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A Review of Australian Microgrid Technologies

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About Grids Energy

Grids is a small consultancy helping out startups, companies and governments navigate the energy transition.

It provides services in energy strategy, policy development, regulatory assistance, modelling, product development and software development. It has a primary focus on smaller-scale assets like distributed energy resources, distribution networks and small-scale utility generation.

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Disclaimer

Executive Summary

This report describes different technology solutions and functions that microgrid projects require, as well as a review of vendor offerings in relation to these functions. The information contained in this report serves as a guide and examples of what groups can consider when assessing and procuring microgrid technologies.

In each project there are a spectrum of functions that need to be fulfilled to make a project successful. Some vendors can provide all these functions in a single all-in-one solution, while in other cases vendors may need to work together to fulfil different functions. The different functions are as follows:

Edge: The hardware or control method used on-site to manage assets and retrieve data.

Cloud: The off-site location that data is stored, processed, and viewed, and where data and instructions are sent to sites.

Asset Services: The optimisation and smart control of assets.

Market Services: Operating assets directly in the energy market to earn additional revenue.

Off-market Accounting: Reconciling off-market revenue streams such as peer-to-peer trading, power purchase agreements, and other arrangements.

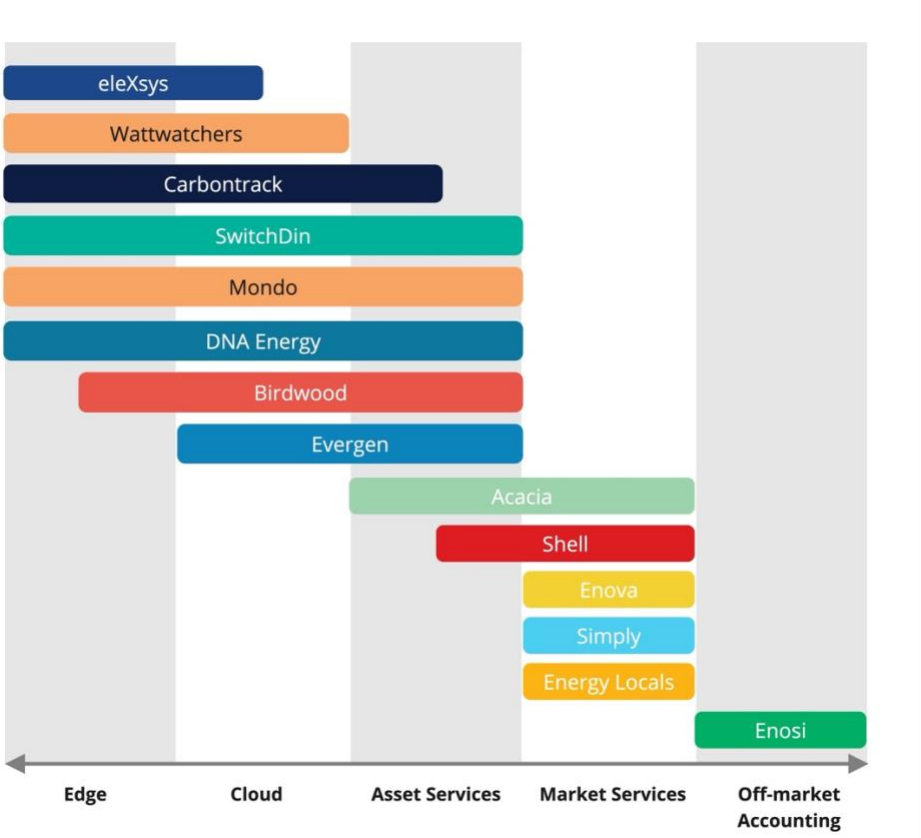

Figure 1 An example of the spectrum of functions different vendors provide.

Figure 1 demonstrates how a sample of microgrid technology providers sit across the spectrum. As offerings from any single provider don't fulfil all functions, many projects use multiple providers in partnership to deliver end to end solutions. Vendors within the same function can be largely differentiated between how they deliver functions and which projects may be suitable to their solutions. For example, some "Edge" providers will integrate into a wide range of different assets and devices, whereas others may only integrate against a smaller, preselected list of assets that are well supported by the company.

Due to the new and emerging nature of modern microgrid offerings there are opportunities for vendor offerings to improve over time to better fit customer needs. It's useful for project developers to understand potential shortfalls in current microgrid offerings, and for policy makers and investors to understand how these solutions can improve over time. The areas where there are opportunities to improve microgrid technology solutions are:

In depth EPC and integrations for smaller projects.
Large projects can procure in-depth feasibility studies, specialised hardware selection, and ongoing support of the projects. For smaller projects this may not be as viable and instead they must choose from more standardised solutions. We hope in the future the cost of upfront modelling, technology selection and technology integration become cheaper through automation and vendor maturity so projects of all sizes can access fit-for-purpose solutions that maximise the outcome.

Data access and rights
It's essential that projects understand the rights, access, and commercial agreements in relation to data and their project's technology solution before commencing their implementation of the solution. Common misunderstandings that can occur in projects are an inability to retrieve data from vendors, the projects themselves not owning the operational data from their sites, and contractual impediments to projects installing new microgrid solutions after the initial solution was installed.

Regulatory barriers for "on-grid" applications
In off-grid or embedded network applications there is some flexibility in how you can design financial offerings for sites within this network. Where you are directly connected to the broader electricity network there are more stringent requirements such as having to pay standard network charges and interact directly with the bulk electricity markets.

These requirements can make it more difficult for arrangements to financially be feasible such as community energy or peer-to-peer programs, as well as undervaluing certain types of resiliencies (such as a precinct being able to run on backup energy if the network is not available). These barriers are being resolved over time through a variety of reforms and trials.

Sophisticated claims in offerings but simple case studies
Many vendors claim abilities in intelligent control, optimised systems, and lucrative market access, but often the examples of their deployments are relatively simple arrangements that don't

demonstrate advanced functionality. We suspect that this is a combination of current customer needs often being simple, and selling a future of what could be possible with the right project and market.

We would recommend more funding and focus on the cutting edge of the value and services that microgrids can provide, such as: 'whole of microgrid optimisation' where a diverse set of assets and flexible loads are orchestrated rather than just solar PV and batteries, and different methods that microgrids can improve resiliency within a community.

Introduction

This review is to aid the audience in better understanding vendor offerings in relation to microgrid control, monitoring and reporting that can best match each customer or community's drivers whether they be resilience driven, cost related, progressing to Net Zero or a combination.

Microgrid systems and their associated infrastructure have life cycles that span over decades, and through this review we provide advice and insights that help projects make good decisions around microgrid vendor solutions that put them on the path to long term success.

What is a Microgrid?

This review uses a broad definition of microgrids as a system of energy users and assets that are interconnected and operate with a common objective. This could be an off-grid regional microgrid that must balance supply and demand within the system, a grid-connected embedded network such as a university campus which wishes to operate assets like solar, batteries, and thermal storage in a way to reduce costs and emissions of the campus, or even a community energy project with participating houses and a neighbourhood battery, which allows the community to store their solar in the shared battery, reducing their energy bills.

What is common across all these examples is that control and energy usage of these separate assets and sites are related to each other, and technology solutions must be capable of taking the entire system into account when controlling, optimising, and reporting on outcomes. The opportunity of microgrids is that synergies can be created where the outcome of the microgrid is greater than what the individual parts could achieve in isolation, as well as greater resiliency of energy supply in that system.

How to use this review

The purpose of this review is to aid you in understanding vendor offerings in a number of essential microgrid functions so that you can build technical solutions appropriate to your project.

How this review is structured

Due to a wide audience, and the changing nature of companies and technical solutions, we begin by speaking abstractly about the functions needed in a project such as controlling assets on site, processing and visualising data, and connecting into the energy market. In each of these functions we describe risks and opportunities to look for in solutions, as well as questions that can be asked to vendors to ensure their solution is fit for purpose.

There is a case study on Yarra Energy Foundation's first community battery and a fictional user story about a commercial precinct developing a microgrid solution to demonstrate different scenarios of how technology procurement can work.

We then assess various vendors in the Australian market using the framework developed in the first section. This allows you to see the framework in action, and how it can be applied to reviewing different types of vendors such as hardware suppliers, software suppliers, and market participants.

Finally, we outline potential shortfalls and areas that could be improved in microgrid offerings. This is both for customers to be aware of when assessing solutions, and policy makers, funding sources and companies to support the improvement over time as the industry matures.

Residential vs Commercial & Industrial Offerings

The level of detail this review goes into is most suitable for larger projects that have in-depth procurement processes. This is due to the fact that these details are of greater importance to these complex, bespoke projects and offerings can be tailored by service providers to suit these customers.

As projects get smaller, some of the details will matter less, and offerings will move towards more standardised solutions due to the homogeneity of these smaller projects. E.g. households are quite similar so will tend to have standardised offerings from suppliers, with a lower ability to customise, whereas solutions for energy precincts are likely to be highly customisable.

If you are running a smaller project, don't be overwhelmed by the level of detail in some of these examples, it's more important that you understand the general theme of what you should be looking for, e.g. asking "will this also work with my smart hot water system?" rather than "what are all the physical interfaces you support?".

Functions

In each project there are a spectrum of functions that need to be fulfilled to make a project successful. Some vendors can provide all of these functions in a single all-in-one solution, while in other cases vendors may need to work together to fulfil different functions. The different functions are as follows:

Edge: The hardware or control method used on-site to manage assets and retrieve data.

Cloud: The off-site location that data is stored, processed, and viewed, and where data and instructions are sent to sites.

Asset Services: The optimisation and smart control of assets.

Market Services: Operating assets directly in the energy market to earn additional revenue.

Off-market Accounting: Reconciling off-market revenue streams such as peer-to-peer trading, power purchase agreements, and other arrangements.

Generally, you will need a range of companies to fulfil different functions. For example, one vendor may provide the Edge, Cloud, and Asset Services functions, with a retailer providing the Market Services. It's important to examine both how each of the vendors provide the functions, and the interfaces between them (e.g. how does the market partner get data to and from the asset operator?) to ensure smooth integration and ongoing operation of a solution.

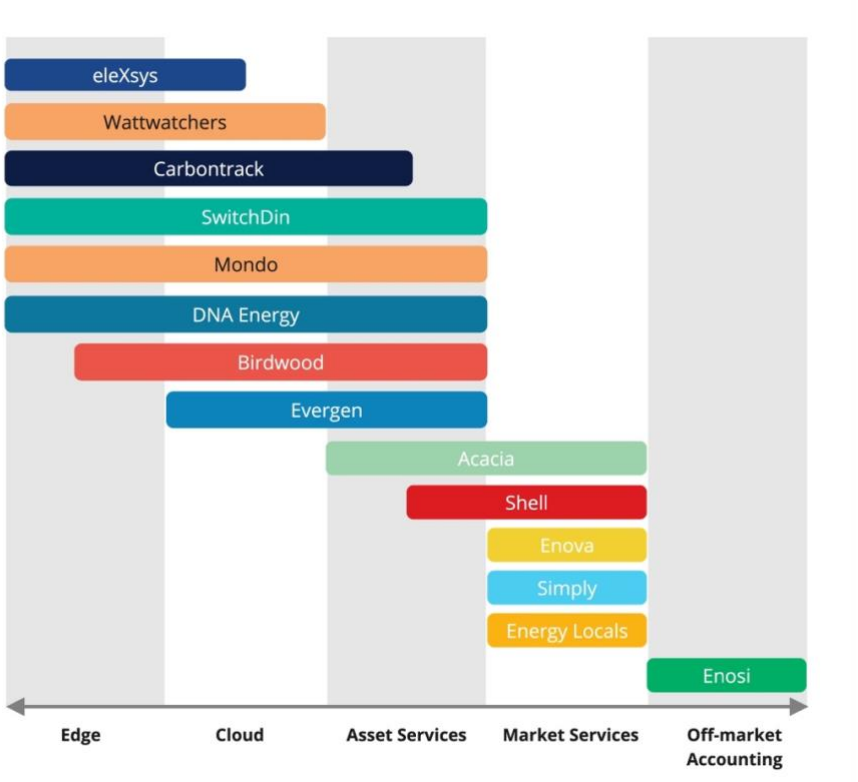

Figure 2 An example of the spectrum of functions different vendors provide.

Edge

Often when managing assets on-site, a service provider will install or use an existing on-site energy management system (EMS). This is a physical box that can send and receive signals from onsite assets (such as solar, batteries, controllable loads, etc) and send and receive information to an off-site source such as a cloud server.

Where customers have a single asset, such as a solar system, an energy management system is less typical. The main advantage of an EMS is controlling and collecting data from multiple assets at the same site.

This connection can be done through physical interfaces, such as RS485 or wireless interfaces. A communication protocol is then used over this interface, such as Modbus or Zigbee.

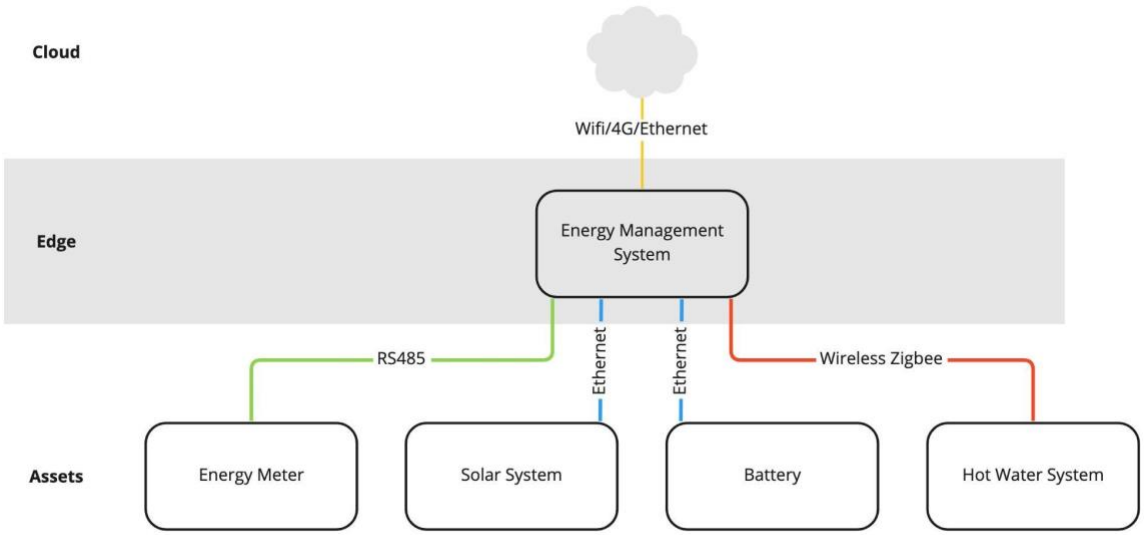

Figure 3 Example of an Energy Management System connecting to multiple onsite assets.

Three considerations when selecting edge equipment are:

1. Will it work with other current and future devices at the site that I would like to control? Some hardware solutions can create 'vendor lock-in' where you are limited in which devices are compatible with the energy management solution.
2. Is it capable of being used in certain electricity markets I may like to participate in?
3. How does it send and receive data from a remote source?

Connecting to Onsite Assets

It's important to understand the interfaces to assets that you may want to monitor and control together at your site. Energy management systems may have a limit of how many devices they can control together, the physical interfaces they have available, or the communications protocols they support.

