply and demand of customers, in a way that efficiently integrates local sources of generation and storage of electricity ('local supply') with electricity supplied from or exported to the grid ('network supply').*

A microgrid could have the following characteristics:

- A site within a private distribution network ('embedded network') or a public distribution network ('microgrid zone');
- One or more sources of electricity generation connected to the embedded network ('embedded generation');
- On-site electricity storage ('battery storage');
- Supply of electricity to multiple third-parties ('supply');
- A dynamic supply and demand control system ('control system');
- A single connection point to the distribution system ('connection point');
- A third party microgrid system operator ('microgrid operator'); and
- Grid connected, but capable of islanding ('islandable').

FIGURE 1: CORE ELEMENTS OF A MICROGRID



Microgrids could provide customers with services that are not available from the distribution network to which they are connected. Specifically, microgrids enable customers to:

- Share and maximise the value of local supply; and
- Minimise the cost of network supply.

Microgrids can also provide a range of network services including:

- Demand response;
- Voltage control; and
- Frequency control.

In contrast, a Virtual Power Plant (VPP) or other shared metering arrangement containing elements of a microgrid as defined in the box above, do not typically operate within a defined infrastructure boundary. A VPP manages electricity transactions over a broader region through the wholesale market, whereas a microgrid focuses on optimising DER in a local geography behind a single connection point to the broader market.

Microgrids can cover a diverse range of applications, which vary primarily by their location and strength of connection to existing electricity network infrastructure. Different microgrid applications include:

- **Urban microgrids:** Also known as grid-connected microgrids, these are located in regions with existing embedded networks and connected to existing electricity network infrastructure
- **Fringe-of-grid microgrids:** These are connected to the network in remote regions or where significant network augmentation is required. These locations are likely to experience supply reliability and power quality issues
- **Off-grid microgrids:** Also known as isolated or islanded systems, these are not connected to existing electricity network infrastructure

Despite the perceived similarities in microgrid applications for different market segments, all microgrid applications require somewhat different technical capabilities and commercial models. The Smart Energy City project aims to inform both fringe-of-grid and urban applications as Monash is developing a grid-tied microgrid, but not off-grid applications as islanding functionality is not (initially) being tested. Outcomes from the Smart Energy City project may be relevant to customers listed in the table below.

| Urban and fringe-of-grid microgrids<br>(Applicable to Monash University microgrid)                                                                                                | Off-grid microgrids<br>(Not applicable to Monash University microgrid) |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------|
| Airports, commercial & industrial precincts, retirement villages, caravan parks, public buildings, shopping centres, university campus & schools, government, military, hospitals | Mining, agribusiness, rural/remote communities                         |

## The Monash Microgrid

As a campus environment in a strong part of the distribution network, Monash is able to test technologies with a maturity level lower than would be acceptable in alternative environments. Monash’s Microgrid provides a realistic and useful platform for research into technological, business and customer behavioural features of the deployment of distributed resources and their coordination through microgrid operations. The microgrid system is intended to be a fully functioning local electricity network and trading market with dynamic optimisation of resources interacting with an external energy market.

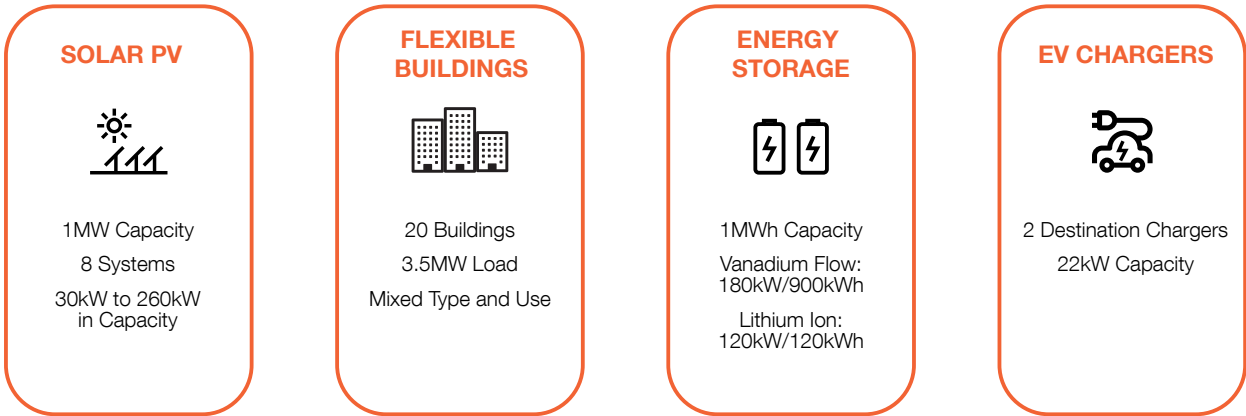
Replicability is at the core of Monash’s Microgrid pilot design philosophy with the following design principles:

