Centre for Sustainability
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Smart Grid Edge Technologies

Case Studies of Early Adopters

A report for the Smart Grid Forum

Report Prepared for New Zealand's Smart Grid Forum

May 2016

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Please cite this report as: Ford, R. (2016). Smart Grid Edge Technologies: Case Studies of Early Adopters. Dunedin, NZ: University of Otago.

ISBN: 978-0-9941371-1-1

Acknowledgements:
The author would like to acknowledge the Smart Grid Forum for funding this research.

We also acknowledge our reviewers, John Hancock and Gerry Carrington.

Front cover: Dave Pearce Photography.

Executive Summary

The future management of New Zealand's electricity grid will be impacted by changes in the way that consumers interact with electricity.

These include uptake of micro-generation, electric vehicles, storage, and energy management systems.

Uptake of these smart grid 'edge technologies' is currently at an early stage in New Zealand, so it is too soon to quantify their impact on the grid.

This report is therefore a qualitative assessment of how households, businesses and communities are perceiving, and acting on, the opportunities offered by these technologies.

Six case studies were undertaken: two 'early adopter' households; two businesses involved as consumer and service provider respectively; and two communities that are actively pursuing opportunities for collective benefits.

Drivers for adoption of edge technologies differed between these groups.

The main motivators for the early-adopter households were having fun and trialling new technologies, along with saving power and a desire to improve resilience.

For the businesses, the main drivers were related to cost, scalability, and alignment with existing business mandates (internal focus) or the markets within which they operate (external focus).

Aspirations for resilience and sustainability were key drivers for the communities.

Barriers to adoption were similar across all three cases. Key barriers were lack of easily accessible information about edge technologies, and the complexity and lack of interoperability. For businesses an additional barrier was that existing systems and infrastructure did not allow easy incorporation of edge technologies.

The upfront cost of edge technologies (purchase plus installation) is another barrier common to all groups. The projects that have been successful are those in which the value propositions are clear for all actors (and aligned with their existing mandates and values), and in which solutions are easily implementable.

Future uptake will require more easily accessible (and less technical) information, and "plug and play" solutions that are easily integrated into homes and businesses without the need for technical experts.

If these smart technologies are to be incorporated into the smart grid of the future, they need to be able to communicate with signals from the system operator so that they can be harnessed to improve grid flexibility and resilience.

Introduction

New types of technologies, including micro-generation, electric vehicles, storage, and energy management systems are enabling consumers to interact with the electricity system in entirely new ways. Changing market dynamics, policy settings, and grassroots innovations are creating a shift in energy systems, driving toward a system where customers engage more dynamically with a smarter grid. This report documents a series of case studies, which record the experiences of households, businesses and communities in New Zealand who have begun to change they way they think about and use energy.

This study contributes to the Smart Grid Forum's interest in benchmarking New Zealand's performance around the uptake of distribution edge technologies and identifying any systemic obstacles to NZ staying on the frontier of efficient best practice in energy use and energy management. Typically the metrics used to conduct benchmarking look at the numerical uptake of a particular technology (e.g. numbers of smart meters, PV installations). Although this is easy to measure, it doesn't provide much insight why people are taking up new technologies, how uptake might be driven forward (or may drive itself forward), or the impacts of new technologies on behaviour. Additionally, these traditional metrics do not address the value of the technology to consumers, the barriers in engaging, or the way in which obstacles were overcome such that consumers could participate.

Numerical measures also only pick up technology uptake at the household (or business) level. However, new grid-connected technologies and associated information and communication technology and energy management systems are making it possible for households, businesses and others to form collectives that interact with the grid in new ways – such as peer-to-peer sharing; smart communities that optimise local generation and storage; shared dynamic storage and demand management. It is important to understand how these new opportunities may support a scaling up from smart homes to smart communities, smart businesses and smart cities, and why these aspirations for collective ventures are emerging.

This report documents a series of 'stories' told by early movers who have began to challenge the traditional operation of the electricity grid either by shifting expectations and aspirations related to energy in the community, or directly through the adoption of smart grid-related technologies. Interviews have been conducted (between December 2015 and February 2016) to describe the experience of two households, two businesses, and two communities that have chosen to adopt edge grid-connected technologies or practices. They are documented here and explore the value that new types of energy engagement model provide, the benefits derived, the barriers encountered, and the mechanisms by which change has been facilitated.

Household 1

The first household interview was conducted with a male participant, in the census age bracket of 35-39 years, living with his wife in a detached home in the Manawatu-Wanganui region.

The story so far...

The story for this household began in 1995 when they moved to New Zealand and were shocked with the poor housing stock and cold temperatures inside their home. As a result of this they decided to build a home with insulation, double-glazing and central heating. From their experience overseas they were aware of technologies like solar hot water, and as part of the building process they ordered an evacuated tube system from Germany. Five years ago the first controller for their solar hot water system broke, and the one that they replaced it with was able to take a web input (though this functionality wasn't required by their existing system).

Two years ago the family decided to install solar PV. Their system had a connection to the web so they were able to see their electricity generation data. This lead the interviewee to start exploring what else the information from the PV system could be used for, and in doing so he came across Open Energy Monitor, a web-based project to develop open-source energy monitoring tools using a Raspberry Pi.

Because the interviewee had a strong technological and programming background, he decided to create something similar himself; he purchased current clamps to measure the energy his home was drawing from the grid as well as the solar energy produced, and wrote accompanying software code to display this data.

Following the creation of this real-time data collection kit, he investigated appliances that offered demand management potential, and identified that their household dishwasher and washing machine were able to resume operation following a power-cut to the appliance (i.e. if they had been set to run in a specific mode before power to the appliance was cut, when the power was restored all the settings remained).

To facilitate autonomous demand management, the interviewee purchased Belkin switches for both the dishwasher and washing machine, and then wrote a Python script to control the appliances based on the amount of solar being generated by their PV array (i.e. once enough electricity was being generated by the solar array, one of the two switches would turn on, and, if 30 minutes later there was still surplus energy, the other switch would turn on too).