For example, if an EMS can only control up to 3 devices through RS485 interfaces, and you have more devices than that, or devices that can only interface through other mechanisms such as wirelessly over ZigBee, you may have compatibility issues. These issues may limit the types of assets that can be installed in future or require a new energy management system to be installed.

It's also important to understand contractual agreements when installing edge hardware. It is often hard to uninstall hardware after a project commences, therefore understanding vendor obligations under different scenarios becomes key, such as what occurs if you want to integrate new hardware that the vendor doesn't support, or the flexibility you may have in choosing retail electricity partners.

Questions to ask that vendors are:

- What kind of assets can work with the energy management system (such as solar, batteries, hot water system, industrial loads, etc)?
- What is the ability for the hardware to be updated in the future to support new or not yet implemented protocols?

Capability of Market Participation

If you are intending on participating directly in the market, which can be done through various demand response and virtual power plant schemes, it will be important to ensure that the hardware installed meets the required performance specifications.

For instance, to supply Fast Contingency FCAS, currently a lucrative revenue stream for virtual power plants, AEMO's *Market Ancillary Service Specification v7.0*[1] states the hardware must meet the requirements of:

- Measuring local frequency and power every 200ms or less[2]
- Measurement of power with an error margin of ≤2% and resolution of ≤0.2%
- Measurement of frequency with an error margin of ≤0.01 Hz and resolution of ≤0.0025 Hz

Additionally, the assets themselves need to respond to a frequency disturbance in a fast and accurate manner to meet performance requirements, and the data of delivering this service needs to be captured and stored for up to 12 months in order for the market operator to validate delivery.

It's imperative that the hardware and software installed on site can meet these requirements, else there is the risk that the hardware may need to be retrofit in the future or those market revenues cannot be captured.

A good question to ask the vendor is: which energy markets or services is the hardware capable of participating in? Additionally, if this hardware is being used in an existing service such as FCAS, the

[1] https://aemo.com.au/-/media/files/stakeholder_consultation/consultations/nem-consultations/2022/primary-freq-resp-norm-op-conditions/market-ancillary-services-specification-v70.pdf

[2] 50ms or less if there's less than 25 sites in the virtual power plant

vendor should be able to reference the FCAS facility using this hardware on AEMO's NEM Registration and Exemption List[3].

Figure 4 is the registration for Sonnen's NSW VPP. Based on this registration you can be assured that the type of Sonnen batteries contained in this VPP are capable of participating in contingency FCAS markets, as the market operator has deemed them capable during the registration process.

Participant	Station Name	Region	DUID	Bid Type	Max Cap (MW)
sonnen Australia Pty Limited	VPP sonnen NSW 1	NSW1	VSNSN1V1	Lower5min	1
sonnen Australia Pty Limited	VPP sonnen NSW 1	NSW1	VSNSN1V1	Raise6sec	1
sonnen Australia Pty Limited	VPP sonnen NSW 1	NSW1	VSNSN1V1	Lower6sec	1
sonnen Australia Pty Limited	VPP sonnen NSW 1	NSW1	VSNSN1V1	Lower60sec	1
sonnen Australia Pty Limited	VPP sonnen NSW 1	NSW1	VSNSN1V1	Raise5min	1
sonnen Australia Pty Limited	VPP sonnen NSW 1	NSW1	VSNSN1V1	Raise60sec	1

Figure 4 Sonnen Australia's NSW VPP FCAS registration

Sending and Receiving Data From a Remote Source

While on-site assets and energy management systems can store data for a certain amount of time, eventually it will get sent back to a remote server for storage and processing for different use cases such as dashboard, alerting, and reporting.

The common ways for sending and receiving data from sites is through Wi-Fi, ethernet, and cellular (3G/4G).

Wi-Fi: Connecting to the Wi-Fi on-site is a simple and low-cost solution. The downsides are that the Wi-Fi signal can be low in the location of the asset, and that changing the Wi-Fi password or getting a new internet router can disconnect the asset, requiring an often-complicated process to reconnect the asset with the new password. This method is common for residential use where cellular costs or a cable run to connect ethernet may be prohibitive.

Ethernet: Connecting an ethernet cable directly to the asset is a low cost and reliable way to connect to the internet. This is dependent on being able to run an ethernet cable to the asset and keeping it plugged into the router.

Cellular (3G/4G): If the cell signal is strong enough where the asset is, this can be a reliable and low maintenance communication option. As this bypasses the on-site internet connection, there's no dependency on the on-site internet. The downside is an ongoing cost, often around a few dollars per month, to maintain this connection for the life of the asset.

Many vendors support multiple ways of connecting, and the most suitable connection method will depend on your use case. For instance, larger sites may go with a cellular solution, as the ongoing cost is small relative to the value of reliability and simplicity.

[3] https://aemo.com.au/-/media/files/electricity/nem/participant_information/nem-registration-and-exemption-list.xls

Additional pieces of information to know from vendors is:

1. *How do you ensure good connectivity during installation and commissioning?*

When using wireless connectivity options (Wi-Fi and cellular) the strength of the signal at the asset is a key factor in the ongoing connectivity of the site. Vendors should have processes in place to test connectivity before and/or during installation, and remedies to poor connectivity (such as larger antennas, wired options, or installing the asset in an alternate location).

2. *What are the processes if my site loses connection to the internet?*

Vendors will generally have processes in place to diagnose, alert, and resolve connectivity issues. Understanding whether they will contact you if there is a loss of connectivity, and how they will support you in reconnecting, will ensure a smooth process down the track if anything goes wrong.

3. *What are the financial and data implications if I lose connectivity?*

Financial impacts of losing connectivity can impact revenue streams such as losing market revenue as your asset can't bid into the market and increased bill costs due to losing certain asset optimisations that require an internet connection to function.

On-site assets and energy management systems can generally continue to store data for a period of days or weeks, and when the connection is re-established, they are able to send that information to a cloud server for storage and processing. If the connection is down for longer than the period it can be stored locally on site for, you may experience data loss.

Cloud

Now that we've gone through the function of controlling assets locally on site, how do we get access to operation data, as well as send data and instructions back down to the site? This is where the cloud comes into play.

Energy data is sent from the site to the cloud, through the methods explained in the above section. Once in the cloud, it can be processed, analysed, and viewed for different purposes. The two key factors to consider are: what kind of information and data do I want access to, and in what form does that information come in?

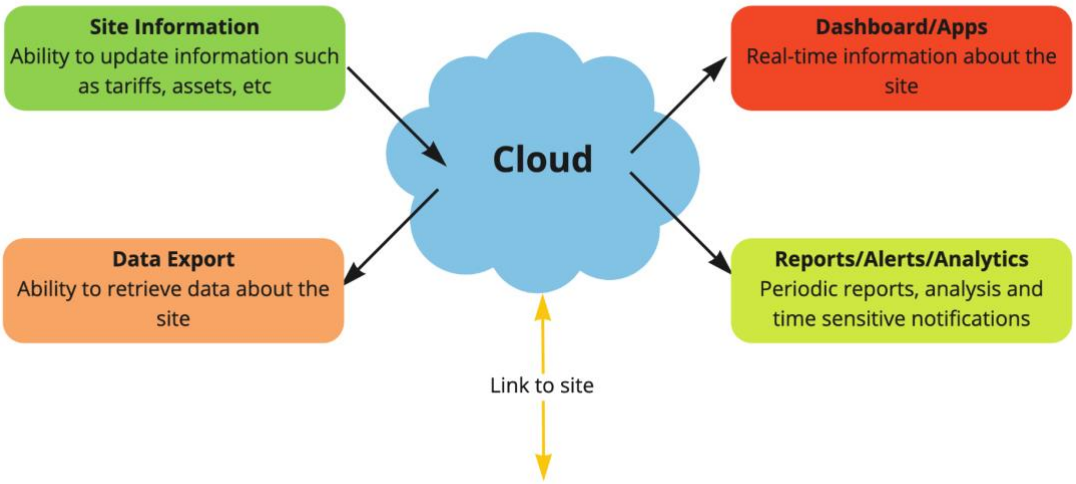

Figure 5 Functions performed by cloud service.

Communities and microgrids have a wide range of objectives and data requirements. Perhaps you are aiming for certain financial outcomes and cost savings, self-sufficiency and resiliency benefits, or reaching environmental and emission goals. Based on these objectives, a key requirement to look for in a vendor is they can both operate assets to achieve these objectives, and get you the data required to verify, report, and improve these outcomes.

Another factor when considering the cloud functions on offer is how they can aggregate data and sites together. Microgrid projects tend to have multiple assets and sites that may want to be viewed, or data retrieved, in aggregate. While vendors are fairly standardised on the asset level data offerings, fleet wide capabilities can vary widely and suit different use cases and levels of required sophistication and customisation.

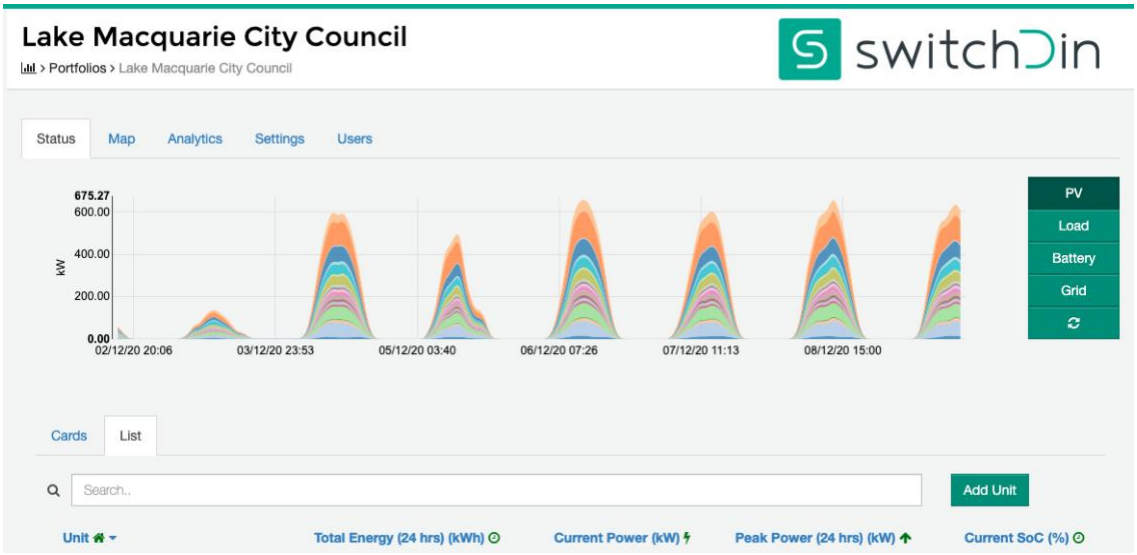

Figure 6 Aggregate view of asset performance across multiple sites with solar PV in SwitchDin's Stormcloud portal. Source: SwitchDin

Larger projects will often have more ability to work with the vendor to customise data and visualisation elements to suit them, and an alternative option is to acquire raw data from the vendor and post-process it yourself. For instance, a vendor may not offer emissions-based information, but by acquiring the raw energy data in an ongoing manner from the vendor (e.g. through an API or regular CSV export) and understanding emissions factors of on-site assets and on the electricity grid, workflows can be created to calculate these numbers independent of the vendor. It's key in these situations to determine the feasibility of this approach and communicate these needs to the vendor before the project has commenced.

Where and how your data is stored by the vendor may also be an important consideration. There are many factors such as:

- Some projects or funding schemes have the requirement that data is housed in Australia.
- There may be reporting requirements on the project owner that requires retrieval of certain data housed by the vendor in a timely manner.
- Understanding the data security and policies of the vendor, both from a technical (e.g. IT and infrastructure security) and process perspective (e.g. what personnel can access which data for which reasons, and systems built to administer that).

A common downfall of projects after they have commenced is that required information can't be provided to the project owners to carry out their duties, or information isn't stored, accessed, or used in the way the project requires. The consequences of this can be large expenses on the project as vendors must unexpectedly augment systems and processes to suit the requirements, or in the worst-case scenarios cease development work on the project and the project owner must go back out to market to find a vendor capable of fulfilling the requirements.

To get into the details of features and functions that may be required from a cloud provider, we've broken them up into four areas: Dashboards and Apps, Reports and Alerts, Data Export, Site Information.

Dashboards and Apps

Dashboards and apps allow for the examination of real-time and long-term information in a dynamic way. They are often made available through one of more of these means:

Web Application: Accessible through the browser, this type of application is generally best viewed on a computer, allowing for more rich data insights on the larger screen and often the ability to download the data for further analysis.

Figure 7 Mondo's Web Application. Source: Indigo Power

Mobile Application: Suitable for being able to quickly check in on the project and real-time notifications. Most commonly used as a primary way to view the system in the case of households as those sites are simple, but may not be as useful for larger, more complicated sites.

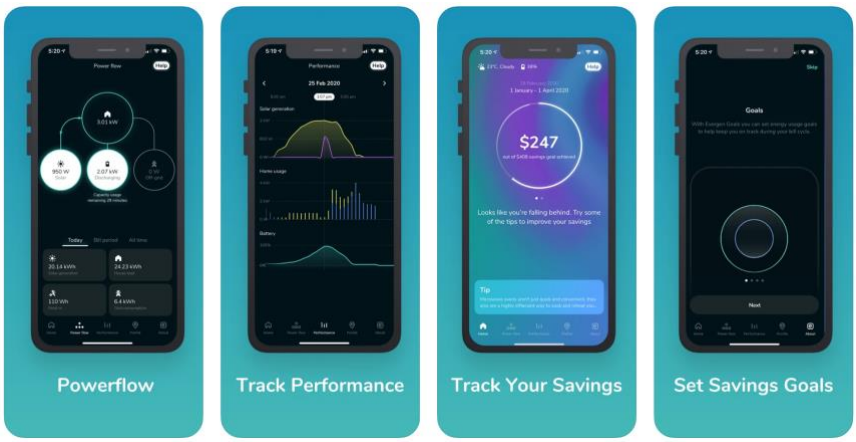

Figure 8 Evergen's Mobile Application. Source: App Store

Desktop Application: Some operators in a project may not be able to access the web application due to company firewall or policy rules, in that case a desktop application may be available, which is similar in functionality to a web application.

Three use cases of these apps are for the public display and promotion of the project, assessing performance and diagnosing issues with sites and systems, and delving deeper into the data for analytical purposes.

Dashboards are often considered for internal use, but potentially can also be used to display and promote your project publicly. This may be through simple visualisations to show in a kiosk or office TV screen, a publicly accessible website that anyone can go to and see the operation of the project, or screenshots of the dashboard to use in reports or other collateral. Not all vendors provide this kind of functionality, but some may provide it as a standard offering or as an ad hoc customisation to your project.

An alternative to a vendor supplied public dashboard is building your own, this will require you to have an ability to export data from the vendor to display on the dashboard but may give you more flexibility in how you present the data. An example of this is the University of Queensland Battery Dashboard[4] which presents live operational data from the battery.