- Assets treated as customers
- Low upfront capital cost
- Be scalable
- Utilise existing building automation system functionality and standard communication infrastructure (e.g. 3G/4G network)
- Be open source and service agnostic
- Integration of platforms and architecture
- Provide electrical control & market response
- Be flexible to rule change
- Must be replicable to non-campus precincts
- Provides a living laboratory to drive innovation that can be translated to the market.

Monash is developing a microgrid which includes a range of customers and DER assets at our Clayton campus, 20km south east of Melbourne’s CBD. The microgrid connected buildings closely replicate a real community with a variety of old and new buildings and a wide diversity of load profiles that emulate high occupancy spaces (arts theatre, laboratories and lecture theatres), light industrial (swimming pool complex), commercial (retail and staff offices) and residential (self-contained apartments).

There is a diverse mix of DER included in the microgrid as outlined in Figure 2.

FIGURE 2: MONASH MICROGRID DER



## Potential Benefits of the Smart Energy City

By managing distributed energy resources, microgrids can benefit customers on the campus by:

- Lowering energy costs by shifting demand to lower price periods and avoiding peak demand charges;
- Managing batteries and behind-the-meter generation to respond to changes in energy generation, demand and price; and
- Allowing prosumers to share or trade renewably generated energy with each other.

Through their interaction with the broader electricity network and wholesale electricity market, microgrids could also:

- Reduce pressure on the network during high and peak demand;
- Sell renewable generation in the wholesale market, reducing emissions;
- Provide frequency and voltage control services to the grid through the ancillary services market; and
- Help the grid respond to emergencies.

A Monash University study for the Victorian government found increased deployment of microgrids could provide \$22 to \$36 million in gross economic value for the state. Additional economic value could potentially be unlocked across Australia.

Monash University estimated the economic value of these benefits to the Victorian state economy in a study supported by the Victorian government.

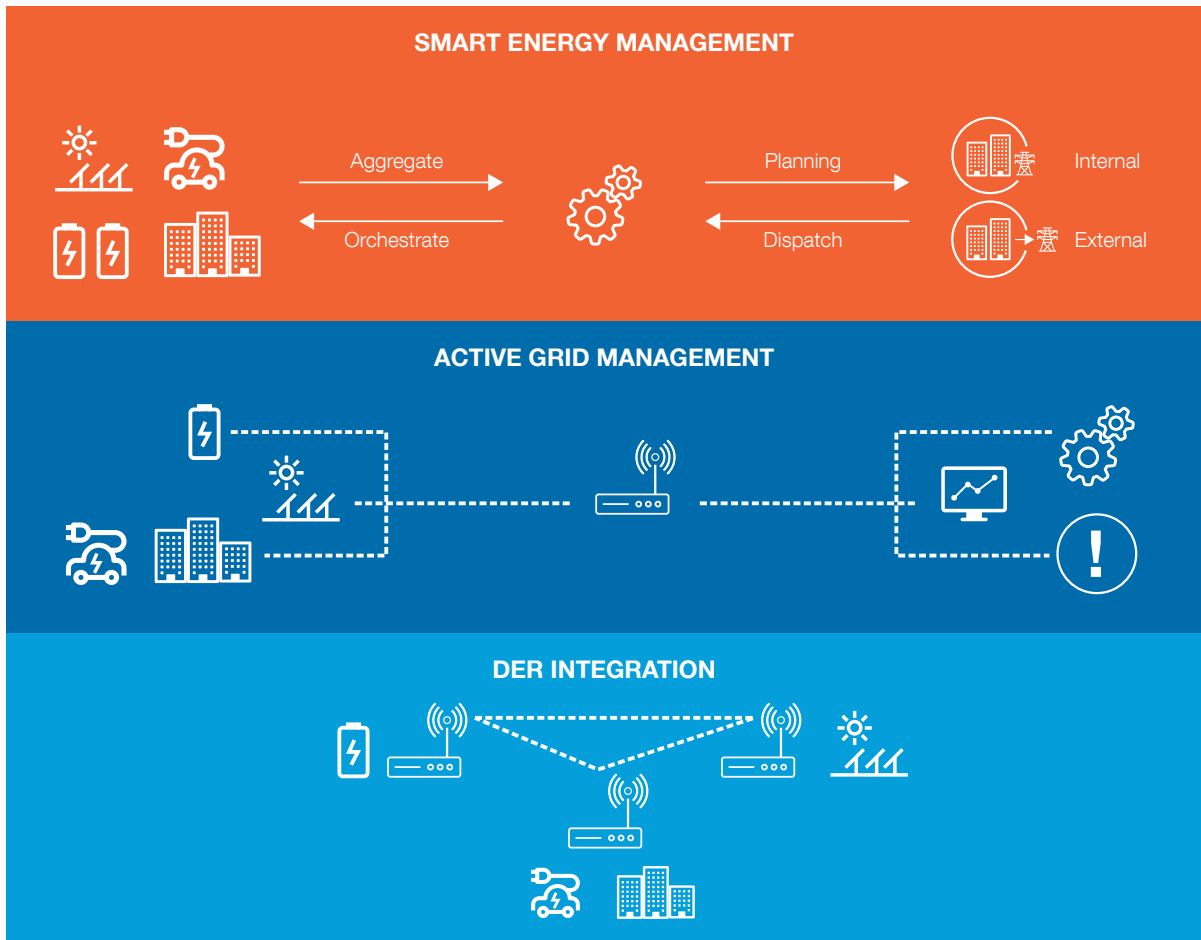
The Smart Energy City project can support accelerated uptake of microgrid systems and microgrid operator business models, enabling this economic value to be unlocked across Australia. The project could:

- Inform the development of standards, guidelines and regulations for technology platforms to support microgrid operation
- Support potential microgrid operators to participate in the energy market and bid into ancillary market services
- Enhance competition for demand response services, potentially leading to more cost-effective network support and investment
- Support the safe production, storage and consumption of DER provide a research and teaching platform to develop new solutions and train the next generation of energy industry professionals.

# The Smart Energy Framework

As part of the Smart Energy City project, the Smart Energy Framework has been developed to deliver on the design principles of scalability and replicability outside of the Monash environment. This framework is a design and implementation method for the introduction of Smart Energy Management to precinct scale microgrids. The introduction of smart energy management enables the application of energy management strategies that can address objectives such as maximising DER value and providing network services.

FIGURE 3: SMART ENERGY FRAMEWORK LAYERS



Three framework layers (DER Integration, Active Grid Management and Smart Energy Management) drive the design and deployment of Smart Energy Platforms that are aligned to a microgrid's capabilities and objectives. The layers represent both incremental phases of platform deployment and the system layers of the deployed platform:

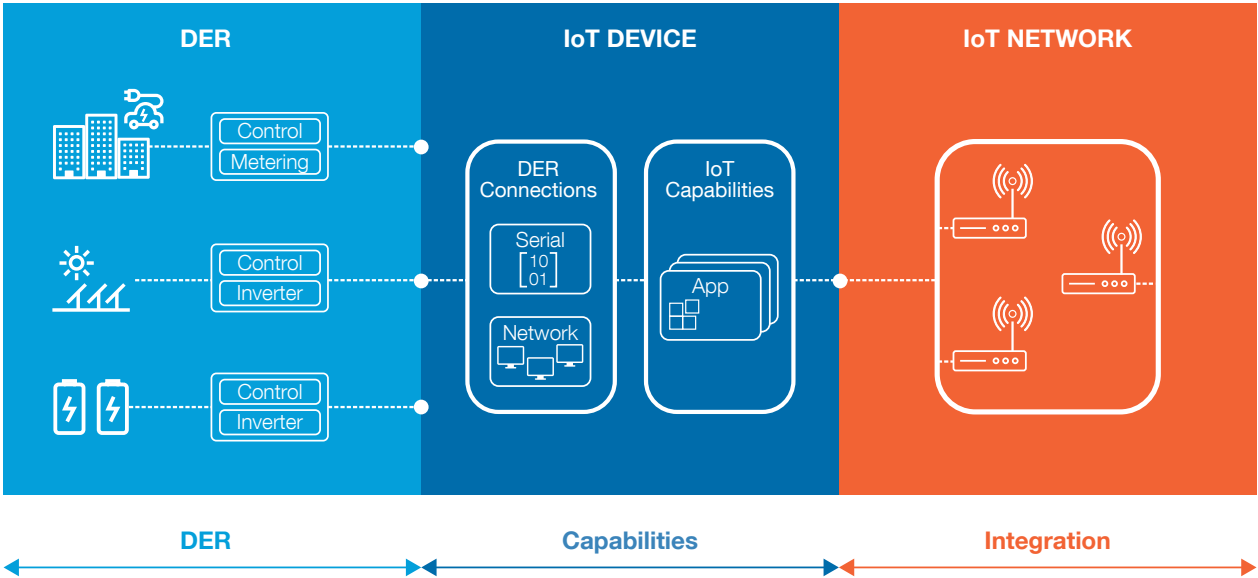
- The first layer of **DER Integration** requires the integration of IoT devices with all DERs and the networking of the IoT devices together in a secure IoT network.
- The networked DER IoT devices enable the next layer of **Active Grid Management** to be deployed as distributed energy applications.
- With the grid management systems in place, the microgrid is running at a suitable level of the resilience and transparency for the introduction of the final layer of **Smart Energy Management**.