Following the successful operation of the PV/Belkin-switch system, the interviewee recalled that their household hot water system had a web-connection that enabled the hot water system clock to be re-set. By setting their hot water timer to turn on at midday, and using the web-input to control the clock (and set it to midday when it was desirable to turn the hot water system on) the interviewee found a mechanism by which the hot water controller could be remotely or autonomously controlled. The key challenge with this was balancing the solar hot water and solar PV inputs so as not to overheat the water in the tank, but some experimentation using the sensors in the evacuation tubes enabled this to be successfully achieved.

Following this technological shift, the interviewee noted that household behaviour has not really changed; because they are a family with no children, and who already cycle and walk to work, they don't see what else they could do to change their consumption patterns having already insulated and double glazed their home, installed solar hot water and solar PV, and tackled the washing and dishwasher operation. Their home currently uses gas for powering the central heating system, and they are not keen to switch this out because they don't believe that using a heat pump could get the water hot enough. The interviewee did note that if the technology improved he would consider this, and might also consider a wood chip burner in the future, but having only recently invested substantial money in the gas boiler, they are unlikely to replace it until it breaks. Furthermore, heating systems are generally not compatible with solar electricity generation (due to time differences between generation and use) so an electric system would be powered by the grid regardless.

This household does not have battery storage, in part due to the high costs of the battery in itself, and in part due to the energy costs of constructing and shipping the batteries. The interviewee also noted that battery storage is only really cost effective for off-grid homes, which is not desirable as it limits power use within homes and may prevent households from using multiple appliances at the same time. Furthermore, to be off-grid their home would require additional PV generation, as their current usage is such that it is always greater than their total generation.

Key drivers, barriers, and enablers

For this interviewee, "fun" was the main motivation for exploring demand management opportunities in their home. He is generally interested in technology and gadgets, and has been playing with tracking technology as a result of his triathlon training during which he started writing code for his tracking watch. It was easy for this interest to be transferred to energy monitoring, especially with sources such as Open Energy Monitor providing useful information and insights to learn from. He believes that his technological competence was a major source of help, as well as the networking ability of technology; now that many devices are able to connect into a network people are able to more easily write and run their own codes.

Additionally, he was concerned with the lack of resilience in the existing electricity infrastructure in New Zealand resulting from the substantial generation in the South Island reliant on the Cook Straight link for providing power to homes and businesses in the North Island; a situation with a high failure risks for homes in the North. He believes that if people (in homes and businesses) can take greater responsibility for their own electricity demands then this could support future proofing electricity infrastructure; local generation could reduce grid constraint issues in a future with more fully connected and smarter infrastructure.

The main barrier to action has been the time commitment and his wife's concerns that too much time is spent "playing" with the technology, as well as concerns about what might happen if something went wrong. Additionally, there are security issues and concerns that homes can be "hacked" so that others could access data or control technology. However, the interviewee noted that the system he had created did not export any data beyond the home network, preventing remote access.

The interviewee said that he didn't know of many others doing the same sorts of things he was (with regards to energy management) and that, while he has talked to others about what he has done, it has been too expensive and time consuming for other to follow suit. For household demand management to become widespread in New Zealand, the interviewee believes that the systems must be cheap, and must become "plug and play". Integrating such demand management functionalities into solar products could be an opportunity for New Zealand, though he doesn't know of any companies doing this beyond hot water control.

What the future might hold

When asked about what the future might hold, the interviewee mentioned that he didn't think that everyone will be generating their own power, for example, some areas may be unsuitable due to weather conditions, and other may be due to physical infrastructure constraints (e.g. families living in flats without access to space for PV systems, although body corporations could address this by installing solar on the roof-space). However, he does believe that new types of business model can provide options for those how can't afford their own solar unit to lease locally generated power.

The interviewee thought that community scale action would be fantastic as it provides the opportunity to invest in larger and more varied systems (e.g. wind as well as solar), and enables things that are not possible at a household level (e.g. waste to energy systems). However, he doesn't see any community actually driving this change, and thinks that Kiwi "clean and green" cultural values could be a substantial barrier to widespread action. He believes that Government will need to play a role in pushing community level generation and stimulating motivation to change.

Household 2

The second household interview was conducted with a male participant, in the age bracket 40-44, living with his wife and three children in a detached home in the Wellington region.

The story so far…

For this participant their interest in home energy management was sparked through similar business energy management initiatives undertaken in their workplace. Their engagement started with the Current Cost device that used current transformers to measure household demand and provide real time feedback to an in-home display. They also explored the Belkin Wemo suite of products to enable automation of household appliances.

Much of the information for this interviewee was sourced online; through Kickstarter and AliExpress they found many different home energy management technologies that could monitor and control household energy use (of which some worked very well and others less so). One of the products that worked very well for this household was the Neur.io device, consisting of CT clamps to provide current and voltage sub-second monitoring. The advantage of this product over other similar products was that the Neur.io is also able to analyse the data collected to identify individual appliance use and provide the family with more granular feedback on their energy demand.

The interviewee also mentioned that the household had recently switched to power companies, joining one offering a time variable tariff. Coupled with their energy feedback, the increasingly granular information this enabled them to receive (by time, price, and demand) led to them taking additional measures to reduce consumption, for example, replacing 41 light bulbs with LEDs (partly because they wanted wireless lighting to enable remote and autonomous control of the bulbs and LEDs were the only type available).

However, there were some initial teething problems due to disagreements between family members as to which appliances can be switched off when their electricity tariff is high; this has largely been remedied through coming up with an action plan and agreeing on what their household response should be for future events.

They also shifted their behavioural patterns, for example, using the delay function on their dishwasher so that it only runs after 11pm when power is cheaper, turning the heat-pump on at night rather than having it on all through the day, and pre-heating their home when needed. Although some of these actions required a little playing around with to get right, as a consequence the interviewee's household reduced their energy consumption by 27%, saved substantially on their power bill, and saw improvements to family health.