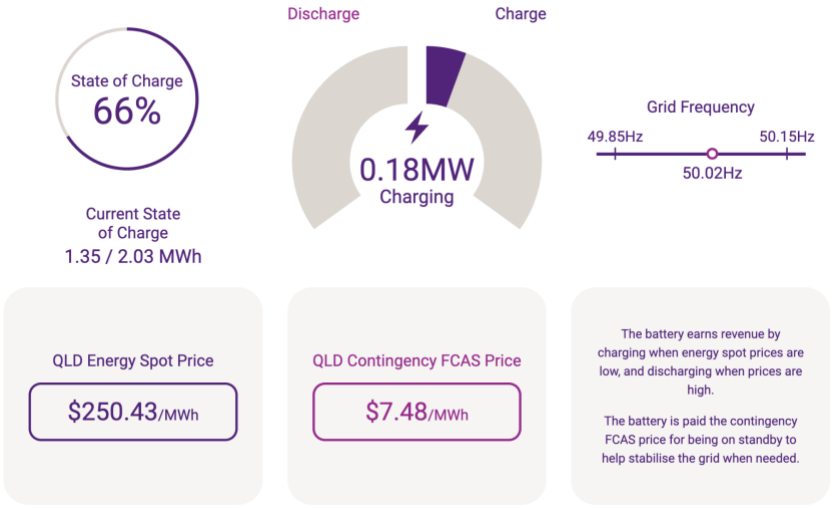

Figure 9 Part of the University of Queensland Battery Dashboard. Source: UQ

Dashboards can also be used to diagnose issues in your assets. These will tend to be communication issues, such as the internet being down, or operational issues, such as the asset not following control commands or behaving unexpectedly. There is a spectrum of capabilities that dashboards may provide in identifying and diagnosing issues. The simplest being displaying data about the assets which would allow you to identify that there is a problem, e.g. there being no operational data if the system is offline. Next on the spectrum would be displaying the status of the asset, e.g. the dashboard showing a "status: offline" message for the asset. In the best case there is a proactive alert giving you information about the issue as well as ways to remedy and verify the solutions to the problem.

[4] http://dashboards.sustainability.uq.edu.au/engineering-precinct-battery/interactive/#/

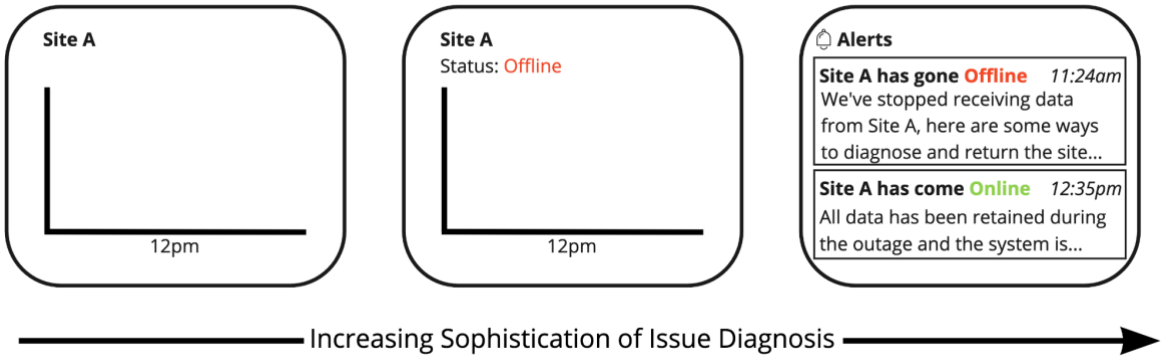

Figure 10 An example of different ways a dashboard may represent to you of an issue with at the site.

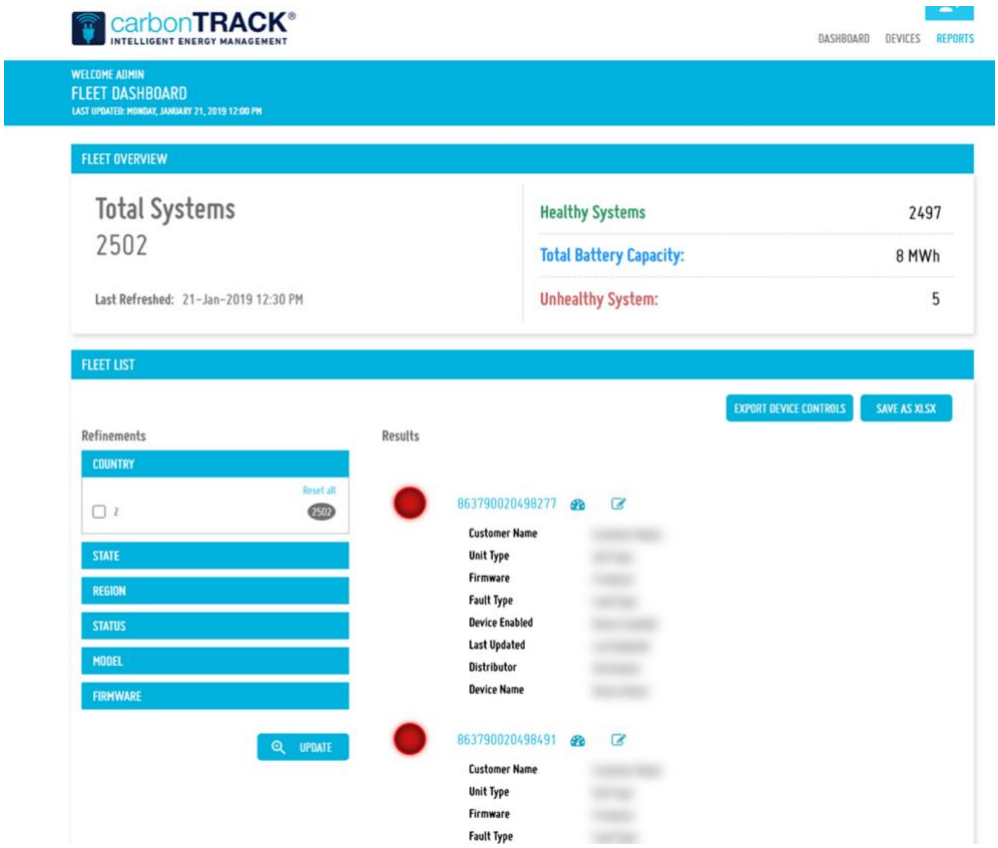

Figure 11 carbonTRACK's fleet level overview, allowing you to quickly see issues with specific systems.

Dashboards can also be used for deeper analysis. During product demos or in proposals you should assess whether the vendors dashboards and other digital offerings can support the level of detail and access you'll need for this analysis.

Reports and Alerts

Vendor offerings may include reports that are periodically sent to you in a standardised format. The advantage of these reports is that they don't depend on users going to the dashboard or the app and can quickly show an overview of how the project is performing over time. Good reports can also show opportunities and insights for how to improve your outcomes.

Timely alerting is a key feature to aid you in remediating any issues with your systems. It's imperative that these alerts not only make you aware of the problem but provide you with enough information to know what should be done to fix it, and potentially the consequences of this problem. For instance, if a vendor loses connectivity at a household, it may not be imperative that the household be alerted immediately as quite often connectivity can be lost for small periods of time before being re-established and the consequences of that are low. As time goes on and the site does not reconnect, the vendor should have processes to increasingly alert the homeowner or other relevant party to the problem such as:

- Push notifications on the mobile app alerting them to the lost connectivity, with common solutions to this problem.
- Periodic emails relaying similar information, in case the owner doesn't use or check the app.
- In the case of longer run outages, contacting the customer by phone in order to remedy the problem with support staff.

For larger projects like commercial and industrial or precinct wide installations, the same idea applies, although processes are likely to be much more structured and agreed upon with the vendor beforehand, often through service level agreements (SLAs).

Data Export

When certain information can't be provided through apps or reports, or displayed in the way you'd like, another option is to export the data and analyse it yourself. The level of access to data export capabilities necessary will depend on your project goals and the dashboard, app, and reporting capabilities offered by the vendor. For instance, households or small C&I sites may have little need for direct data access, as understanding that their system is working and achieving its objectives can be seen through other tools, but large projects with uncommon or bespoke needs may heavily rely on the ability to export data from the vendor.

There are a variety of ways you can access the data, such as:

Exporting through a webpage or dashboard: Some vendors will provide data export functionality through a webpage or dashboard. This allows the user to select the type of information they want, and other parameters such as timeframe, time interval of data (such as 1-minute, 30-minute, daily) and be able to export this data as a CSV. The advantage of this method is that a wide variety of users can easily access this information.

Exporting through an application programming interface (API): A direct API connection to the vendor and your data is the most powerful way to access your information. Vendors will often make

an API available to larger projects to programmatically retrieve their data. Good questions for vendors are what documentation is available for accessing the API, what is the process if we'd like to access data not currently available through the API, and are there any software development kits (SDKs) available to more easily access the API[5]?

While retrieving data from an API requires skills in programming to access, maintain and extend, this connection is often the most flexible way to access the data. This method can also be used to build your own automated workflows or app. For instance, if you'd like reports on emissions intensity or asset uptime, and the vendor doesn't supply that information directly, you can fetch some base data from their API (such as energy or operational data), and extra data sources from a 3rd party (such as grid emissions data from AEMO) to create your own reports. Alternatively, this development work could be done for you by a 3rd party vendor if your project doesn't natively have these capabilities.

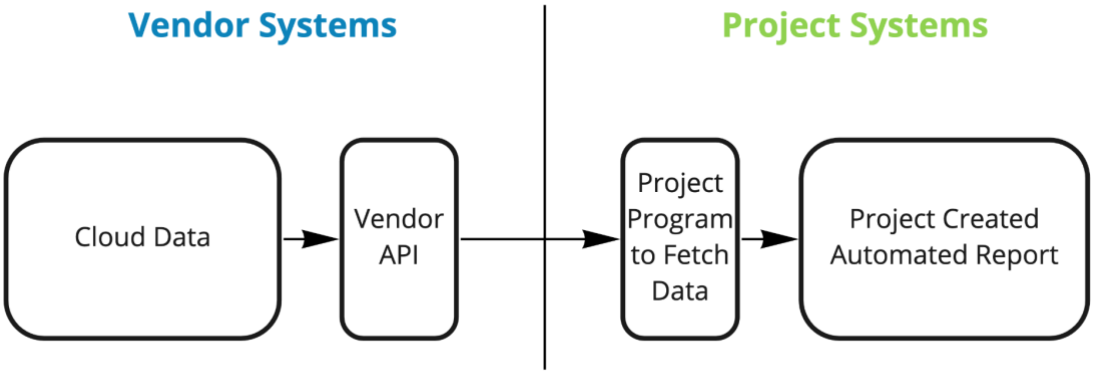

Figure 12 Simple architecture of a project building their own program to fetch data from the vendor's API and create an automated report.

In these scenarios where you are building critical processes and applications on top of a vendor's API, it's important to understand up front what level of support is available if things go wrong with the API, or if project developers are having difficulty interfacing against it. Additionally, it's important to understand what costs and processes there may be to extend the vendor's API to access data currently not supported or increase the speed and performance of the existing API.

Sometimes in projects giving API access can be used as a quick solution to small use cases or needs of the project, such as exporting basic information each month for the project to do their own analysis. These APIs can sometimes be poorly supported or limited due to the ad hoc nature of these solutions. This therefore runs the risk of a project expanding their use and dependency of the API over time, without proper agreements and processes in place, leading to poor outcomes for both the vendor and the project. Due to this it's imperative that if API access is needed for a project, that strong, well understood agreements are made upfront between the vendor and customer.

[5] An example of an SDK from Reposit Power: https://github.com/RepositPower/reposit-python-client

Exporting through the vendor's support: For ad hoc requests, or before automated solutions are put in place, it may be possible to export data through the vendor manually retrieving data and sending it to you. This will often be limited in what they can retrieve, may not be timely, and may cost money, but if you need data for non-recurring use cases, such as project milestone reporting, and the data can't be retrieved though easier means such as through the dashboard, this may be an avenue to access this data.

Site Information

While we've spoken about getting information out, there is also the function of getting information in. As your circumstances change you may need your system to understand this, such as getting on a new energy tariff or adding new assets to your site. Vendors have different ways to communicate this information, from updating it directly in a dashboard or webpage, to emailing support.

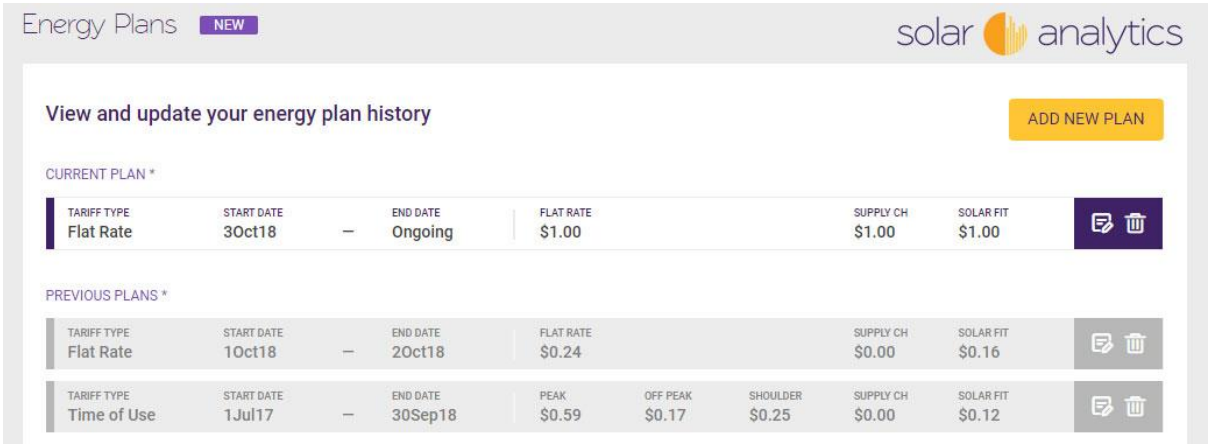

Figure 13 Solar Analytics dashboard to update energy tariffs.

You may also want to communicate real-time information about the site, such as changing the level of power stored in your battery in case of an outage[6], if you're expecting to use more or less energy than usual over a period[7] (so the intelligent asset optimiser can adjust), or if the system is going down for maintenance.

There is a wide range of capability between vendors in offering those functions, so if these use cases are useful for your project, it's important to know which of these vendors do, or could, support for your project.

[6] An example of this is Tesla's "Backup Reserve" https://www.tesla.com/en_au/support/energy/powerwall/mobile-app/powerwall-modes

[7] An example of this Reposit Power's "Hibernate Mode" https://blog.repositpower.com/how-reposit-looks-home-away

Asset Services

Next up is how should these assets be controlled? In some situations this may be simple: solar generates when the sun is shining, the battery charges when there is excess solar generation, and discharges to offset the site's energy needs overnight.

Often though there are factors in which more complicated decisions must be made in how an asset operates, such as:

Residential & Commercial Industrial: Time of use tariffs, demand charges, and virtual power plant schemes require the battery to charge and discharge at specific times.

Community Energy: Operating a community battery in a sophisticated manner to charge from local solar exports or operating around a sophisticated network tariff[8].

Campus Precinct, Embedded Network, or Microgrid: Often multiple assets are being coordinated for a common outcome, such as energy balance within the local system. This requires understanding which systems should be dispatched in which order, e.g. battery, diesel genset, or load flexibility as well as ensuring the systems can meet future short term energy needs.

How assets are operated in these scenarios can have a large impact on financial, emissions, resiliency and other key outcomes desired in these projects. Therefore, vendors often put a large focus on the "smarts" in their offerings and compete on the fact that they can save you more, drive down emissions even further, and make your system smarter.