## DER Integration

DERs within a smart energy system have integrated network accessible IoT devices that support the deployment of distributed applications for DER management, control and data access.

This foundation layer of the Smart Energy Framework is the essential base required for the deployment of the further layers.

FIGURE 4: DER INTEGRATION LAYER

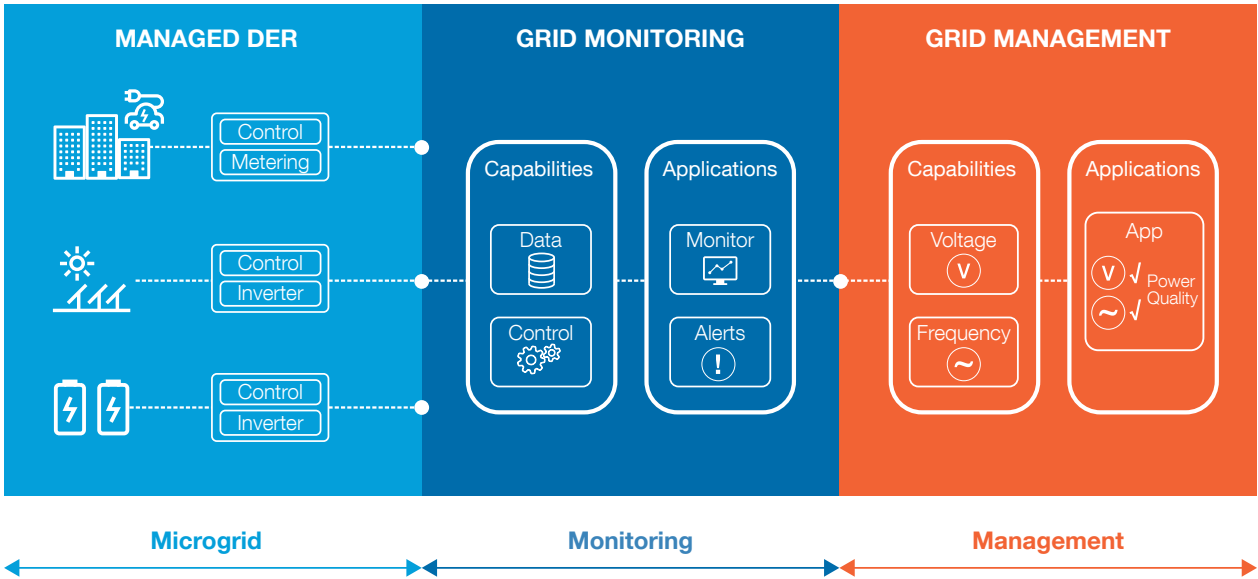


The IoT devices are integrated with the DER through connections to metering and control systems. Applications are deployed to DER IoT devices to enable access to DER energy data and capabilities as IoT functions.

# Active Grid Management

The foundation of DER integration with networked IoT devices allows the microgrid to be extended with Active Grid Management systems.