The next action they hope to take is to purchase a solar PV and battery system. They are particularly keen to get a system with a battery (which they may well install first) to take advantage of charging the battery at night when their electricity tariff is very low and to manage their peaks in demand. However, they are holding off on this as they may be moving home.

Key drivers, barriers, and enablers

Attaining savings in energy and cost has been a driver in itself for this household. The differential pricing offered by their power company, coupled with real time feedback about their demand, provided them something to aim for and showed them the consequences of their actions. While the requirement that they have a smart meter installed was initially a barrier, this was overcome quite easily through requesting one from their electricity provider. As an increasing number of homes around New Zealand are switched over to smart metering, this barrier should become an ever-decreasing issue.

Another motivation was the desire to generate a proof of concept for residential demand response and identify how this could be made easier for other residential consumers. Home energy management technology is not mainstream in New Zealand, making it hard for consumers to access. Many are also expensive, and/or have a set up that requires technical know-how with instructions for use that tend to be unclear. Technologies are dependent on the Internet to operate (which is not 100% reliable), and this also introduces security issues. This presents barriers for the use of energy management technologies in general.

A further barrier when thinking about how home energy management technologies could work with residential demand response comes from the interoperability between demand response signals and energy management systems; there is currently no real integration of these in the home. While demand response at the household level is offered in some nations, few products that enable remote or advanced control capabilities are able to read this signal and respond to it. Agreement on standards to enable smart hardware to talk to demand response systems is critical if this functionality is to be offered in New Zealand.

The interviewee mentioned that one product (the Nest thermostat) seems to have done things well; when you set it up you are able to enter information about yourself (including where you live) which then enables the product to hook into your electricity retailer and register for their demand response program (if they have one and have partnered with Nest). The process has been made easy, and, as this interviewee identifies, is key if home energy management and residential demand response is to be driven forward in New Zealand.

What the future might hold

The ability to bring home automation and demand side management to consumers via various types of aggregators (which could be product based like the Nest, or client based akin to those used for larger consumers) could see households heading in the direction of smart communities and smart cities akin to plans for the Fujisawa sustainable eco-town just outside Tokyo; within the group of homes a suite of products inclusive of microgeneration, storage, appliances, and transportation could be fully networked together to enable routing of autonomous vehicles to be optimised, and appliance use and battery storage to be scheduled according to generation and usage patterns within homes. While this may stimulate thoughts of "big brother", some elements of this may become more widespread due to the energy, cost, and resilience benefits it could bring.

In New Zealand, the interviewee mentioned that awareness of home energy management and smart home technology will be stimulated through offerings made by telecommunication companies, such as Morepork by Spark extending from home security to home energy. In addition, Google (works with Nest) or Apple (works with Homekit) products sold in high-street stores like Harvey Norman or Noel Leeming would likely drive the uptake of these products. While there is a legitimate concern as to whether the New Zealand market will be big enough to attract these manufacturers, the country could provide a great test bed for products, and should be looking to influence the larger but lagging Australian market. He believes that residential demand response could be the start of something new and very big, and key to its success is the ability for manufacturers and the industry to work together.

Business 1 - Countdown

Countdown is a full-service supermarket chain in New Zealand; from small beginnings in May 1981 when the first Countdown store opened in Christchurch, they are now the largest single supermarket chain in New Zealand in terms of number of stores. They are a subsidiary of Progressive Enterprises, itself a subsidiary of Australia's Woolworths Limited.

The story so far...

Countdown have been gradually increasing their energy related initiatives over the last 8-9 years since they were purchased by Woolworths Australia. Initial efforts began with collecting energy feedback data and using this along with invoice data from suppliers to explore how different sites were using energy, identify high performing and poorly performing stores, and see where improvements could be made. However, the focus of this was more around fault detection and optimisation (e.g. how equipment installations may be modified through efforts such as changing set-points of operation, or the impact of installing new technology in stores) rather than demand management, largely because electricity demand is very predictable and highly dependent on customers.

Other efforts undertaken by Countdown over the last few years include the installation of glass upstands (to prevent cold air escaping from cases) and lids on coffin freezers, the replacement of lights with LED lighting in refrigeration cases, and the use of LED lighting in new stores (including retail areas, office areas, and car-parks). Furthermore, this financial year a further 60 supermarkets will be retrofitted with LED lights in the retail area. Automation has also been added to the store lighting so that after stores close at 10pm (and are then occupied only by the night filling crew) lighting automatically switches down to half lighting.

Dynamic energy management in stores has been tougher to tackle, particularly because most supermarkets don't have a Building Management Systems (BMS) integrated into their electrical distribution board. However, Countdown has started to innovate here with their refrigeration system. Refrigeration is one of the main draws of energy across the Countdown stores, and as such could offer opportunities for dynamic demand management or inclusion in demand response programs. Their refrigeration system controller has built in sub-metering capabilities and Countdown are currently exploring opportunities to layer software platforms onto the controller to act as a portal to read the data collected by the system, placing the refrigeration system at the leading edge of building energy management for the store.

While Countdown has not yet taken a strong focus on energy generation, they are talking to solar providers about opportunities here, particularly because solar generation patterns are a good match to the store's energy consumption patterns. Additionally, they are exploring the option to replace back up power generation systems (typically diesel generators) with battery back-up systems, which could also be used to reduce peaks and create savings on power and distribution costs.

Electric vehicles (EVs) haven't been a substantial topic of conversation to date, however, Countdown are pricing up the cost of installing an EV charging station.

Key drivers, barriers, and enablers

To understand some of Countdown's drivers and barriers of action, the first key thing worth remembering that Countdown is a business, and a core function of any business is to make money to ensure it can continue to pay staff and deliver products and services. With this in mind it is perhaps unsurprising that the main driver (and barrier) of any energy related initiative undertaken by the store is financial; beyond providing a net positive energy benefit to the store, a successful initiative must also provide a net positive financial benefit. As an example, a past project with EECA to install doors on diary cases resulted in substantial energy savings, but fundamentally failed because it simultaneously reduced sales by restricting shelf browsing and impulse purchases.