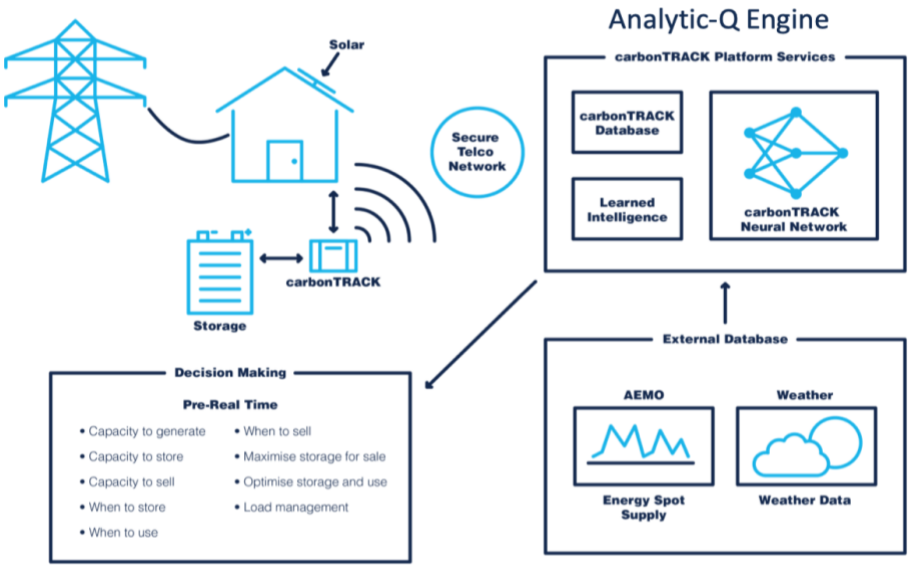

Figure 14 An example of carbonTRACK's intelligent energy management offering.

[8] CitiPower, Powercor and United Energy's community battery trial tariff https://media.powercor.com.au/wp-content/uploads/2022/02/28084618/Community-Battery-Trial-Tariff-factsheet.pdf

Vendors achieve these results by predicting the future needs of your system, such as solar and load predictions, understanding how your assets perform, such as battery round trip efficiency, and external factors such as predicted wholesale prices and weather. With this they can then create schedules to operate your asset in ways that achieve better outcomes. Should that battery discharge now or later, when should the chiller operate, and how can we reduce the financial impact of this evening's peak load usage are the types of scenarios these asset optimisation services can cater for.

Additionally, vendors can optimise asset use to stay within warrantied operational usage, such as a maximum amount of battery cycles over a period or maximise the usable life of an asset such as reducing the amount of time a battery is at 100% or 0% state of charge or experience high charging and discharging rates.

When assessing vendors, it's important to understand which of these services they provide, as "smart control" can mean many things. As these claims of smart control are often easy to make, being able to understand the impact of this control is key. Questions to ask vendors to better validate their claims are:

1. *Are there any case studies or examples demonstrating how this control improved outcomes for a project?*

Current or previous project examples demonstrate the existing ability of a vendor to provide these asset services. Ideally these examples should provide detailed information about how these outcomes were achieved, rather than just high-level statements such as "customer X saved 20% of their energy bills through our smart control".

2. *Can you analyse and estimate our potential savings before the project commences?*

This may be through feasibility studies, modelling exercises, or estimates, and can give some reassurance on the ability for the vendor to achieve their claimed outcomes. Due to the overhead of providing this kind of tailored analysis it may only be available to larger projects.

3. *How can we validate in an ongoing manner that we're achieving these outcomes through smart control?*

Vendors can often provide overall savings of the system through simple means such as comparing your current energy bills to bills you had before the system was installed, but ideally, they can also provide metrics or indicators of the impact that their smart control directly had on your project.

As vendors often use complex algorithms, and baseline cases of what would have happened without smart control can be hard to examine, this can create opaqueness which causes difficulties for a project to assess different vendor offerings. Additionally, as there are no commonly accepted methods to represent the positive outcomes of these services, and outcomes can vary widely depending on the scenario, it can be difficult for vendors to clearly articulate their capabilities. Due to this it's unlikely that vendors will "tick all the boxes" and provide a level of upfront and ongoing information to perfectly assess their offering in this area, and the best approach for projects is to collect enough information to make an informed, risk-based decision.

Market Services

Market services are using your assets directly in the energy markets, which can earn extra revenue for your project. To get access to these services you need a market partner. This market partner will be a registered participant in the national electricity market (NEM). The market partner will take care of bidding into the market, sending back your market obligations which dictate how you operate your asset, and periodically sending the money to you which you've earned in the market.

Since 2017 market rules have been adapted to allow smaller and more diverse assets to provide services into the NEM such as small-scale batteries and industrial loads[9]. This has spurred on new entrants who can provide specialised access to certain markets, alongside existing electricity retailers. While direct market participation isn't necessary to achieve many objectives of a microgrid project, in some scenarios it can be a lucrative way to be further rewarded for the value your assets can provide to the energy system.

An important operational aspect to consider is how your market partner will work with your downstream vendors such as edge, cloud, and asset services providers. Data and instructions are passed between these different functions so ensuring that all parties can integrate against each, and that there are clear responsibilities such as who resolves different issues is key to the smooth operation of your project. In the case that the market partner has downstream vendors that they are strongly partnered with or have worked with on previous projects this is generally not an issue, but if you are selecting these different vendors separately and getting them to work together for the first time then extra care and focus should be taken in understanding how they will work together. Key areas to examine are design, commissioning, registration, and during market or operational anomalies when operating the assets.

The financial arrangement with the market participant is also key to consider. These participants have different cost structures for accessing the markets through them, some take a fixed fee per amount of capacity, a percentage of revenue, or both. There may also be costs passed on for IT integrations. In scheduled markets, such as FCAS, or RERT, different providers have differing abilities to earn revenue, based on the size of their existing portfolio which may impact the revenue you're able to earn.

Off-market accounting

Under the national electricity rules, all energy that flows through a market meter must be settled in the spot market. This means that energy that flows in and out of your home or site must be settled in the bulk electricity market, and is settled by the Australian Energy Market Operator (AEMO)

There are, though, opportunities to trade with different parties outside the market. Say you'd like to buy energy from a local wind or solar farm, or you live in an embedded network and would like to trade energy with your neighbour. This can be achieved but requires a 3rd party to measure and reconcile the energy and financial flows, so the parties can understand how much they owe each

[9] https://www.aemc.gov.au/news-centre/media-releases/more-options-for-demand-response-in-providing-1

other. These 3rd parties can also tell you where your energy came from, giving firm clarity to the emission impacts of your energy use.

Historically these financial instruments have only been available to big energy suppliers (utility scale generators) or users (retailers, large industrial users) through bilateral contracts or through markets such as ASX energy, but new companies are making these kinds of functions available to smaller users, with increasingly more sophisticated arrangements and settlement structures.

Often these functions can be bolted on to existing control solutions, as it is a fully digitised function, meaning the off-market accounting providers can take in data from your existing solution, and output prices, financial flows, and emissions attributions where required.

One aspect to be aware of is that under Australia's National Measurement Act, meters used for financial settlement must be "pattern approved". This is a testing and approval process that has been undertaken for the smart meter at your home or site, but rarely for your solar, battery or energy management meters. Due to this it's important to understand which of your meters are pattern approved and suitable for this kind of financial settlement, as well as who can easily access that meter data to provide to the off-market accounting vendor.

Questions to ask vendors of off-market accounting solutions:

Can you quantify the potential benefits of these arrangements before project commencement (such as through a feasibility study), and how can we see the value being created on an ongoing basis?

Does the solution scale to suit the size of the project?

Off-market accounting can get complex quickly, especially for something like a community energy project that could involve hundreds or even thousands of sites. It's important to ensure that solutions can scale with your needs.

Case Study and User Story

This section includes a case study on the Yarra Energy Foundations's first community and a fictional user story about a commercial precinct developing a microgrid solution to demonstrate different scenarios of how technology procurement can work.

Case Study: YEF Community Battery

The Yarra Energy Foundation (YEF) is piloting a community battery project.[10] Two objectives of the pilot are to investigate: "How to design a system which is financially sustainable, and ideally replicable and scalable", and "How battery control software can be optimised to manage the flows of electricity and interfaces with users."

YEF were procuring this for their first pilot battery, in North Fitzroy, Melbourne, but as they are aiming to scale the project were looking to create a structure that would scale both financially and technically to support hundreds of batteries over time.

YEF assessed the market for solutions and found it difficult to identify a suitable "full stack solution" from a single vendor due to the new nature of community batteries, and the need to have a low cost of operations. YEF ended up designing a modular system, with different parties fulfilling each of the functions, and YEF building some of the parts themselves. This required a high level of coordination between the different partners and vendors, as well as capability uplift within YEF.

Their technology stack is as follows:

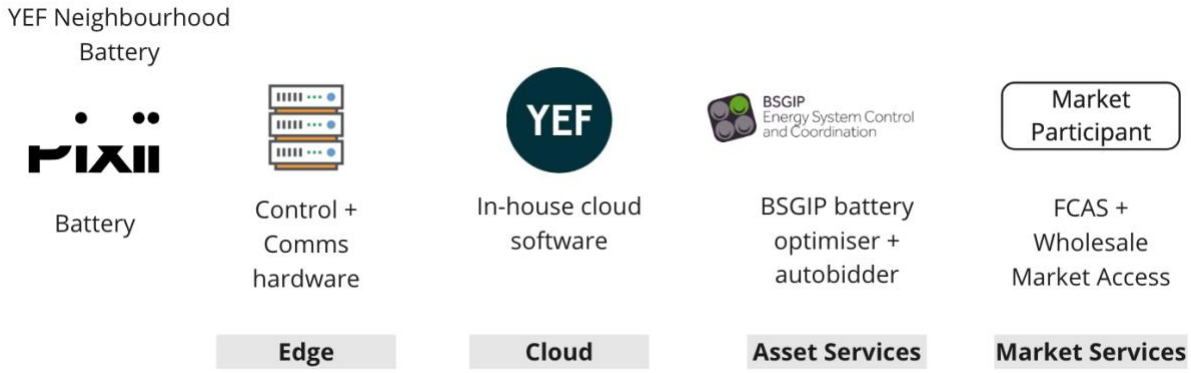

Figure 15 YEF community battery technology stack.

- Battery: After receiving many applications from vendors, YEF selected pixii battery due to its suitability for use in a community setting (quiet, small footprint), modular design, competitive cost, and support provided from Pixii.
- Edge: This monitoring and control hardware chosen was compatible with different partners (Pixii, cloud) and suitable for market services such as FCAS.

[10] https://www.yef.org.au/community-batteries/yarra-community-battery-trial/

- Cloud: YEF are building their own internal cloud software to control costs as the number of batteries scale. Their cloud solution routes data to different functions, stores that data and does alerting.
- Asset Services: YEF are using battery optimisation and auto bidding software developed by ANU. YEFs modular solution means their cloud solution can send operational information to ANU, ANU then sends back an optimal control strategy which is forwarded to the battery, and FCAS bids which are forwarded to the market partner.
- Market Services: YEF has chosen a market partner who is a registered participant in the energy market, to provide exposure to wholesale electricity prices, and bid into FCAS. This market partner provided metering solutions for market purposes and worked very closely with the other functions (YEF cloud and ANU auto-bidder) to ensure a reliable end to end integration. This market partner will aggregate YEF's batteries, and sites of their other customers together for FCAS purposes.

Below is the operational model for data flows between the different functions. With YEF in the middle transmitting and storing information they are well positioned to leverage that data to achieve a lot of their data objectives of the project.

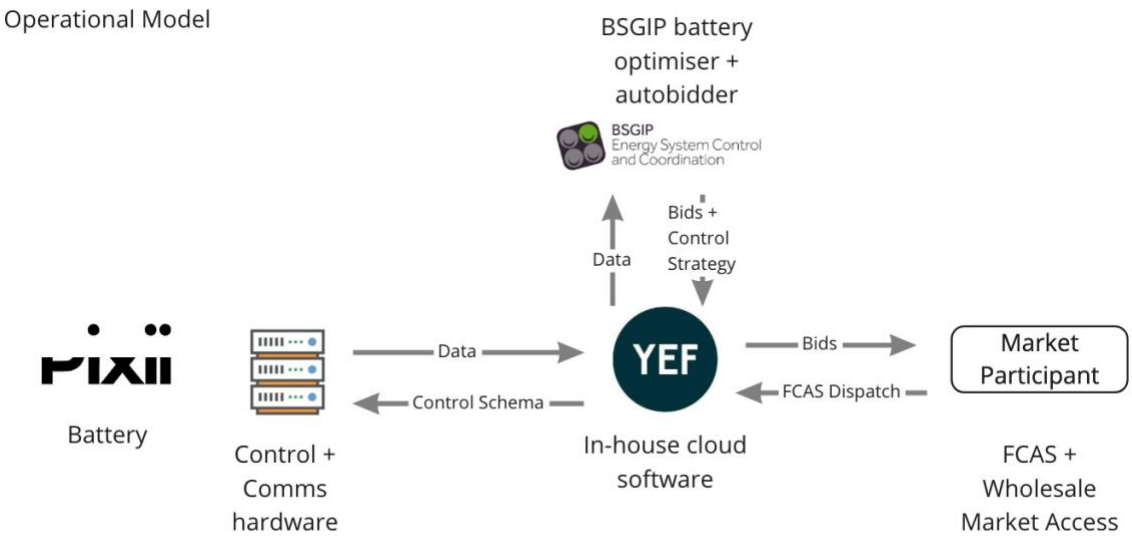

Figure 16 YEF community battery operational model.

User Story: Commercial Precinct Microgrid

Bob is the energy and sustainability officer at a commercial precinct. This precinct involves a number of offices and commercial spaces for small businesses connected within an embedded network. Recently the precinct decided to generate some of their own electricity locally, as well as reduce emissions and improve the operational efficiency of energy consuming assets such as HVAC and chiller plants. They decided to do this to achieve the objectives of reducing energy bills for the precinct, as well as sustainability and resiliency goals.

Bob hires a consultancy to do a feasibility study on ways they can best achieve their objectives. The study outlines economic and emissions outcomes of installing local generation and improved operation of current assets under a variety of scenarios such as the size of local generation and extent of optimisation of different assets. Based on this study the precinct decides to do a staged approach, first installing a small amount of generation and optimising the operation of larger assets, and then having the option to do a second phase with more generation and assets under control in the future. This de-risks the project in that it allows trialling the solution on a smaller scale before a larger implementation.

Bob puts out a request for proposal for a vendor to develop a solution and manage the delivery of the project. In the proposal it outlines preferred features and approaches outlined in the feasibility study that are relevant to the precinct, as well as current electrical equipment within the precinct.

Multiple vendors responded and the precinct decided to go with New Energy Co as their delivery partner. New Energy Co is a commercial and industrial focused retailer who also offers project development and different technology partners they often work with. Due to the complex nature and large size of the job, the precinct valued having a single company to manage the project, rather than the precinct having to manage multiple companies implementing the different microgrid functions.

New Energy Co spent time with the precinct understanding their current and future requirements for the project, and for many of the microgrid functions brought in partners that had suitable solutions for the project.