FIGURE 5: ACTIVE GRID MANAGEMENT LAYER



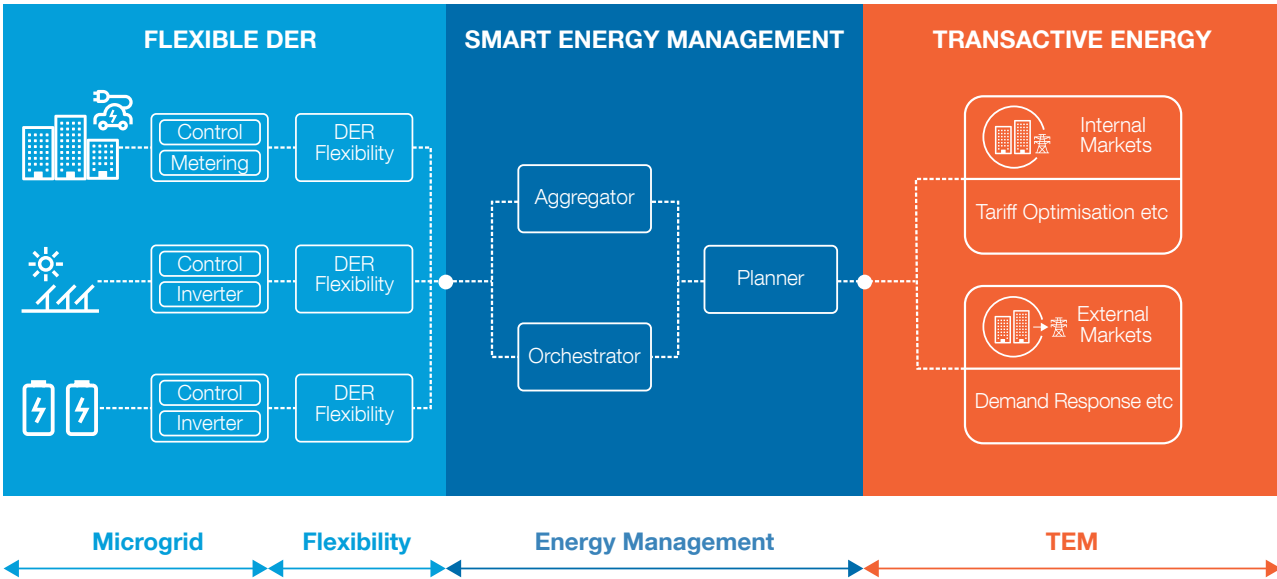
DER are extended with grid management capabilities that expose data and control as IoT functions to integrate with the Active Grid Management system.

Microgrid power quality is managed by using exposed DER capabilities to monitor data, predict power quality and using IoT control of DER capabilities to maintain power quality.

# Smart Energy Management

The managed quality and access to DER data gained through the incremental implementation of DER Integration and Active Grid Management provides the environment required for the introduction of Smart Energy Management.

FIGURE 6: SMART ENERGY MANAGEMENT LAYER



Enabling the participation of DERs in a distributed smart energy management system requires the deployment of the core Smart Energy Management capabilities of flexibility and forecasting to DER IoT devices.

DER flexibility is the ability for a DER to increase or decrease its demand and supply while ensuring the DER continues to operate within acceptable bounds. For example, flexibility can range from a slow load reduction of a building through the control of HVAC systems where the impact on occupant comfort is minimised, or the fast response of batteries through varying the scheduled charging and discharging.

The DER forecasting capability enables the generation of energy forecasts that include, in addition to the expected supply and demand, the predicted level of available flexibility.

Smart Energy Management uses the aggregation and orchestration of DER flexibility and forecasting to enact energy management strategies such as optimising DERs and transactive energy markets.