They second key thing worth remembering is that Countdown is a retailer; their core business model is around selling products to customers. This means that capital needs to be first and foremost invested into the core business of retail, with energy management investments coming secondary. However, sometimes highly successful energy management initiatives can be facilitated when the two goals sit hand in hand; for example, the use of LED lighting in stores to both enhance shopping experiences for consumers (and boosting Countdown as a retailer) and reducing electricity demand. Another example of this type of initiative may be the installation of an EV charging station in stores may encourage customers who drive (or who support) EVs to shop there.

The installation of solar panels on the roof of stores could also simultaneously provide energy benefits for the store and support their core business (by providing a boost in customers who supported local renewable energy projects). However, substantial barriers exist due to contractual issues around building ownership; because Countdown do not own the buildings that house their stores, individual landlords would need to be included in this type of initiative, providing added complexity and mismatched landlord/tenant incentives.

Further barriers stem from the decision making process itself. Reflecting on the company's experience with installing LED lighting, the interviewee described how it was hard to know which technology to choose due to the number of different providers and different offerings. A similar path is emerging around solar panels; there are many different providers and installers, and it's hard to know who to go with, what differences exist between different technologies, and what the best technology for their situation may be. While the competition in this space may serve to drive down costs, it is also muddying the water when it comes to making a purchase decision.

The final key barrier encountered by Countdown is one related to information and communication technology. Although the stores have a major opportunity to deliver demand response equivalent to approximately 30% of their total load (due to the substantial refrigeration and A/C demands, and potentially even more should Countdown purchase back-up batteries to replace older diesel generators) there are key telemetry issues that need resolving first to enable the Demand Response signals to be translated into switching signals for the connected loads.

Despite the existence of the financial, contractual, and technological barriers to action, Countdown has a strong team to explore how these issues may be overcome and support future initiatives. They have: (1) created a part time role dedicated to energy management of stores, (2) sourced a good team of engineers who have specialist knowledge of the major equipment and loads in stores, and (3) convened a working group on energy, inclusive of the energy manager, engineers, and operations team, to implement initiatives and track results. The Woolworths Australia team provides further support, and Countdown's membership on the Major Electricity Users' Group has helped them stay on top of the industry.

What the future might hold

When asked about the future, the interviewee referred to the substantial increase in residential consumers generating their own energy, and the likely continued growth in consumers at home taking on board more responsibility for either generating electricity using solar PV and/or managing demand with battery storage systems. This could provide a challenge for electrical generation and distribution businesses, who should eventually set about to modify their billing models and eliminate variable billing for the fixed pass through costs of transmission and distribution (e.g. power demands) as a driver in their invoicing. This could result in an increase in consumers going off the grid, and thus ramp up grid connections costs for businesses to cover but it will certainly provide better transparency of connection costs for every customer so they can make informed decisions.

As a further consequence, businesses may need to start investigating their opportunities for increased independence. While the interviewee acknowledged that supermarkets are not in an ideal position to come off-grid, they do need to think about options and opportunities around generation and usage; for example, over the next 10 years Countdown could create their own micro-grid through investment in solar PV and large battery stores at each of their supermarkets. However, due to some of the complexities involved in decision making processes (e.g. around choice of technology, contractual issues with landlords), Countdown are likely to be a follower of change rather than a leader.

In terms of driving change, the interviewee reflected that their personal opinion was that Government should be driving technology transition by subsidising new technology in the energy space; but the technology should be able to stand up with a good business proposition on its own and be driving change through providing a better service than currently offered. However, declining solar and battery costs and performance increases are resulting in fast changes in this space being driven by consumers, which sits in contrast to the typically slow moving pace of the industry. A key role emerging for Government to play is therefore one of managing the transition; working with the industry to prepare them for the disruption New Zealand is going to see over the coming years.

Business 2 - EnerNOC

EnerNOC was founded in 2001 in New Hampshire (USA) in response to the desire for demand-side solutions to tackle large summer peaks from air conditioning use on hot summer days. Their head office is based in Boston, Massachusetts, and they operate across North America, Canada, Australia, New Zealand, the UK, Ireland, Korea, Japan, Germany, Austria and Switzerland. EnerNOC's business focuses on promoting demand response business into competitive electricity markets where they can build scale quickly (generally over 100MW), as well as on energy intelligence software to support consumers in managing electricity and energy costs. They are now one of the largest providers globally of cloud-based energy intelligence software for commercial, institutional, and industrial customers. This work explores how they have built on smart grid technology designed and deployed in New Zealand.

The story so far...

EnerNOC's presence in New Zealand began in 2011, when they purchased Energy Response[1], a start-up aggregator based in Melbourne and Wellington. Energy Response was using New Zealand developed smart grid terminal meters and this service was marketed mainly to industrial customers, to enable them to participate in the Instantaneous Reserves (IR) market through Interruptible Load (IL). The IR market supports the grid though frequency management; Fast IR arrests frequency fall and Sustained IR restores frequency. A large generator or the HVDC at high power flows can create the Contingent Event risk and need for IR, which is delivered from fast responding load or IL and spinning reserve.

The IR market is well established – the cost of procuring IR in this ancillary services market is around $20 million annually – and this has underpinned the revenue that EnerNOC needed to establish their aggregation business in New Zealand. Like in other international markets, they realised that sustainable demand response programs require a stable market in which the rules for competition with generators is fair and while bi-lateral agreements and side-payment programs may realise additional customers, they are not sustainable in the long term. As a result, EnerNOC built a business model, around the ability to scale quickly to offers of over 100MW capacity into the IR market (in 2015 their portfolio was over 200MW).