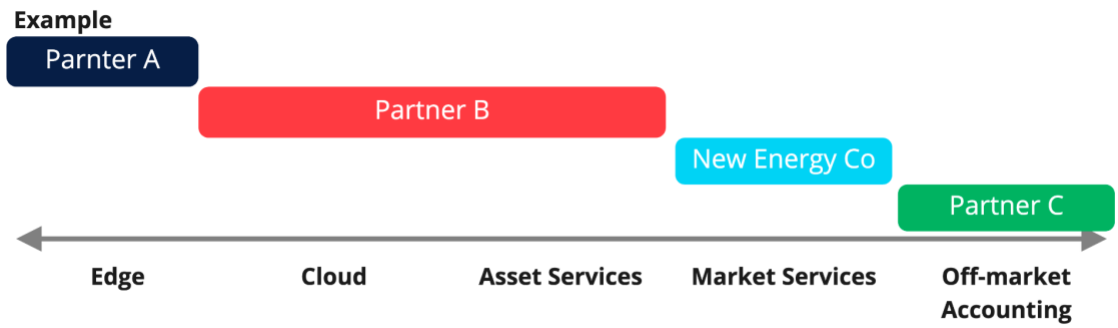

Figure 17 New Energy Co and partners making a holistic microgrid solution.

The project was managed and delivered through New Energy Co, who gave regular updates to the precinct during the process. As the project was reaching compilation, New Energy Co trained precinct staff on maintenance and troubleshooting aspects of the assets, and how to retrieve and display information through the digital platform. New Energy Co would also remotely monitor the project, identifying any issues and reviewing outcomes over time.

This process allowed the precinct to offload much of the complexity and domain knowledge required in implementing the solution. When selecting a project manager, the precinct looked for a vendor that had developed solutions for similar projects and that would spend enough time before and during the project understanding the precicint's requirements and giving updates and training. This

resulted in a smooth operational handover once the solution was implemented and successful outcomes for the project. Bob and the precinct are currently monitoring their outcomes and assessing when the right time is to expand to future phases.

Vendor Market Scan

In this section we review a selection of vendors operating in the Australian market. Research on these vendors was conducted through publicly available information, and where possible customer interviews and interviews with the vendors directly. Due to the differing level of available information and access to these companies, there is a range in the depth that each review goes to. We believe these reviews are best used as examples of how questions from the functional framework can be applied to vendors, as well as a high-level overview of the range of different vendor offerings, and which kind of projects they're likely to be suitable for.

Below is a mapping of the vendors onto the different functional areas. As you can see, vendors fall on a spectrum, with many fulfilling multiple, adjacent functions.

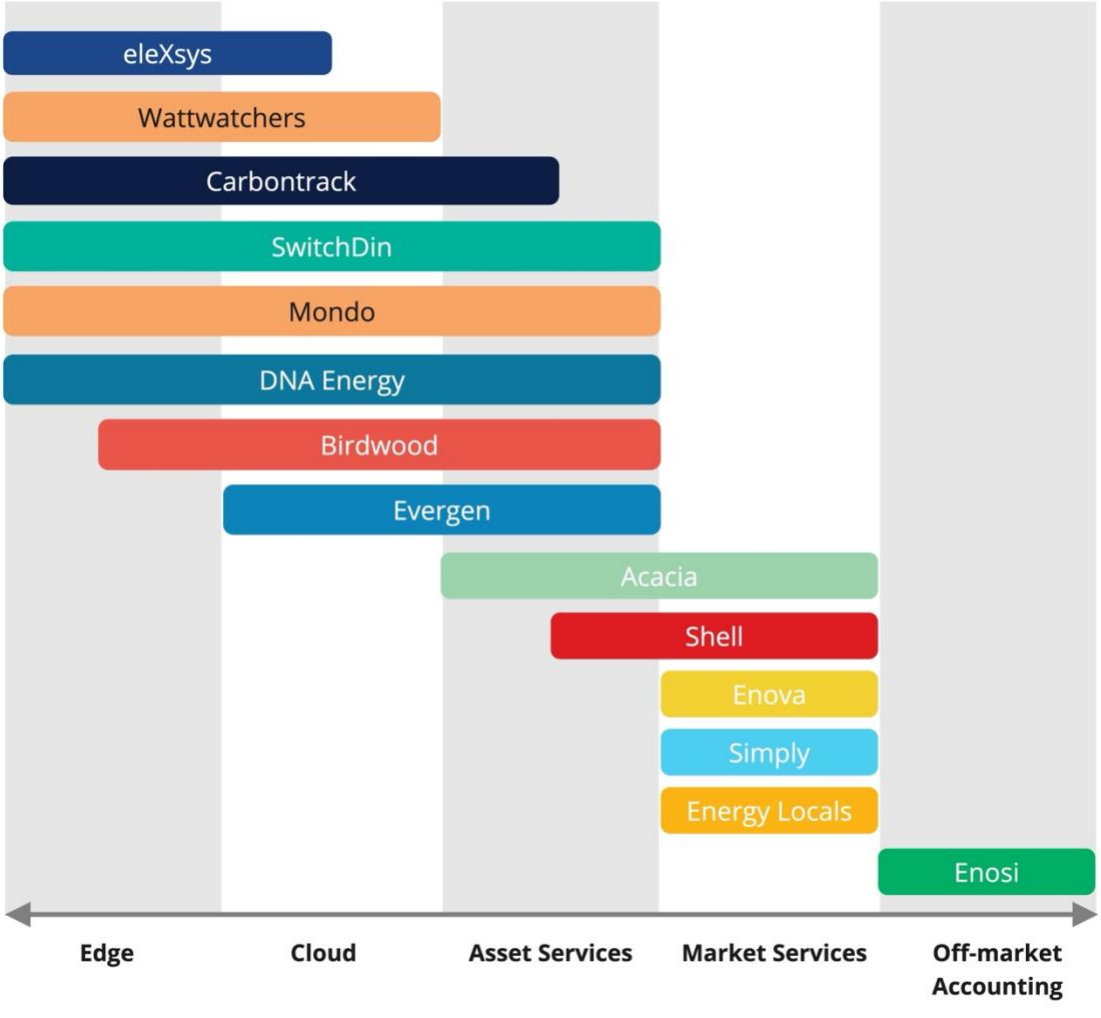

Figure 18 An example of the spectrum of functions different vendors provide.

End-to-end solutions will involve multiple vendors in combination to fulfil the different necessary functions of the project. This coordination between vendors can fall primarily to the project operators itself, or one of the vendors can be a lead vendor which partners and manages the others. Below is a fictional example of this, where Birdwood energy is the lead partner and in charge of

cloud and asset services functions. They procure carbonTRACK as the edge hardware, which they integrate their cloud against, partner with Simply Energy as their make partner in the solution, and use Enosi for enhancing the energy offer.

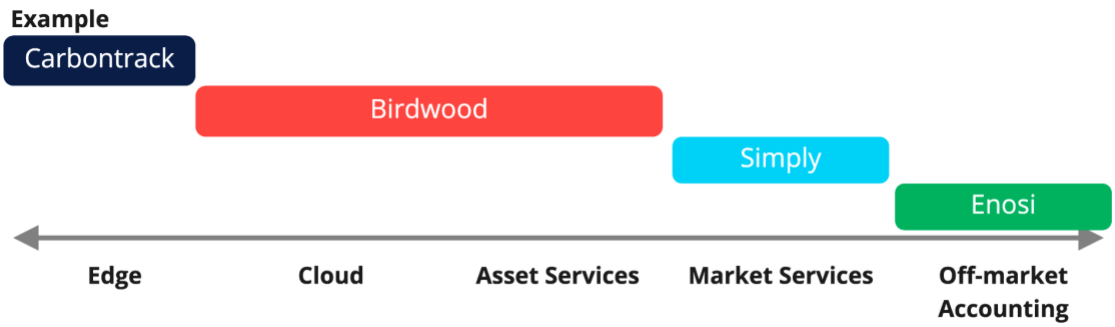

Figure 19 An example of integrating multiple providers in a solution.

This example illustrates the modular nature of typical solutions, but also that where vendors can provide overlapping solutions (e.g. both Birwood and Carbontrack providing cloud services) oftentimes they can still be made compatible through only one party providing that service.

Technology Providers

eleXsys

Edge Cloud

eleXsys is a specialised hardware provider that can help manage voltage and power factor in a microgrid project. It does this through a proprietary static synchronous compensator (STATCOM) that they install to manage the supply of electricity at the site. This technology is typically utilised by networks to improve the quality of the network.

This hardware is suitable for projects that have poor access to the electrical network, perhaps because they're near the "grid edge", or projects that are an isolated microgrid. Being able to manage power quality in these scenarios may allow more power to flow through the system, avoid costly network upgrades, or allow more renewable generation to operate in the microgrid. It's important to understand whether your project would benefit from this technology and the extent to which these benefits may be realised.

The benefit of eleXsys for projects that need power management hardware is their all-in-one solution. The hardware not only functions as a STATCOM, but also as an inverter for solar, battery and EV charging assets meaning that a single solution can both control the assets and electrical quality at site. EleXsys can also provide "engineer, procure, construct" (EPC) services to design and install assets within a microgrid, such as solar, batteries, and EV chargers, as well as their hardware solution.

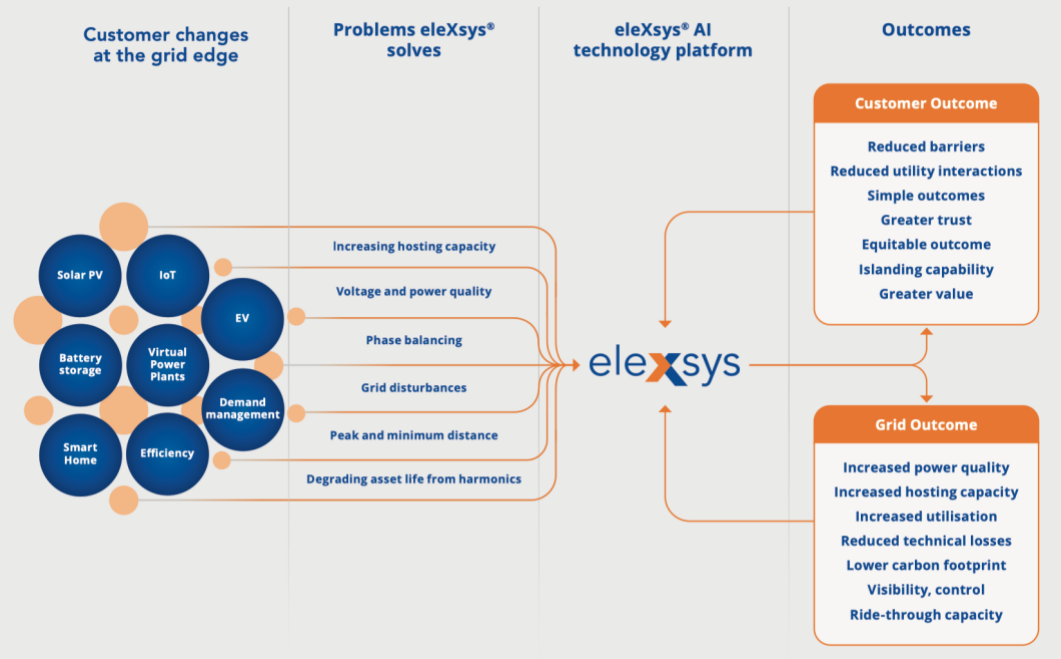

Figure 20 eleXsys all-in-one solution.

eleXsys hardware has been demonstrated in field through their IKEA microgrid project[11]. Here they installed 1.2MW of solar, a 3.4MWh battery, and 3 electric vehicle charging stations on a constrained part of the network the ordinarilly couldn't support these assets without eleXsys's hardware. Over the 20-year project, eleXsys will also provide asset services such as "trading algorithms to provide frequency services stabilising the grid and spot market energy trading from the BESS". While this capability is currently less mature than other companies focused on asset services such as Evergen or SwitchDin, eleXsys are well positioned to expand their offerings to provide this as they are already providing whole-of-site management and monitoring.

Wattwatchers

Edge Cloud

Wattwatchers is a hardware focused energy data acquisition company. They provide energy monitoring devices for residential and small to medium business applications.

Two key features of Wattwatchers are their focused specialisation in hardware and open nature of accessing data through their cloud platform. This is somewhat of a rare combination when exploring microgrid hardware offerings. Often pure hardware companies can be lacking in easy options to retrieve and extend data captured by their devices, and companies with strong cloud options may be incentivized to offer more advanced, upstream services, and therefore aren't as open to 3rd party vendors using their data, instead electing to create their own proprietary value-added services. Wattwatchers though is built on the mantra of providing well-built on-site edge solutions, getting the

[11] https://elexsys.com/media/case-studies/ikea-elexsys-microgrid/

data back to the cloud, and then allowing you or 3rd party vendors to use that data as they like, or as they like to call it "built-in portability of data ''.

Edge

Wattwatchers offer two core Edge products, the Auditor 6M[12], which can monitor up to 6 circuits up to 800 amps each, and the Auditor 3RM[13], an industrial version, which can monitor 1 3-phase circuit up to 3000 amps. These offerings use 4G as default (they come with a $5/month data and cellular fee) and have versions with WiFi for comms, switches to turn off or on circuits, and revenue grade metering addons for non-NEM market billing such as power purchase agreements and embedded networks.

These pieces of hardware monitor the standard electrical properties at sites, such as power, voltage, and frequency and periodically send that data back to Wattwatchers' cloud for storage and processing. How often data is measured by each device is configurable by the user (5 to 150 seconds) and devices use around 18MB/month on bandwidth if measurements are being sampled every 30 seconds.

In Auditor versions that include switches, circuits can be switched on or off through a contactor. This switch can be toggled through the Wattwatchers dashboard, or through the API, allowing projects to programmatically control these switches. As these are switches for circuits, there is limited ability to control devices directly, and are only suitable for a subset of loads such as hot water and pool pumps.

For projects that need more sophisticated control options for assets that need variable control such as batteries or HVAC there are likely more suitable options out there. While sites can "double up" on monitoring and control equipment, such as installing Wattwatchers as a passive monitoring device, and another solution for active control, this increases operational and complexity of the project. There are scenarios where it may be suitable to "mix and match" Wattwatchers hardware with another supplier if there is a mix of sites with no active control necessary, which can use Wattwatchers, and sites with active control, which can use another hardware option. This does create the situation of having different clouds where the data is stored, and will likely need to be recombined together, but may be a suitable solution for projects such as community energy projects.