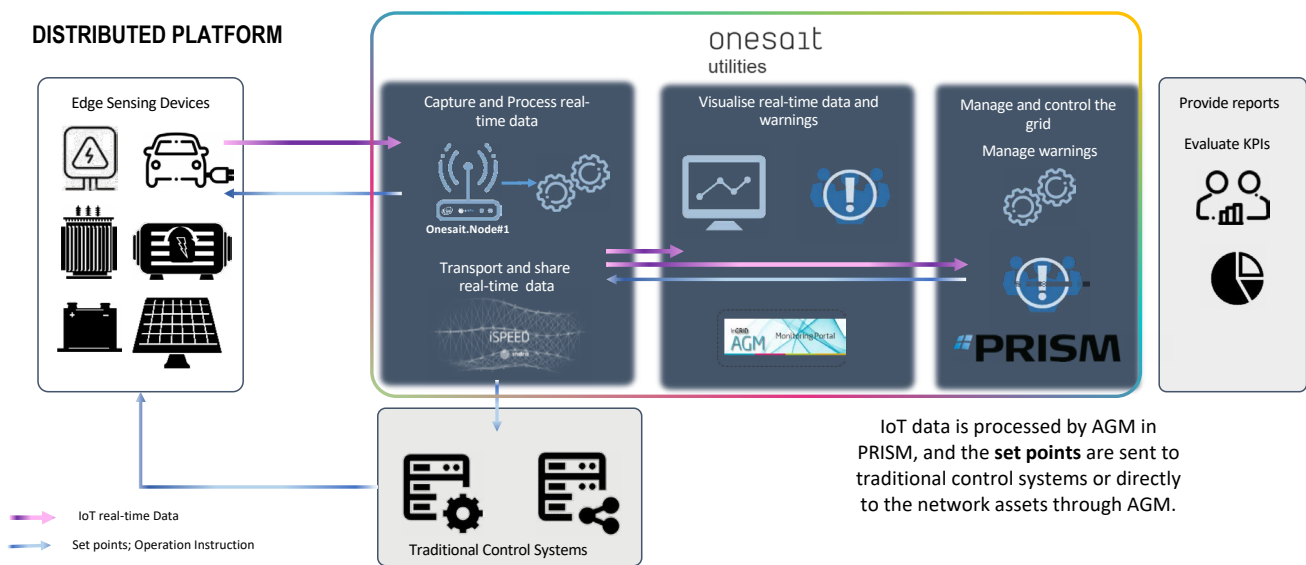
# The Smart Energy City Platform

As part of the Smart Energy City project, the Smart Energy Framework has been applied to develop the Monash Microgrid as a grid-interactive precinct. The first two layers of the Smart Energy Framework are achieved using tailored solutions from Indra's Onesait Energy Platform and the Smart Energy Management layer is being provided through a Transactive Energy Market (TEM) solution being developed by Monash.

## DER Integration: Indra Node#1 and iSPEED

For the Smart Energy City project, each DER asset is connected to the Active Grid Management layer via a smart gateway node to collect, monitor, analyse and manage the data. Node #1, Indra's Edge Platform and iSPEED, Indra's Real-Time Data bus make the DERs visible and controllable by the Active Grid Management and Smart Energy Management layers.

FIGURE 7: INDRA'S ONESAIT PLATFORM FOR DER INTEGRATION AND ACTIVE GRID MANAGEMENT



### Node#1

Node #1 is Indra's edge IoT platform that runs on the smart gateways connected to the DERs. It is a comprehensive set of tools that enable the connectivity between the physical and virtual world in real time based on the interaction with field devices. From the raw data provided by field devices to the full potential of Cloud services, Node#1 can perform all the functions that an IoT system requires including:

- Unify information from different sources in the field and with different protocols (wired or wireless devices and protocols, data servers).
- Process this raw and heterogeneous data and turn it into information.
- Perform Edge Computing features (event processing, database management, analytics, etc.).
- Flexible communication with Cloud Platforms through open communication standards or specific brokers.

In this instance, Advantech's™ UNO-2271G gateway model was chosen for the project due to its robustness, flexibility and power, but Node#1 is flexible and can be loaded in any Intel™ board based gateway. The UNO-2271G model features a 3G/4G modem that allows communication to other devices on the field and to/from the cloud (centralised) components of the solution. A secure and private mobile network has been setup and connected to the cloud components of AGM and in the near future of the TEM.

In Monash, Node#1 will be gathering the data from the DERs by connecting to them via Modbus TCP/RTU one of its many available protocols.

Node#1 implementations are usually accompanied by the Node#1 Edge Management System. It is a web application running on a cloud server that allows the remote management of the edge devices including access, diagnostics, configuration and updates.

### iSPEED

iSPEED is Indra's real time data bus that allows communication between the different elements. It is a publish/subscribe interoperable data bus that is loaded into Node#1 and other components of AGM to allow the secure exchange of real-time data. It does not require (in given cases) any centralised infrastructure to be deployed, only a light client or API in the element that wants to share data.

Based on DDS protocol and designed for fast transmission, it has a comprehensive data model that allows for robust and reliable communications.

For the Smart Energy City project it will serve to communicate all the different elements, including devices that are in the 3G/4G mobile network.

# Active Grid Management: Indra Onesait Platform

AGM is an industrial IoT software platform that monitors and manages power networks through distributed control.

AGM monitors and rapidly processes power system operations across the network by means of the combined actions of intelligent processing nodes at the edge of the network, and a centralised analytics engine.

Rather than relying on the conventional centralisation of data storage and computing, AGM uses a combination of edge-computing and centralised analytics, to provision the grid with real-time decision making capabilities closer to the “edge” avoiding the network transfer and latency that could exist. AGM is a platform that provides a modular approach to resolve grid challenges.

There are a range of elements to the AGM which will be utilised in the Smart Energy City project to provide the monitoring and orchestrated functionality required. Below, is the description of the main components that are centralised in this solution but that can be distributed when required.

## PRISM DERMS

Indra’s Distributed Energy Resource Management System (DERMS), known as PRISM, is a suite of distributed applications built to maximize DER capability and effectiveness, including increased hosting capacity, while mitigating adverse effects on the grid. PRISM DERMS is a versatile SCADA platform that has been providing services to the industry for over 30 years evolving and adapting to new challenges.