EnerNOC's focus has been on industrial customers, who are motivated to participate by the financial benefits and the cheque that comes to them every month in return for offering their load available and ultimately providing grid support. Cold stores were the first sector to help pilot and demonstrate this approach to aggregation. Refrigerated cold stores have high thermal inertia and the ability to turn off their loads very fast. These cold stores would not have been able to offer their loads by themselves because the uncertainties in their load patterns, but in aggregate their total load becomes more certain. Cold stores now only make up a small part of EnerNOC's portfolio, which is dominated by steel, pulp&paper, meat, fertiliser and water industries. Since 2008, EnerNOC has paid the cold store sector well over $1 million from the IR market which would not have been possible without this approach.

The next challenge for EnerNOC in growing their range of offerings is in getting DR to work in the wholesale energy market. The Dispatchable Demand (DD) regime was launched in May 2014, to allow Dispatch Capable Load Stations to be offered at firm prices but without any payment to customers. However, the recent Dispatchable Demand Code and dispatch tool changes prepared under the electricity reform act didn't provide for aggregators to enter the wholesale energy market; it was assumed that retailers would fill this gap but this hasn't happened for a variety of reasons. Currently, a Code amendment proposal has gone to the Electricity Authority, which would allow aggregators, like EnerNOC, to build a load portfolio to be block dispatched by the system operator.

Key drivers, barriers, and enablers

Alongside market access, one of the main barriers for EnerNOC is the lack of awareness, understanding, and engagement with DR. Industrial customers have proved easier to work with because they tend to employ people with a technical background who understand the concept of DR and associated risks. However, smaller business customers tend to be less technical and do not understand electricity systems in quite the same way, so getting them to agree to IL with much smaller payments has proved to be very hard; they need to be engaged in a different way to the larger customers, and offerings need to be framed around security of supply rather than turning things off without notice. Many opportunities are untapped because of misperceptions around risk; for example, the data centre industry, who are is particularly risk averse even though they have invested in substantial back-up capacity, are worried about the impact of power outages on their service, yet an IL event could be seen as a controlled test for their back-up equipment.

1 Energy Response was the first aggregator to enter the IR market through an exemption from the Electricity Commission in 2008. Their smart grid technology was designed by a Wellington company called Energy Intellect (now owned by EDMI) and the investment came from Meridian Energy and their subsidiary EFI, (now owned by Pioneer Energy).

The lack of engagement and lack of trust in the service from these customers indicates the lack of value they perceive in DR offerings, and one way to raise awareness, educate, and engage could be through demonstration projects. Such projects are not funded in New Zealand to the degree indicated by international proposals such as the Global Apollo Report[2], and this additional resource (0.02% of GDP or $50 million each year of public funding for demonstration of clean technologies) could enable real-world learning about smart grid technology along with energy storage and engagement of multiple actors in the system (from consumers to distribution companies, retailers and aggregators to the system operator), as well as facilitating investment and delivering value to consumers.

However, this requires getting around policy, business, commercial barriers put in place by market incumbents whose business could be at risk as the way electricity is bought and sold changes, particularly in managing dry year risk as more thermal is shut down. On the supply side hydro offers 10 weeks of storage, but this needs to be carefully managed with the demand side; keeping the balance will require different business models around pricing and risk products. New Zealand generators should realise the value of distributed storage (i.e. process storage enabled through DR) with smart control, and consider investing in this technology to minimise dry year risk. The right sort of modelling (combining technical capabilities of storage with supply side and long term economics) can help realise the business case value of energy storage; the main problem right now is that there is a lot of value to many different actors, but it is not explicit in current business models.

Ensuring aligned incentives, getting around generator thinking, and making sure the market is right for the demand side is key to engage additional consumers and grow demand side offerings. Market design needs to make sure that tariffs send the right price signals if you want customers to react to periods of grid and/or network capacity constraints. And, this needs to be done in an automated way to deliver value to smaller consumers in the mass market; consumers can't wait for a signal to take action, but instead the market needs to send automatic price changes to controller(s) that can adjust load. Making sure that this happens is a future role for aggregators

Demonstration projects could also hold the key to exploring the value of DR and process storage for a wider range of mass-market consumers and system actors. This could start by looking at different feeders to explore what storage exists on feeders, how it could change load shape, what addition storage might be needed, and where it should go in the system. The focus isn't so much the science and engineering, but understanding *how* to do it, so that over a number of years you can change the whole performance of the feeders to move peaks, control frequency and harmonics, and offer additional value to consumers (including those who don't understand things like frequency and voltage). Once you have done one feeder, you can do another until you have scalability and a sustainable offering.

But the challenge is that a project like this, engaging different actors and realising multiple value chains, requires new multi-disciplinary thinking; researchers need to work hand in hand with distribution companies, retailers, and those who have the financial capacity to scale, and run projects on real feeders to understand existing and potential storage, advanced control opportunities, and how control on feeder(s) to control peaks, asset replacement costs, frequency, voltage, and security may all work together. If this is done well, with a collaboration of partners to ensure value is delivered to all, the advantages of distributed load control should just fall out; from improvements to property values, community access and understanding, new business, charging EVs, freedom of choice, and sharing power with neighbours. This taps into new models and way of thinking about the electricity grid of the future.

What the future might hold

As with demonstration projects, a new way of thinking about the grid of the future could be to reframe it around feeders; retailers could supply at the substation level, with power purchased in bulk by communities and traded, along with distributed generation and local storage, between households and businesses in that community. This could help to maximise storage and renewables within a feeder, with new business models enabling companies to support and manage the dynamic distribution of power. New billing/settlement opportunities within the community exist for companies who can manage large data sets in real time, offering benefits beyond today's smart meters, which don't deliver much value to consumers or grid operators.