[12] https://service.wattwatchers.com.au/hardware/a6m-overview

[13] https://service.wattwatchers.com.au/hardware/a3rm-overview

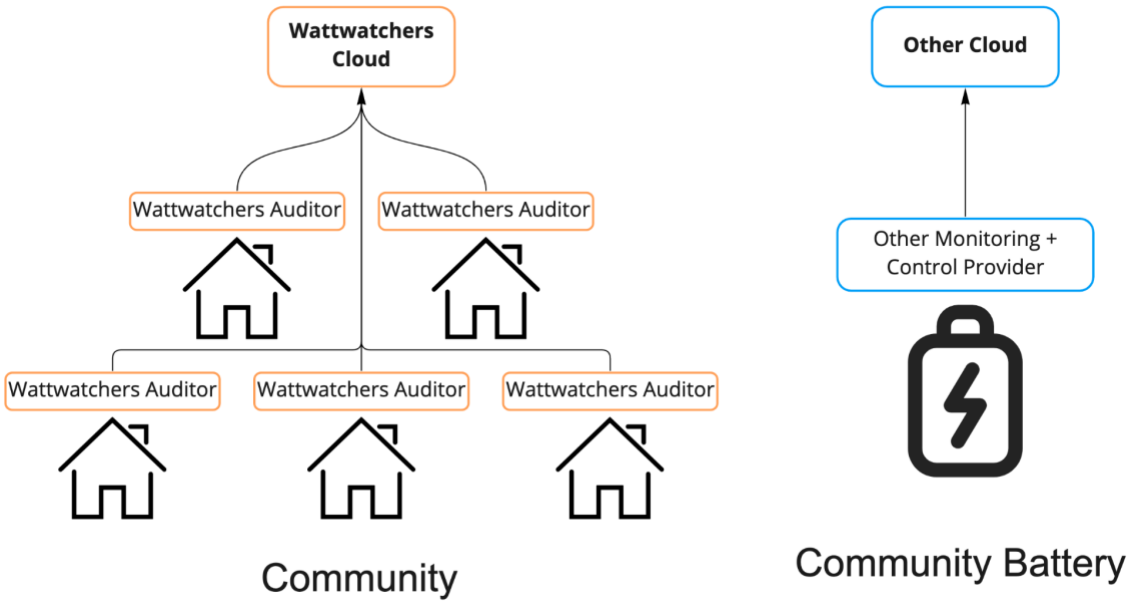

Figure 21 An example of using Wattwatchers and another monitoring and control provider at different sites in a single project.

As one might expect from a hardware specialised company, Wattwatchers provides robust installation processes and systems. Their installer app, called Onboarding, steps installers through correctly setting up the system with flexibility such as naming the sites, circuits, and switches, and quickly identifying issues to be rectified.

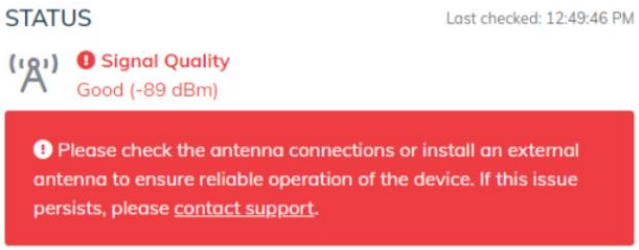

Figure 22 An example of poor connection quality identified and communicated during installation.

Cloud

Once the data is uploaded from sites to Wattwatchers cloud, Wattwatchers provides a suite of tools to visualise and access that data.

The dashboard is designed for single-site use cases such as a house or small business and provides site level and circuit level energy data, as well as the state of any switches. It can visualise data on a variety of timescales and allows you to export data from any graph to CSV, creating a rudimentary but accessible data export option.

For multi-site visualisation and administration functions, Wattwatchers provides a fleet interface. This includes being able to view device information and identify any areas, see live and historical energy data, and control the state of switches throughout the entire fleet.

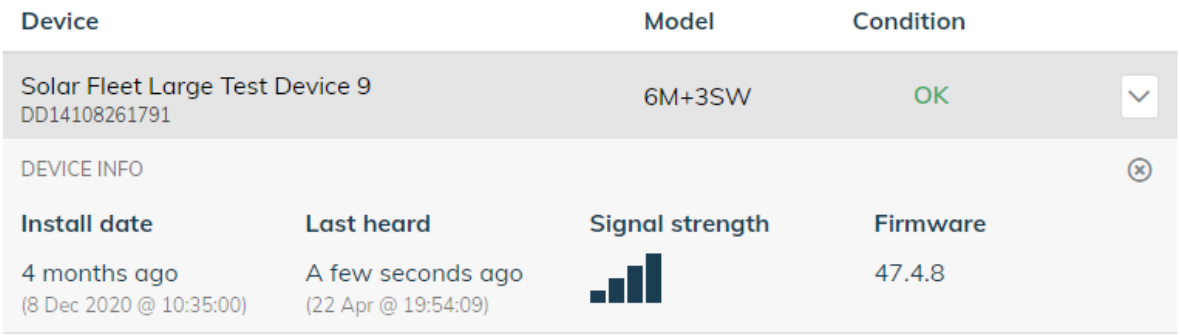

Figure 23 Wattwatchers fleet device information.

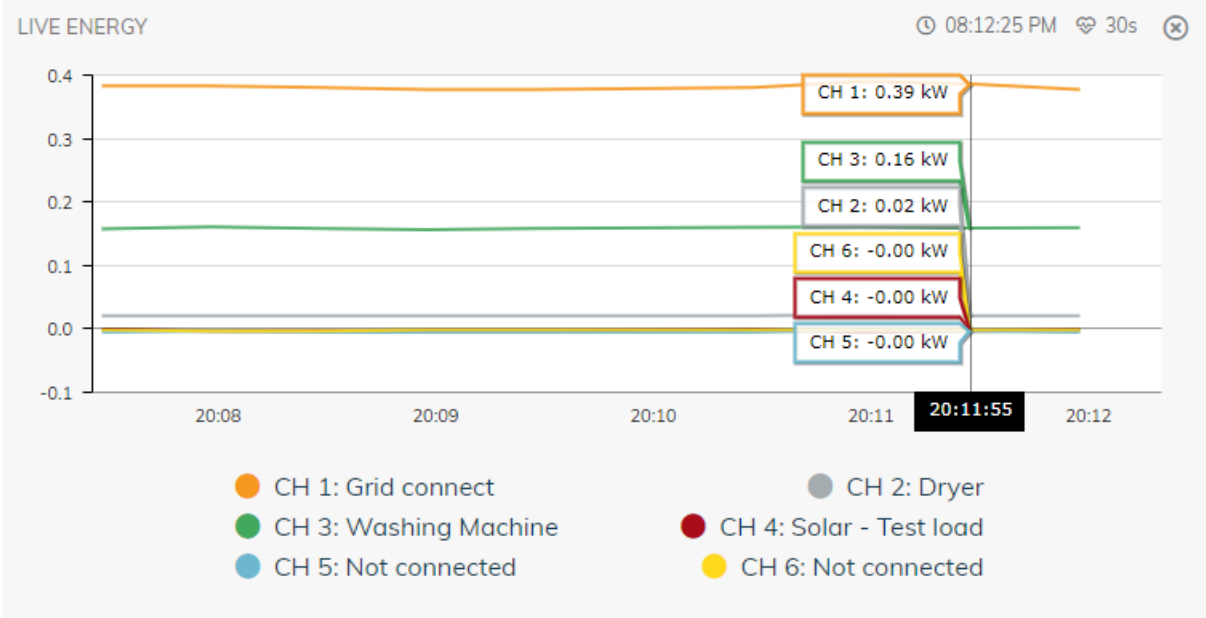

Figure 24 Wattwatchers Fleet Live Energy Data.

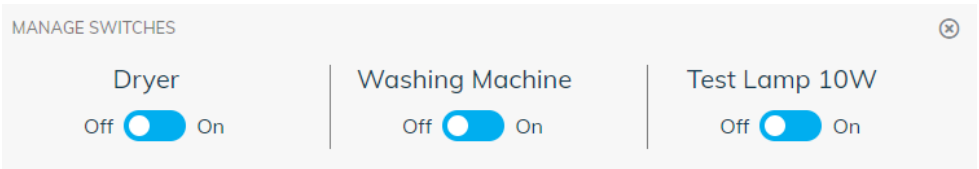

Figure 25 Wattwatchers Fleet Switch Management.

Wattwatchers provide the gold standard when it comes to data accessibility. They provide a very well documented API[14], including their endpoints[15], which allows developers and 3rd party vendors

[14] https://docs.wattwatchers.com.au/api/v3/

[15] https://docs.wattwatchers.com.au/api/v3/endpoints.html

to retrieve data and build applications on top of this API. As a core feature of the Wattwatchers offering is to enable others to use the collected energy data for value added functions, it's understandable that the ability to retrieve this data is robust, easy, and encouraged.

While many microgrid projects focus on the sophisticated control and optimisation of assets within their system, often they are starting from no or limited visibility in the energy use of the project. Having a robust monitoring solution, with flexible access to energy data and simple circuit level control can get many projects far in their journey. For these kinds of projects Wattwatchers is a safe and reliable solution to get energy data in the form they need.

Carbontrack

Edge Cloud

Edge

carbonTRACK provides a smart gateway, called the CT200i, that can communicate wirelessly with assets over zigbee and z-wave. carbonTRACK can also provide "ZB485" zigbee-to-RS485 converters to connect wirelessly to hardwired interfaces generally found in solar systems and batteries. It can monitor 4 circuits (such as a 3phase grid supply + single phase solar) up to 3000A and has 3 30A circuit relays. The carbonTRACK gateway can send data back to its cloud via cellular or wifi.

carbonTRACK also offers energy management hardware such as smartplugs, infrared HVAC controller, and smart thermostat, all which can communicate with the CT200i smart gateway via zigbee.

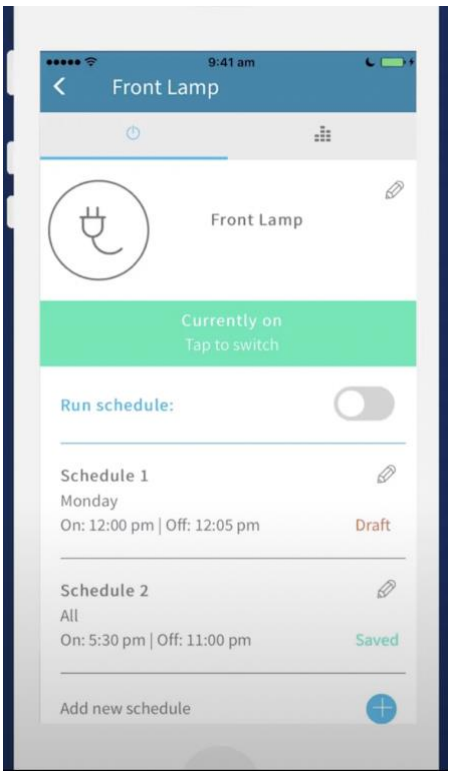

Figure 26 carbonTRACK smart home integration.

Cloud

carbonTRACK uses a subscription model starting at $6/month to operate and store data on their system. This data is accessible via dashboard, mobile app and API.

carbonTRACK's apps and API provide a range of control, such as switches, timers, and remotes, which can be set and monitored by the users. Due to carbonTRACK's zigbee smart home support, it's offering is quite advanced in respect to controlling other zigbee compatible assets such as lights and air conditioners, and provides control and customisation options in the app akin to other smart home apps such as Philips Hue or TP-Link's Kasa Smart.

Asset Services

carbonTRACK's smart management of assets caters well to simple use cases such as self-consuming solar through a battery (i.e. charging the battery when the site is exporting,

and discharging the battery when the site is importing), and demand reduction through hierarchical switching (i.e. turning off loads, or discharging a battery when demand exceeds a certain level).

While there is ample discussion about virtual power plants, preparing for future energy markets, machine learning, and peer to peer trading, these applications are hard to verify from existing information and case studies, and it may be necessary to procure another vendor to provide these services through the carbonTRACK platform. Functionality such as solar or load predictions, sophisticated asset operation in multiple markets, and market access and bidding seem not included in carbonTRACK's smart management offerings. Some vendors install carbonTRACK as a control, monitoring and cloud solution and then add their own ‘smarts’ on top by taking in carbonTRACK's data, applying their own technology and algorithms to then send asset control decisions back to carbonTRACK's cloud.

SwitchDin

Edge Cloud Asset Services

SwitchDin is a well-established hardware and software provider with experience in a wide range of microgrid projects. They can control and orchestrate assets, provide cloud and data solutions for analysis, and work with retailers to provide access to energy market revenues.

Their strengths are in their wide range of solar and battery integrations, combined with their ability to control devices “cloud-to-cloud”. SwitchDin has an advanced analytics suite, letting users create complex dashboards, reports, or do deep analytical work within the SwitchDin software platform, removing the need to export data into the users’ own analytics pipeline.

Edge

SwitchDin manufactures an energy management system called a Droplet. This device can connect to a range of onsite assets such as battery and solar inverters, and controllable loads to intelligently control these assets, and retrieve data to send back to the cloud. The droplet can communicate with assets over a wide range of methods such as USB, RS232/422/485, Modbus, CAN, Ethernet, Wifi, and Bluetooth.

The Droplet can also be run “virtually”, meaning that its control and data acquisition functions are performed in the cloud, and instructions and data are sent to the asset manufacturer’s cloud server, to then be passed on to the device. There are a growing number of manufacturers that offer the ability for their assets to be operated this way, and this reduces costs by not having to install an energy management system directly at site.

One solution that SwitchDin enables from this, which is relatively rare in industry, is allowing a mix of on-site hardware Droplets and cloud-based virtual Droplets in a fleet. This allows solutions where hardware is installed on assets that either can’t be communicated to via the manufacturers cloud or require the smart controls to be close to the assets, and then to control other assets via the cloud. There are tradeoffs between each solution, and SwitchDin being technology agonistic between them

allows the greatest flexibility for a customer to build a mix of control equipment that's suited to their requirements.

SwitchDin has a relatively wide range of integrations, with an on-site integration lab that allows them to quickly integrate into new assets. SwitchDin may not offer a completely bespoke integration service that will integrate into any and all assets you have, instead they need a business case with enough potential future volume to justify building and maintaining the integration.

Figure 27 An example of SwitchDin compatible inverter brands.

Cloud

SwitchDin's core offering for fleet management and analytics is StormCloud. This platform coordinates and receives data from the Droplets in your fleet. Data can be accessed through API, web platform, or mobile platforms, with standard cloud features such as graphs and visualisations, data export, fault diagnosis and remote reset, and customisable alerts. This service is typically hosted on SwitchDin's private cloud, but they also offer the option of deploying and operating it on your own servers.

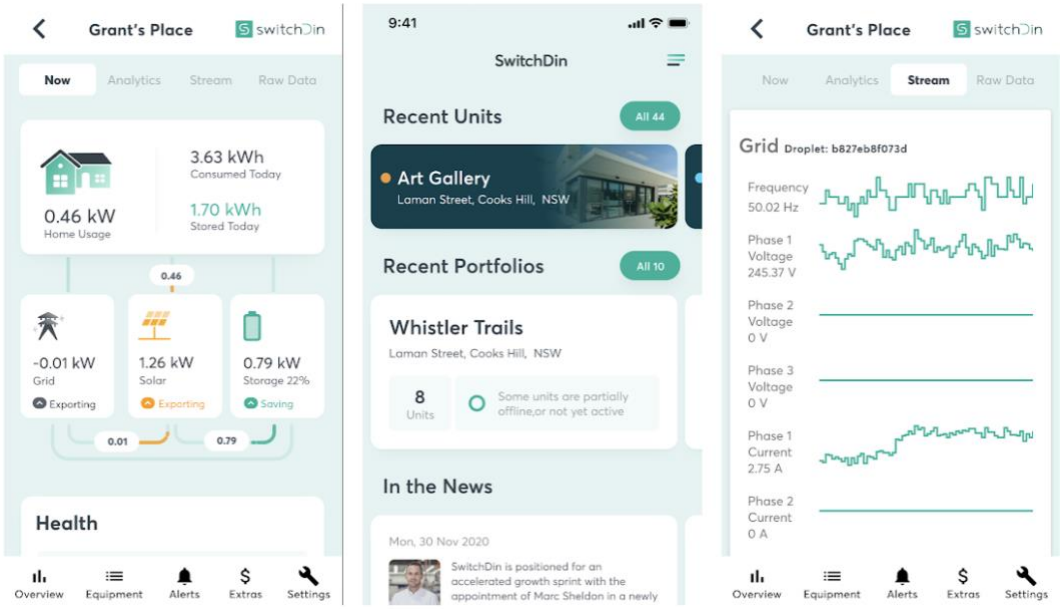

Figure 28 SwitchDin Android app screenshots.