For the Smart Energy City project, PRISM DERMS will be used as the core monitoring and control system of the LV network to maintain proper operation and power quality parameters.

## Monitoring Portal

Monitoring Portal is a component of the AGM system that allows users to visualize on screen graphical representations of the Smart Energy City real-time data, events and warnings, as well as historical data. Monitoring Portal delivers a set of standard visualization dashboards, screens and charts leveraging real time data. It features, Chronograph visualization tool and InfluxDB timeseries database.

## iPowerAnalytics (iPA)

iPA is a component of the AGM system that delivers automatic, real-time grid analytics. It is natively integrated with iSPEED (the real-time data bus) to share results and information with other control elements of the grid.

## OTS (Operator Training Simulator)

OTS is a component of the AGM system that simulates the steady-state real-time behaviour of grids.

Natively integrated via iSPEED to receive real-time data from the field it can simulate and analyse behaviours of microgrid elements under different simulated scenarios. Its main purpose is to train the future operators of the microgrid.

# Smart Energy Management: Transactive Energy Market

The Monash TEM is a transactive energy solution to the smart energy management of a precinct scale microgrid. It will drive the management and control of the aggregated DER flexibility in order to achieve microgrid management functions, such as tariff optimisation, as well as providing external services such as demand response and network services.

The strategy for aggregating the microgrid’s available flexibility will be based on an internal market approach where each DER will act as an independent customer that will, where it chooses to, offer and commit to providing their flexibility as a commercial service to the TEM. The TEM will then be able to use this internal market functionality to aggregate the microgrid’s available flexibility.

The TEM will complete the application of the Smart Energy Framework in delivering a smart energy platform for the Monash Microgrid. It will demonstrate how smart energy management enables a precinct microgrid to provide aggregated flexibility services through the creation of internal competitive markets that ensure DERs are able to optimise their energy cost while also being rewarded for contributing their available flexibility towards TEM internal and external goals.

# Key Areas for Investigation

The Smart Energy City project aims to provide targeted insights from design, deployment and operation of the microgrid to support broader uptake of microgrids on appropriate sites around Australia needed to make this type of Smart Energy City a reality. Consultation has been undertaken with a selection of external project stakeholders to understand some of the key issues to be investigated, and a list of questions identified by those stakeholders is provided in Appendix 1. The key themes and areas of interest to stakeholders is summarised below.

## Microgrid Costs and Benefits

A microgrid can theoretically provide numerous benefits to its customers and the electricity network. The Smart Energy City project could assist others in developing the business case for further microgrid applications. Questions relating to the costs and benefits for organisations looking to invest in or operate their own microgrids relate to a number of areas:

- Microgrid business models and ownership structures;
- Financial performance of microgrids in terms of capital costs, operating costs and revenue streams, and measures to improve this;
- Broader financial and non-financial benefits of microgrids;
- Site characteristics for commercially viable deployment of microgrids;
- Regulatory and market reform required to improve business case for microgrids.

## Microgrid Design, Deployment and Operation

The Smart Energy City project will see the design, deployment and operation of a microgrid at Monash's Clayton campus. This will allow for real world challenges to be unearthed, and learnings shared so that the industry can refine this approach and hence reduce costs. There are a number of areas related to the practical operation of the microgrid which stakeholders are interested to better understand:

- Microgrid design framework;
- Minimal infrastructure requirements for microgrid operation;
- Partnerships required for microgrid operation;
- Maximising available building flexibility for both retrofits and new builds;
- Safety and cybersecurity considerations;
- Stakeholder engagement practices;
- Monitoring and evaluation parameters to assess microgrid performance under different conditions.

## Running a Smart Energy City

The Smart Energy City project will also explore broader behavioural, economic and engineering issues that impact the entire electricity network. Stakeholders have identified a range of areas which they are seeking further information on, including:

- The role of flexibility, efficiency and electrification in developing 100% renewable powered precincts;
- Measures to influence customer behaviour and customer response;
- Regulatory and governance requirements for development of microgrid control systems;
- Requirements for demand response and network service markets;
- Key areas for further research and development.

# Next Steps and Call for Feedback

The Smart Energy City project provides a platform for research into technological, business and customer behavioural features of the deployment and optimisation of DERs. Over the course of 2019-2020, Monash and Indra will work with industry, government and consumers through a series of engagement events and roundtables to share insights from the Smart Energy City project and ensure it provides value to relevant stakeholders. Specific opportunities for input include the **Monash Energy Conference** on 19<sup>th</sup> September 2019, and workshops with peak energy and property industry bodies.