In such a future, an aggregator could provide load management on the feeder, tapping into opportunities afforded by the diversity (and patterns of diversity) exhibited by clusters of different loads in commercial and residential buildings. Leveraging improved information and communications technology could provide real time data on all loads that could be interrupted, such as turning them off and on for voltage control when PV generation is at its highest on a hot summer day, and tweaking loads or turning storage loads on/off to manage at a more granular level. Advanced metering can do all settlement and reconciliation at the substation level, but this won't happen unless everyone in this community agrees, and for this the benefits need to be clearly demonstrated to all participants.

2 http://cep.lse.ac.uk/pubs/download/special/Global_Apollo_Programme_Report.pdf

However, aggregators are unlikely to have the capital to establish all the small loads. Yet they need to scale quickly and be able to trade on same level as, for example, a peaking plant so their business models work and they are taken seriously in the market. This scale needs to be delivered within a few years of embarking on a new programme, so they are only able to play in this space if others are also putting money in to facilitate transition to a smarter and more fractal grid. Once scale has been reached it's much easier and investment is ripe, but getting to scale (from single buildings, to communities, to multiple communities) is much harder.

Regulation needs to enable this to happen and protect consumers so they trust demonstration projects and are interested in exploring new opportunities. The Electricity Authority are responsible for market performance, but don't regulate the monopoly network businesses, which is done by the Commerce Commission. Having two regulators with different points of focus and mandates create potential conflicts and confusions. Further, a smarter and more dynamic grid requires a shift away from economic regulation to total system thinking; regulators will need to ensure the whole system doesn't collapse if something goes wrong (e.g. cyber attacks, price signals stimulating mass instantaneous turn on/off of devices), because total system failure and black-start will be trickier and will eventually force more consumers off-grid.

This requires a multidisciplinary perspective, incorporating systems engineering, behavioural science, and a collaborative approach. Collaboration between actors within New Zealand's electricity system, as well as with other nations also exploring new models for consumers to interact with electricity systems is key to identify the wide ranging value propositions and learning about how best to design and implement a system that can ensure that the energy system trilemma of security of supply, environmental goals, and affordability are all in balance.

Community 1

Otaki is a coastal town (population 5,778 at the 2013 census) situated in the Kapiti District Coast on the North Island of New Zealand, 70km north of Wellington. The district is agricultural, and the town's economy is mainly dependent on service industries for the rural community, a retail outlet, and clean technologies businesses.

The story so far...

A significant start to Otaki's engagement with smart grid edge technologies dates back to 2009, when a senior manager at the Kapiti Cost District Council (KCDC) started to work with the community, looking across the district and its vision for the future, as part of what became known as the "Greater Otaki project". As part of this visioning process there was a focus on how the district could develop economic activity in the area in a way that wouldn't detract from the greater metropolitan area. This spawned a focus on Clean Tech and energy, driven initially by the KCDC, and endorsed by both the council and the community board.

A key element to this vision was thinking about the town as a system, and while this didn't necessarily call for a focus on energy, local aspirations of Otaki as an off-grid town and sustainable energy community began to develop. This may have been facilitated by the solid relationships between different groups living in Otaki, the strong sense of town and place held by members of the community, and their firm desire to ensure their children have a good future. In addition, people in the town were very interested in technology and many were already engaged in some sustainability practices, but they weren't yet looking at the big picture.

The community, supported by the KCDC, were opportunistic about initiatives, and at an early stage in their visioning process brought in some people who lived off-grid to talk about what this might look like for the town. Learning from these conversations and shared experiences, Otaki relented on the idea of being "off-grid"; it was seen as being too hard at that time, requiring substantial investment in storage, and resulting in electricity becoming an all consuming focus, dominating other important non-electricity sustainability issues. While the off-grid idea remains powerful and retains appeal to those in the community, Otaki refocused their goal to being a net exporter of clean energy, not to try and replace the national grid, but to complement it and address big picture sustainability and resilience problems, reduce lines losses, and address social inequity issues.

Otaki's vision and aspirations unfolded in three ways; (1) the KCDC's initiative of a clean technology trust, (2) the institution of the Clean Technology Centre, which was a result of funding from Grow Wellington (the regional economic development agency) and, (3) the formation for the community group "Energise Otaki" (EO).

A change of council and lack of Government support resulted in the clean tech trust falling apart toward the end of 2013, and just under a year later Grow Wellington pulled funding from the Clean Tech Centre. Twenty-seven different tenants had occupied the centre since opening in 2010, bringing a number of clean tech businesses into the community. While the building, which includes micro-wind and solar generation, is still managed by Grow Wellington who let it to industrial tenants, a number of clean tech businesses have remained in the area.

Despite the setback of losing both the clean tech trust and Centre, EO has continued efforts to engage the community in various energy related initiatives. This community group got going in earnest in early 2011, with weekend and evening meetings and talks held at the Clean Tech Centre. Since it's conception EO has been backed by the KCDC, who have sought to support the ideas and enthusiasm from the community by creating a structure within which they could develop into projects. In fact, even the name of the group (Energize Otaki) and its logo came out of a community naming competition.

However, over time the evening and weekend meetings fell away as the community found it hard to strike the right balance of practical tips, talks, and high-level strategic conversation. In early 2014 a group of enthusiastic individuals started up the meetings again, but during business hours rather than evening and weekends; they started having monthly working group meetings during the day, mostly with retirees or business people working in the area (particularly those who had moved to the area as part of the clean tech initiatives) who had interests around sustainability. However, in an attempt to re-engage the wider community, EO arranged for Rod Oram to give a public talk around clean energy issues in late 2015.

While EO has proved to be a great forum for stimulating conversations, creating networks, and seeding ideas via the monthly meetings, it's not a formal entity and so cannot directly run projects. To date, projects have been driven by individuals under the EO banner, rather than being run by EO as an entity, and EO currently stands as a collection of smaller initiatives. A substantial number of these have been run in collaboration with Otaki College, whose engagement with EO has been pivotal.