SwitchDin also can provide a separate platform for in-depth analytics. Often cloud providers have analytics functions that are suitable for common needs, but sometimes don't quite fit what complex or larger projects need. In these cases projects often continually export their energy data from the cloud provider into their own database that they can build analytics tools on top of. SwitchDin leans in to supporting this need and allows customers to build their own complex data queries and custom interfaces and reports within the SwitchDin platform, removing the need to handle the data externally.

Asset Services

SwitchDin provides generation and load forecasts that operators can use to understand how their sites are expected to operate. While there is some asset optimisation, such as hierarchical control (e.g. charging the battery first, then curtailing the solar if necessary at an export limited site), the current offering is somewhat limited. More complex optimisation algorithms are currently being developed, including "fleet wide" optimisations that can operate multiple sites to a common, shared objective.

SwitchDin has a strength in financial settlement and reconciliation. They have real-world examples where they are calculating benefits and then sending money between parties for projects such as community battery programs, where community members are distributed benefits from the operation of the shared community battery. This can be extended to other community programs where benefits are being calculated and distributed outside of the existing energy market.

SwitchDin are retailer agnostic, meaning that any energy retailer can use the SwitchDin platform or API to operate assets for market purposes or develop new products and retail arrangements.

SwitchDin have experience providing market and network services, as well as experience in large, market facing projects such as Simply Energy's Virtual Power Plant[16].

Mondo

Edge Cloud Asset Services

Mondo provides energy asset monitoring and operating solutions for households, businesses, and microgrids. Mondo is owned by electricity distributor Ausnet, which leads to Mondo having strong engineering foundations, and the ability to help with financing. Mondo has a relatively long history supporting microgrid projects, such as the "Yackandandah Mini-Grid"[17] which began in 2016.

Edge

Mondo manufactures the Ubi, an energy management system that can monitor and control various devices such as solar, and battery, and controllable loads at a site. The Ubi sends real-time information to the cloud via a 4G connection.

Figure 29 Mondi Ubi.

Cloud

Through the Ubi Portal Mondo provides a range of ways to access data such as dashboards, data downloads, and sustainability reporting, as well as ways to control and track individual appliances that are directly metered by the Ubi. Mondo also provides fleet monitoring platforms, allowing microgrid and community energy projects to see data from multiple sites in a single place.

[16] https://www.switchdin.com/blog/2021/12/1/switchdin-simply-energy-vpp

[17] https://mondo.com.au/news/1000-cars-off-the-road

Figure 30 Mondo web dashboard.

Mondo has an API that allows customers and 3rd party providers to access near real-time information from the Mondo Cloud. One example of the API's capability is: "energy data from 40 properties is passed to the "Demand Management platform" at a frequency of 3 API calls per second, per property"[18].

Asset Services

Mondo provides some asset optimisation and market participation via their solution. This includes reduced network tariffs through peak demand reduction and off-peak charging, as well as responding to external price signals, enabling demand response applications.

While Mondo doesn't currently participate in the Frequency Control Ancillary Service (FCAS) markets, they claim that their hardware can meet these market requirements. They are also participating in Project EDGE[19], a DER market integration trial requiring aggregators such as Mondo to dynamically operate customer assets in wholesale energy and network support markets. This trial demonstrates Mondo's capability to forecast, bid, and operate assets under complex pricing arrangements with multiple parties.

A unique capability Mondo offers in the hardware and cloud provider space is engineering, stakeholder management, and finance services. Mondo can help design solar and battery solutions for a wide range of customers, from single businesses up to community projects and councils. They can also support project development of community projects from advice based on their experience

[18] https://mondo.com.au/news/ubi-integration-capabilities-expand

[19] https://aemo.com.au/en/initiatives/major-programs/nem-distributed-energy-resources-der-program/der-demonstrations/project-edge

with many similar projects, attend info sessions and educate potential participants on the benefits of the program. Finally, Mondo can finance the solar, battery and EV charging assets through offering $0 upfront deals that are paid back overtime through a power purchase agreement (PPA).

DNA Energy

Edge Cloud Asset Services

DNA Energy control and monitor energy assets at commercial and industrial sites. DNA Energy's strength is their broad range of integrations, and willingness to integrate against a wide range of industrial control equipment such as HVAC, industrial loads, EV chargers and inverter based solar and batteries.

They offer tiered services starting at simple monitoring of sites and assets, site-level optimisation against retail tariffs or import/export limits, all the way up to operating assets in energy markets.

Edge

DNA energy installs a gateway at each site which monitors site level data such as energy flows and has algorithms to make decisions on how to operate the site. At each asset there is a smart integrated device (SID) that can monitor and control individual assets.

The gateways and SIDs are connected via a wireless mesh network and connected to DNA Energy's cloud via 4G or ethernet. This allows for minimal wiring to be needed, with the only hardwired physical interface needed being between the SID and the asset.

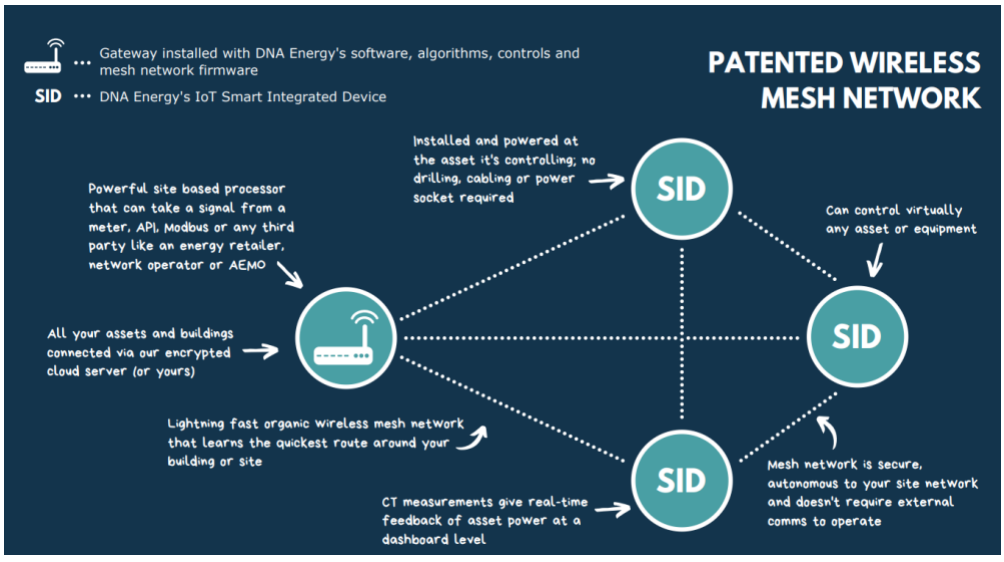

Figure 31 Diagram of DNA Energy's mesh network.

This setup allows for a simple and scalable expansion over time by adding more SIDs to the system for additional assets you want to monitor or control. DNA Energy has sites with over 100 SIDs installed on assets and controlled through gateways.

DNA Energy has integrated against a wide range of assets, especially HVAC systems, and has a good understanding of how to control different devices. Solar, batteries and EVs often have simple control schemas, where you can command it to output at a certain power level. For more complex systems, such as thermal control equipment, it may be more complex to coerce a system to operate how you'd like, such as having to under a variety of operational modes of the device. DNA Energy understands these complexities and specialise in operating these more obscure control systems.

While DNA Energy currently has limited experience in providing market services with their hardware, they have thought ahead by validating the response times of their devices through third party consultants, demonstrating that they respond fast enough to operate in common NEM markets such as Frequency Control Ancillary Service (FCAS) markets.

Figure 32 Results of DNA Energy local response time testing.

Cloud

DNA Energy provides a live energy dashboard with in-depth asset level data. While many providers show site level data, as well as typical energy management assets such as solar and batteries, DNA Energy can show in-depth information about other sources such as HVAC or industrial control equipment due to their direct integrations into these products.

Fleet management is well supported, and DNA Energy is able to integrate multiple brownfield data sources into their platform, such as existing solar to allow customers to see both DNA Energy and 3rd party monitored assets in the same platform. This capability is demonstrated in a DNA Energy Solar Monitoring Case Study[20]:

[20] https://www.dna.energy/case-studies

> "The DNA Energy dashboard takes solar generation data from a number of third-party metering solutions and inverters already installed at sites and aggregates on its dashboard for the solar company and its client to monitor.
>
> In some instances, additional metering was provided by DNA Energy with no licensing conditions, meaning the solar company and its client is able to access the data if it stops using our dashboard.
>
> Where a PPA is being monitored, the dashboard also shows 'live monthly bill' for the solar company's client.
>
> The dashboard is ready to upgrade to our controls system."

DNA Energy has an API available for customers to programmatically retrieve and analyse energy usage and operations at their site. There are examples too of 3rd party providers using DNA Energy as the on-site monitoring and control equipment, integrating against the DNA Energy API and then building value added services on top such as more tailored dashboard or analysis. This flexibility of how a customer or 3rd party can use the data collected on-site is a similar model to what Wattwatchers offers.

Asset Services

DNA Energy can optimise assets with simple but effective algorithmic control. Often this behaviour is rules based or hierarchical switching such as turning off or cycling assets as energy usage reaches a certain level. While this type of optimisation may be less effective at very complex sites or operational patterns, the advantage of this approach over "artificial intelligence" or "machine learning" optimisations is that it's easy to understand whether the system is working as expected or not, and the benefits from it. DNA Energy leverages this by clearly showing in the dashboard when certain rules or limits are in effect and changing the behaviour of the assets.

Two examples of this simple but effective control from their case studies[21] are:

A site was requiring electrical upgrades as HVAC units operating concurrently could exceed the 315 amps per phase limit. Instead of upgrading, DNA Energy equipment was installed that could ramp down the output of different HVAC units over time to ensure the limit wasn't breached.

A site was looking to reduce their demand charges, with HVAC and EV chargers installed at site. To control the site's peak power usage "two algorithm-based control strategies were set; one to reduce demand at 15 kVA and another at 20 kVA. The first controls activate the HVAC systems' AS 4755 capability and reduce HVAC capacity by 25%. The second, more aggressive controls, reduce HVAC capacity to 50% and shutdown the EV charger (if operational). The controls are set to only operate for 15-30 minutes to stop comfort or operational loss."

[21] https://www.dna.energy/case-studies

In both these cases validating that the algorithms are working correctly both historically and in real-time is trivial from the dashboard, allowing the customer to understand the impact of this smart control.

While most of the current uses of DNA Energy's technology is for "behind-the-meter optimisation" where a customer is changing their usage in response to their electricity tariff or connection limit, this platform is suitable for market facing purposes, especially demand response applications where site output is changing based on a simple signal such as price (e.g. reduce load when wholesale price excessed $1000/MWh). DNA Energy is open to working with energy retailers and allowing them to leverage the DNA Energy platform to create value for their customers in the energy market.

Birdwood Energy

Edge Cloud Asset Services

Birdwood Energy is a relatively new entrant in the space, focusing on small to medium commercial and industrial businesses. While many other companies take a product or solution first approach, i.e. taking their existing solutions and applying it to a customer, Birdwood takes an outcomes first approach. This involves understanding each customer it has and tailoring solutions to their objectives and situation.

Edge

This can be achieved as Birdwood Energy takes what we call a "3rd Party Hardware Integrator" approach, where they can select from various off-the shelf products for the Edge solution and integrate them into their cloud where Birdwood offers dashboards, reports, and intelligent control solutions.

The advantage of this approach is that there is more flexibility in the onsite hardware chosen, and in the event that Birdwood is unable to provide services in the future, or the customer wishes to move away from Birdwood, their hardware may be able to be integrated into another provider. The risks are that Birdwood may have less ability to add new features requiring changes to the hardware or remedy any operational problems. Due to this it's important that you understand what kind of information and control you can achieve from the platform, as there may be less opportunity for changes in the future due to hardware constraints.

Cloud

Birdwood provides tailored data visualisation and insights platforms to suit project needs. This includes tracking payback periods, emissions intensity, in depth savings breakdowns and other financial and sustainability figures that are of interest to projects. As Birdwood is more boutique and less a standardised platform, these data visualisations and insights can be tailored to individual project needs.

Asset Services

Birdwood creates a phased approach with their customers, allowing them to better meet their energy objectives over time. Below is an example of a phased approach used for a Birdwood customer involved in meat processing[22]:

Baseline: Status quo.

Phase 1: Introducing Birdwood through small solar and smarthub plus our action centre.

Phase 2: Adding more solar and monitoring to the system.

Phase 3: Building in optimised storage to soak up excess solar, reduce peak charges.

Phase 4: Activating and operationalising the optimisation across the site and start electrification.

Phase 5: Meeting any remaining needs with certificate and credits based on business targets.

This approach de-risks this process for the customer, allowing them to take smaller financial steps over time, and adapt their plan based on experience with the solution.

Evergen

Cloud Asset Services

Evergen is a hardware-lite asset control and optimisation provider. Their thesis is that often there is enough control equipment already at site, such as in inverters, or there are existing "power plant" controllers for larger or more complex sites. Evergen then integrates against these assets, either through the asset provider's cloud (cloud to cloud), or directly to the asset over the internet.

Evergen has a wide range of integrations, but as they are positioned as a platform, they may not be suitable for sites with many assets that will need uncommon or tailored integrations against the hardware. For those kinds of use cases a provider like DNA Energy, who specialise in integrating into less common assets and control specs.

Evergen's simpler "cloud-to-cloud" approach to asset control gives them the flexibility to specialise in accommodating a wide range of preferences and options for how to operate these assets.

Cloud

[22] https://www.birdwoodenergy.com/meat-processing-in-regional-nsw

Evergen offers a dashboard and fleet view to retrieve information. Currently this is mostly focused on asset management needs such as: how the assets are operating, are any experiencing problems, the ability to change their settings, but over time will be adapted to new use cases such as needs of sustainability officers.

There is also a robust API integration, both to extract data about the systems but also to send data into the Evergen platform about prices or fleet settings.

Asset Services

As mentioned above, Evergen's strength is in being able to accommodate a wide range of preferences and options for how to operate these assets. The platform takes in load and on-site solar predictions, energy price data, hardware parameters, and user preferences to create an "Optimise Energy Management Plan" which is a schedule for how the different assets should operate. This plan is created 48 hours ahead of time and re-optimises every 5-minutes.

Evergen benchmarks their intelligent control against simpler control strategies, such as a load following battery, to determine the value this control is providing and improve that over time. These results can be made available to the customer on request.

Evergen is retailer agnostic and are open to working with any retailers or market participants that the customer may have. The flexibility of the Evergen platform also means they can accommodate a wide range of price structures and control strategies to reflect the retailer's demand response program, or even off-market accounting products such as reflecting carbon pricing or peer-to-peer arrangements. Essentially if you can send Evergen a price signal they can operate assets in a way to optimise their performance against that signal.

Retailers

Retailers are increasingly playing a larger role in developing and operating microgrid projects. Not only do they provide retail tariffs and opportunities for demand response, but also can provide project development services, asset operation, and access to sophisticated and lucrative energy markets. The retailers below showcase the wide range of specialisations and customer types that can be served.