In October 2020, Monash University will release the second report in this two-part series. The second report will detail the findings of the Smart Energy City project, related to the key areas of stakeholder interest presented in this report.

If you have any suggestions for the Smart Energy City project at Monash University (including additional research questions), or would like to participate in upcoming engagement events and roundtables, direct your enquiry in writing to: **netzero@monash.edu**

# Appendix 1: Key Stakeholder Questions

## Microgrid Costs and Benefits

1. What are the broader microgrid applications and opportunities where the Monash University Clayton campus microgrid could be replicated? For example, what specific ownership structures and scale of precinct network could adopt the microgrid model?
2. What was the capital cost of setting up the microgrid infrastructure? Were there unforeseen additional costs or cost savings?
3. What is the ongoing operational cost to run the microgrid?
4. What other operational costs are there?
5. What was the amount, value and proportion of total potential benefits actually observed through:
  - Lower electricity purchase costs from the shifting of load from high price to lower priced periods
  - Efficient management of distributed storage and other connected assets
  - Local voltage control from distributed resources
  - Demand side response for network load control following contingencies or under extreme load conditions
  - Reduced energy losses due to lower distances for power flow in the network
  - Reduced under-frequency load shedding
  - Local trading of excess renewable generation between microgrid customers
  - Peak demand management in the transmission and distribution network
  - Frequency control services to the network
  - Sale of electricity into wholesale retail markets
  - Sale of voltage control services to the local network
6. What is the likely return on investment for a microgrid with similar characteristics? What conditions are needed for positive return on investment for microgrids?
7. What is the business model needed to make microgrid commercially viable?
8. What could be done to reduce capital costs in future deployment of microgrids?
9. What regulatory, market or other barriers prevented Monash University from capturing the full potential revenues or value available that were predicted in financial modelling?
10. Does the microgrid provide opportunities for new international, national connections or collaborations?
11. Were there other economic, social or environmental benefits of the microgrid?

# Microgrid Installation and Operation

1. Who are the important partners and stakeholders (both internal and external to Monash University) for the success of the microgrid? Both from Monash University's perspective, and from the perspective of potential future microgrid developers and users
2. What are the respective roles of these partners that contributed to the successful operation of the microgrid?
3. What arrangements (including contractual) with partners including retailers and networks have helped/hindered delivery of benefits to customers and the broader network?
4. What is the role of building tenants, and others (e.g. students, staff) in delivering benefits of the microgrid?
5. What were the safety issues that needed to be considered? How were these addressed?
6. What are the minimum cybersecurity features that a system like this must have?
7. What are the minimum resilience requirements a system like this must have?
8. What infrastructure is required at the precinct and individual building level to establish a microgrid?
9. What are the physical engineering needs of operating a grid-interactive microgrid with a high penetration of renewables and storage, and without emissions-intensive backup generation (such as diesel)?
10. How did the microgrid perform in different weather and other external operating conditions? For example, in situations where the broader network was operating at full capacity
11. Were there any significant operational issues?
12. What are the loss factors and capacity factors arising from generation of renewable energy on-site? How does this compare with factors set by the Australian Energy Regulator, and is there potential for this to inform calculation of local loss factors?
13. What monitoring and evaluation practices have been utilised to measure costs and benefits of the microgrid? Have there been challenges with monitoring and evaluation?
14. What further areas of research are required? Who would be best placed to pursue this research?
15. What was the level of engagement by on-campus customers in the market?
16. What communications and engagement efforts were undertaken for both on-campus customers and external stakeholders? Have there been challenges with communications and engagement?
17. What are the ongoing maintenance costs associated with running a microgrid?

# Running a Smart Energy City

1. What was the role of building operation, including energy efficiency and control systems, in running a stable grid on 100 per cent renewables?
2. What challenges were faced in converting space and water heating equipment from natural gas to electricity? What practical strategies were used to manage the increased electrical load?
3. What market structures and price signals were used to influence behaviour of individual customers, and how did they respond?
4. How did these price signals strike the balance between customers maximising their own benefits, versus providing benefits for the campus microgrid and the broader network?
5. What are the other trade-offs faced by Monash University in operating the microgrid, or by individual customers?
6. What aspects of the project could inform the establishment of future programs to deliver real-life research and teaching outcomes?

**FOR MORE INFO, PLEASE VISIT OUR WEBSITE:**  
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