This engagement was spurred when the College Principal heard about the Clean Tech Centre and the innovative sustainable businesses underway there, and started attending a few EO meetings and meeting with people at the KCDC involved in the initiative. The connections made at these meetings led to a project between the college and Blended Fuel Solutions, supporting a larger vision to engage college students with real world scientific challenges addressing environmental sustainability initiatives. College vehicles were changed over to blended fuels, and as part of the NCA curriculum the students were involved in testing vehicle performance in a truly innovative method of teaching; students were empowered to work on real world projects that also made an impact on sustainability efforts in the local community. The students were also able to visit the Clean Tech Centre, talk to business people around the world to explore both local and global solutions, and start to engage with science in the real world.

Following the success of this initial project between the College and the Clean Tech Centre, plans were set up to establish vocational training programs at the Centre, going beyond traditional training to create a bigger focus on energy and sustainability. However, with the disestablishment of the Centre this training program fell through. The College would love to create additional programs to engage students and provide further opportunities for real world learning working with Clean Tech businesses (e.g. designing and testing wind turbines) but it has been hard for the teachers to find the time to develop a new curriculum to incorporate this into units of learning.

Despite the difficulties in creating further hands on sustainability programs the College has been successful in running an NCA credited bike project with EO, whereby students are able to spend a few hours out of their regular classes to work on repairing bikes and getting them up and running for use by the Otaki community.

Furthermore, as a result of Otaki Alumni Trust funding, 10 kW of solar panels were installed on the roof of the College. As well as generating savings on power bills, which is being used to create scholarships for students and feed money back into the local community, the solar resource is being used to support learning. Data about hourly electricity generation from the panels provides the school with information that has been used in teaching to engage the students with power generation and show them that they really can make a difference.

While the various projects run under the EO banner, particularly with the College, have been highly successful in many ways, they ultimately rely on enthusiastic individuals devoting their personal time. For example, the key to successful programs as the school is ensuring that they tie in as much as possible with the existing curricula because of the difficulties in finding time for teachers to be paid to develop new curricula around energy and sustainability.

To facilitate more structured action around energy, a group of active members of the community formed an Energy Co-operative after they heard about similar action underway in a town in Germany. They are currently getting off the ground, seeking members, and looking for appropriate projects that can be implemented in the community, particularly around LEDs, solar PV, wind turbines, EVs, and storage.

The energy co-op is following a not for profit business model, and exploring two different share options; a transacting share (at $365/share) and a supporting share (at $100/share, and a pre-requisite for a transacting share). They currently have 10 members and are actively seeking more; following a launch in Otaki a number of people have expressed interest in following up, and they are also looking to target other areas of the Kapiti Coast as a starting point.

While the co-op is still young and the members are still learning (so far the major learning has been about how to set up a co-op, which was challenging in and of itself), they are now focussed on getting activity underway. A key element in the projects planned by the co-op is around finding smarter ways to generate and use energy. One interviewee mentioned that many PV installations are not sized or used correctly, resulting in substantial wasted energy and economic return. The co-op is keen to ensure that as part of its projects, systems are planned, tested and designed more thoughtfully to eliminate waste.

Alongside the development of the co-op there has also been debate about EO becoming a formal and legal entity, capable of managing its own funds (particularly following their award of the Project Category of the inaugural WWF NZ Conservation Innovation Awards in late 2014). While some are keen to see this happen to open up additional funding opportunities, others are wary of unintended consequences and loss of flexibility and freedom that result from a less structured model. Regardless, members of the community are hoping that 2016 sees more action and stronger official relationships developed to further EOs interests and goals.

Key drivers, barriers, and enablers

A key imperative for action in the community is the need to address climate change, reduce reliance on fossil fuels, and enable local and clean renewable energy generation. Additionally, the EO vision includes providing people choices about how they use and purchase energy, where their energy comes from, and support to reduce their overall energy use. In particular, a key driver for addressing electricity use results from the power prices in NZ coupled with reductions in PV and storage technologies, providing a strong motive to do something to benefit the community. However, the ideas and projects that drive these visions forward are not owned by any one group, but instead is the result of individuals, businesses and organisations becoming involved.

Despite these broad goals and community involvement, a major barrier for action has been the lack of financial investment to carry out larger projects or set up infrastructure. For example, while shares are a great way to get community buy-in to the energy co-operative, there is an immediate need for additional start-up funding to get projects underway and to encourage others to invest. Current funding and business models are not helping to consider the bigger picture of sustainability and local resilience, and New Zealand needs to seriously reconsider these with relation to energy investments.

Improved funding would enable the community to better resource both people and projects. The ability to employ someone part time would ensure responsibility for driving initiatives forward, and there are a number of projects that have been identified as key to get going. For example, one such project would be around creating an understanding of how energy is currently being used and getting both baseline and on-going measurement because "you can't manage what you can't measure". However, the cost to set this up is largely financially and would require substantial project management (which currently isn't available).

Scale is also a barrier and currently only a subset of the community is strongly active in pushing EO's bigger goals. While lots of people have expressed an interest in the energy co-operative, not many have proved willing to participate, perhaps due to a lack of confidence to take initiative, a lack of understanding about what the co-op could offer, or misinformation about the benefits of and opportunities for local energy initiatives. And while there is a hub of activity underway at the College, schools can't be responsible for sustainability initiatives on their own; they need to be undertaken as part of a community initiative.

Additionally, even when there is buy in (e.g. at the College) it can be hard to create action due to lack of time and resources. However, if the whole community got behind these initiatives then it might also be easier to get Government and industry support. But currently there isn't enough community buy-in to make large-scale change happen.

There also needs to be stronger focus on projects that incorporate whole of life perspectives and smarter ways of doing things. The current reliance on financial drivers to stimulate action is problematic, and we need to develop a social consciousness to ensure enough focus remains on the bigger picture, inclusive of ethical and sustainability drivers of action. One interviewee mentioned that creating a focus on restorative practices could support this shift, but this type of learning isn't part of our learning processes (school or vocational). Pushing environmental sustainability and restorative practice into teacher training programs could support a shift from short-term programs to longer-term visions for a more sustainable and resilient future.