Acacia

Asset Services Market Services

Acacia Energy works closely with communities, small/medium businesses and renewable generators to design and operate solutions. Acacia are not only market participants, but can also help design and install energy solutions, as well as control and optimise these assets directly in energy markets to maximise the value these assets can capture.

To optimise the assets they have an Optimisation and Bid Engine (OBE). The OBE takes into account physical characteristics of the site such as flexible load and intermittent generation, financial information such as tariffs and retail contracts, and market opportunities to create operational schedules for the site's assets every 5 minutes. Acacia can then communicate this schedule securely with onsite controllers to orchestrate these assets.

Acacia can also manage bidding and contracting into energy markets such as Frequency Control Ancillary Services (FCAS), and Reserve Emergency Reliability Trader (RERT) on the customer's behalf, selling excess customer capacity into these markets then ensuring assets are operated in a way to deliver on these obligations.

Acacia, through their partner AEES group, provides engineering, procurement, and construction services (EPC) to develop energy solutions that are integrated into their optimisation services. Their procurement process is technology and manufacturer agnostic which provides flexibility in designing suitable solutions.

Shell Energy

Market Services

Shell Energy (formerly ERM Power) can develop "full stack solutions" for large commercial and industrial businesses. This involves an in-depth, three-part process:

- Feasibility: Site visits, data collection + analysis, tech viability and commercial benefits.
- Implementation: Installation, IT integration, and training.
- Operation: Ongoing reporting and analysis, troubleshooting and optimisation.

As Shell is a single provider in these functions, it reduces the complexity for the customer as Shell builds the solution and integration, ensuring that different parts of the solution can work together.

While Shell Energy supports the installation and operation of solar and batteries, there is also a focus on industrial automation such as HCAC and industrial loads. An example of their industrial automation solutions is "HVAC LoadFlex"[23] which can reduce energy usage, costs (network charges and wholesale volatility), and emissions through installing hardware at chiller plants to optimise use. Shell can even provide this solution while you stay with your current retailer.

Energy Locals

Market Services

Energy Locals partner with developers and precincts to create community energy solutions. This is generally through embedded networks, such as an apartment building, which creates greater flexibility in possible products and financial arrangements that can be achieved.

Energy Locals takes a hands-on approach to developing solutions with their strength in metering installations and energy auditing. They also have strong partnerships with various battery, solar, and EV charging manufacturers to create all-in-one energy solutions for developments. For instance, one of their projects, ALAND's Schofield Gardens complex[24], had 201kW of solar and 24 Tesla Powerwalls installed at the site, meaning that 45% of the complex's power load is met by on-site renewables.

In many of the projects from Energy Locals this type of shared solar setup can reduce tenants' energy costs as well as reduce their carbon impact. This is achieved through sophisticated metering and settlement systems which require a specialised retailer such as Energy Locals to achieve.

Simply

Market Services

Simply Energy has a proven track record in providing innovative retail tariffs and energy management programs. For individuals they offer programs such as their "Reduce & Reward"[25] program, giving customers a bill credit of $10 when reducing the demand during peak demand events, and their Virtual Power Plant (VPP) program[26] where customers with batteries can earn up to $2250 over 5 years in return for Simply Energy occasionally discharging the battery during times of high wholesale prices, such as hot afternoons.

Of interest to microgrid projects is their "Hunter Douglas Powertracer Energy Offer"[27] where export energy from the Hunter Douglas warehouse is "matched" to energy imports at employees' houses,

[23] https://shellenergy.com.au/energy-solutions/demand-response/hvac-loadflex

[24] https://www.canstarblue.com.au/awards-green-excellence/2022-energy-locals-solar-battery-solution/

[25] https://www.simplyenergy.com.au/residential/energy-efficiency/reduce-and-reward

[26] https://www.simplyenergy.com.au/residential/energy-efficiency/simply-vpp

[27] https://www.simplyenergy.com.au/residential/electricity-and-gas-plans/plans/hunter-douglas

giving employees a discount on this matched energy they consume. These arrangements are more complex than one might imagine, requiring smart meters at all sites (including the houses) and sophisticated settlement and billing functions.

Simply Energy's willingness to trial in this space has given them early experience in developing solutions where projects can access financial value in ways that few retailers are currently tackling.

Enova

Market Services

Note: After the writing of this report Enova Energy went into administration. The review of Enova remains to demonstrate the range of innovative community energy offers that could be created by other parties in the future.

Enova specialise in creating microgrid and community energy solutions that aim to install and operate shared community infrastructure, such as shared solar and batteries, to the financial and environmental benefit of the community.

Enova's flagship trial, The Beehive Project[28], involves a 1MW Tesla Megapack that is shared between 500 households both with and without rooftop solar. Households are able to share solar between each other, and use the shared community battery through Enosi's PowerTracer platform. This financially rewards the community for consuming local generated renewable energy.

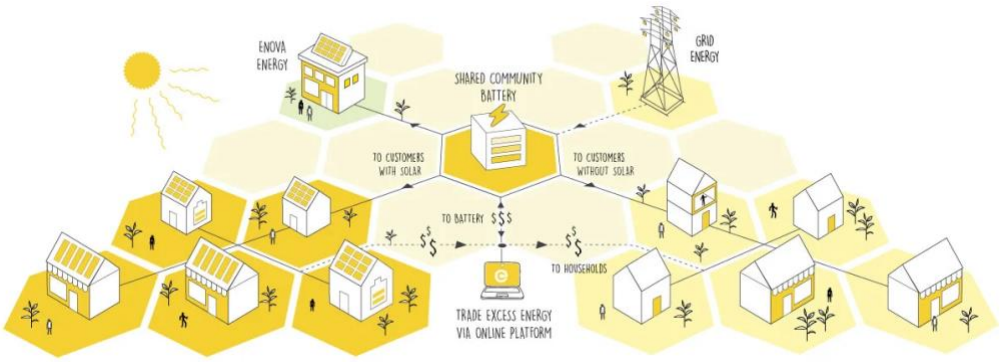

Figure 33 Enova Energy's Beehive Project.

An earlier trial by Enova, the Byron Bay Microgrid[29], allowed businesses within an industrial precinct to share solar energy with each other, increasing incentives to consume locally produced renewable energy and reducing tenants' bills. This trial involved Wattwatchers for hardware and data collection, LO3 Energy for reconciling the peer-to-peer trading of energy within the estate, and support from the local network and University of New South Wales.

[28] https://www.enovaenergy.com.au/shared-community-battery

[29] https://www.enovaenergy.com.au/microgrids

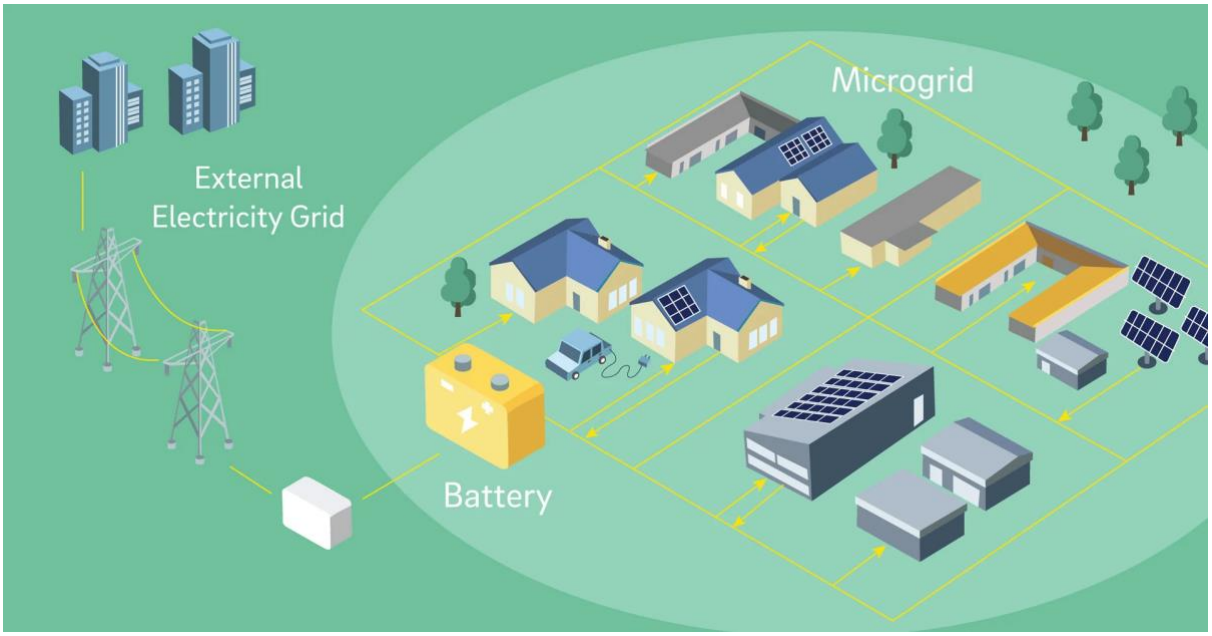

Figure 34 Enova Energy's Byron Bay Microgrid Project.

Community energy projects are currently difficult due to regulatory barriers, immature technology and poor economic feasibility. These projects are small in scale, complex and need generous financial subsidies, which can make them unattractive to many vendors or retailers in the space to participate in. Enova Energy are one of the few outliers in this respect, leaning in to working through complexity to achieve feasible and scalable outcomes over time that can maximise benefits for the community. Through their not-for-profit arm[30] they also support community energy groups and projects with a portion of the main business' profits.

[30] https://www.enovaenergy.com.au/not-for-profit

Off-market Accounting

Enosi

Off-market Accounting

Ensoi's flagship product "Powertracer" provides the ability to attribute where generated electricity is consumed for financial and emissions purposes.

Enosi partners with retailers and can be thought of as an "add on" to a billing system to provide fine grained, and temporal energy pricing and emissions tracking inbuilt into retail energy offers. An example of this is the Simply Energy's offer to employees of Hunter Douglas[31]. Hunter Douglas is a NSW manufacturer that has a large amount of solar on their warehouse roof. The offer is if the warehouse is exporting solar energy, you can get a 9c/kWh discount on your electricity by importing it at that time. How this energy is attributed, or "matched" to different customers is done through the Enosi platform, which determines the customer and retailer reconciled payments required.

While this a small example of how off-market transactions can work, it shows the potential of opening new incentives and revenue streams that can reward value not currently reflected in existing markets, such as aligning the generation and consumption of local energy.

[31] https://www.simplyenergy.com.au/residential/electricity-and-gas-plans/plans/hunter-douglas

Opportunities For Improvements in Microgrid Offerings

Due to the new and emerging nature of modern microgrid offerings there are areas where there are opportunities for vendor offerings to improve over time to better fit customer needs. It's important for project developers to understand potential shortfalls in current microgrid offerings, and policy makers and investors the opportunities for how these solutions can improve over time.

In depth EPC and integrations for smaller projects

Large projects can procure in-depth feasibility studies, specialised hardware selection, and ongoing support of the projects. For smaller projects this may not be as viable, with more offerings of standardised solutions.

We hope in the future the cost of upfront modelling, technology selection and technology integration become cheaper through automation and vendor maturity so projects of all sizes can access fit-for-purpose solutions that maximise the outcome.

Data access and rights

We've heard from multiple projects that often there can be surprises once the project commences on accessing their data, and certain rights they have to their assets or solutions.

Many of the vendors we've reviewed have relatively open data policies, allowing you or a 3rd party to access data collected from the systems in many flexible ways. This isn't always the case though, so it's important to understand from vendors how you can access data. A common barrier is not being able to get the data you'd like, or in the form you'd like. This can result in the complete inability to access this data, or unexpected costs the vendor would need to build out that functionality.

Another surprise some projects have received is being tied into hardware solutions once installed. Examples of this are projects having to include the current vendor in expansions to the project or the vendor not allowing other hardware to access their devices (such as meters or control equipment). Some of this is pragmatic, vendors can't necessarily support new assets that they are not integrated with, or there may be security or cost issues from allowing access to other parties, but once hardware is installed there are risks to projects that they are locked-in to solutions that limit future options in unexpected ways.

In order to set expectations between vendor and customer, and avoid any surprises down the track, it's imperative that customers understand the contractual terms set out and ask the right questions before projects commence. This includes not only questions about how the solution will work in the current project, but around future scenarios and contingencies that may occur. These will be questions such as how the vendor's solution could meet a range of future expansions, as well as if there is the ability for other parties to take on certain functions of the vendor in the future. Understanding the level of flexibility in future scenarios will allow the project to understand the level of risk they may be taking in progressing with different solutions.

Regulatory barriers for "on-grid" applications

In off-grid or embedded network applications there is some flexibility in how you can design financial offerings for sites within this network. Where you are directly connected to the broader electricity network though there are more stringent requirements such as having to pay standard network charges and interact directly with the bulk electricity markets.

These requirements can make it more difficult for arrangements to financially be feasible such as community energy or peer-to-peer programs, as well as undervaluing certain types of resiliency (such as a precinct being able to run on backup energy if the network is not available). These barriers are being resolved over time through a variety of reforms and trials.

This is changing over time:

- Networks are beginning to trial more dynamic network charges that can reward flexibility, or locally using energy, such as CitiPower's residential and community battery tariff trials[32].
- Policy makers have been tasked with making energy market structures fit for purpose for distributed energy resources (such as solar, batteries, electric vehicles, and flexible loads), such as the Energy Security Board's DER Workstream[33].
- Organisations such as the Australian Energy Market Operator (AEMO) and the Australian Renewable Energy Agency (ARENA), are trialling operational models to allow more participation and reward for flexible loads and generation in homes and businesses[34].

There are early commercial projects looking to overcome these barriers such as Enova's Beehive Project[35] or Simply Energy's Hunter Douglas solar sharing offer[36], and we expect over time projects like this become easier to implement, and more financially lucrative as policy measures are implemented.

Sophisticated claims in offerings but simple case studies

Many vendors claim abilities in intelligent control, optimised systems, and lucrative market access, but often the examples of their deployments are relatively simple arrangements to don't demonstrate advanced functionality. We suspect that this is a combination of current customer needs often being simple, and selling a future of what could be possible with the right project.

[32] https://www.aer.gov.au/system/files/CitiPower%20-%20Tariff%20trial%20notification%20-%202022-23_1.pdf

[33] https://esb-post2025-market-design.aemc.gov.au/all-about-2025

[34] https://aemo.com.au/en/initiatives/major-programs/nem-distributed-energy-resources-der-program/der-demonstrations/project-edge

[35] https://www.enovaenergy.com.au/shared-community-battery

[36] https://www.simplyenergy.com.au/residential/electricity-and-gas-plans/plans/hunter-douglas

We would recommend more funding and focus on the cutting edge of the value and services that microgrids can provide, such as:

- Whole of microgrid optimisation: Many microgrid projects install solar, and perhaps a controllable battery, and have the rest of the loads operate as usual. We see great value in offerings building their capability over time to also control other flexible loads such as thermal (HVAC, chiller plants, hot water) as well as other industrial processes.
- Resilient microgrids: Grid-connected microgrids that can operate at times islanded from the main grid, can provide benefits both to those within the microgrid, and the wider community. Operational and hardware solutions should be examined, but there is also clear progress that can be made in valuing and rewarding this type of resiliency, and models for when this islanded mode could or should be operated.