When looking overseas, e.g. at communities in Germany where change has been facilitated, it's clear that both financial incentives/support (i.e. via feed in tariffs) and political leadership within the community have both been critical to their success.

Whilst development of the co-operative is key in establishing the structure to run local energy projects, a major barrier has been in the setup of the co-op structure. None of the members had done this before, and had a lot to learn to just set the co-operative up. Although the members' technical, business development and accounting backgrounds were helpful in bringing much needed knowledge to the table, getting the necessary legal advice at affordable prices was hard to find. Another barrier was around determining exactly what the co-op is, what it can offer, and sharing this information with others. Although the co-op has a mission statement incorporating social values and doing "good", embracing disruptive technology is not easy, and a barrier to action is establishing the structure within which the co-op can work to provide energy services for the whole community, with profits and benefits from these investments being returned into the community.

A claimed "lack of engagement from the local lines company Electra" is also seen as a barrier, and while it hasn't made action around sustainable local energy impossible, it has made it harder for the community. To date EO and the local council has undertaken one project with Electra (installation of PV on library) but it's not yet clear that the lines company sees the value in the vision of a sustainable Otaki developing local energy resources. However, a number of people in the town are still rallying to get Electra on board, and many interviewees mentioned that their involvement would be great, partly because they are a community owned trust themselves, and because they could enable local energy action on a greater scale.

To date, the main enablers of action have stemmed from the initial support provided by the community board and council, providing the initial funding and resources to work on projects. Since then, the financial support and recognition from the WWF has been important to EO in terms of supporting the ability to fund projects and to provide external acknowledgement and validation of efforts.

Finally, a number of individuals with a strong passion for local energy and sustainability initiatives have proven to be key in driving forward and implementing personal and community level projects, engaging with others, and spreading knowledge to others in the community at every opportunity. Connections to people with a technical background and expertise who came to the area during the establishment of the Clean Tech Centre have also been critical to the success of EO.

What the future might hold

Amongst different people within the community there are clear differences in the specifics around what the future might hold. While some take a socialist perspective and envision an energy future in which the state plays a strong role managing a national grid supported by some distributed generation, others believe that improved technology will lead to each home or block of homes being totally independent from the grid. However, regardless of the specific vision, all interviewees saw a role for local energy and sustainability initiatives, the clear need to decarbonise NZ and think about sustainability in a holistic manner, and the importance of community resilience.

And while it's not yet clear what the most cost effective way to decarbonise will be, with co-ordination and appropriate management, the traditional grid can provide zero-carbon energy by using a mix of solar, wind, geothermal, and hydro resources. A smarter grid would have a lot of storage (diurnal and seasonal), would be able to accommodate EVs, and will have to handle peak loads (e.g. EV fast charging). So local generation and more creative use of data and management practices will be required. Additionally, a more creative financial structure will be needed to reflect the services provided by the grid; peer-to-peer financial structures were mentioned as being "the ultimate goal".

The current focus on residential level solar PV is creating and tapping into a demand for energy independence and resilience. Some interviewees expressed concern that while individual level solar could cause the death-spiral to the grid and lead to further financial and energy inequity, it will be needed if traditional methods don't go toward zero-carbon. So we need to provide strong direction toward to the optimal pathway.

There was a clear message that the future isn't about a particular technology, but instead about the need to be versatile and flexible, following whatever it takes to achieve 100% renewable and sustainable generation in NZ. Though it's not yet clear who should be leading these changes. There is an excitement bubbling within the community around the idea of a town being able to produce some of its own energy and to play a role in the transition toward a more sustainable future. And while some well-placed acts in parliament would help, communities also need to play a part, setting the scene for energy to be used more smartly to get the most beneficial outcomes.

Community 2

Blueskin Bay is an area about 15km north of Dunedin, in the South Island of New Zealand. 'Blueskin' refers to a number of settlements (and around 1000 homes), incorporating Waitati, Long Beach, Purakaunui, The Gums, Osborne, Evansdale, Warrington, Seacliff and Karitane. In the 1970's Waitati, the centre-point of energy initiatives in the Blueskin area, was well-known for being a hub of environmental action. Now, the area is often referenced regarding its vision of climate and energy resilience, and its work to establish what will be New Zealand's first community owned wind cluster. Here we provide a brief overview of how this came to be.

The story so far...

The starting point for Blueskin Bay's journey toward becoming an energy resilient community was a workshop held in September 2006, prompted in part by the heavy flooding in April of that year and the realization that a response was needed to address the challenges of climate change and energy insecurity. In addition, the opportunity arose to invite Green MP Sue Kedgley, who was visiting the University at that time, to give a public talk on "Food and Energy" out at Waitati, around which the workshop was developed. The Kinsale Energy Descent plan was used to structure a community discussion and visioning process, through which a "wish list" of activities was developed This included local energy generation through wind turbines and solar, improved insulation on homes, and the establishment of a community garden.

In 2007 the Waitati Edible Gardens group was established as the first tangible outcome of the workshop, and although energy remained on the agenda (in particular following a talk by Jeanette Fitzsimons in Waitati during her "Climate Defence" tour), the community energy project didn't kick off until November that year. This was catalysed by an approach from the Be The Change bus, in a campaign run by Greenpeace, Oxfam and Forest & Bird to inspire New Zealanders to take action on climate change. Be The Change had heard about the events in Waitati and were keen to have a stop off in Blueskin Bay. An Energy Expo was run in conjunction with this, pulling in clean-tech businesses focussed on solar hot water, solar PV, and insulation, micro-wind (amongst other things), the DCC sustainability initiatives, the Otago Regional Council, and student research projects around sea level rise.

Following this event, a detailed funding bid to support the community energy project was prepared, and whilst this was unsuccessful, it led to the development of an annual plan for the community. Actions completed in 2008 as part of the plan to promote energy action in the community included the delivery of Home Energy Rating Scheme audits (provided and administered by EECA as part of a trial program), a second Energy Expo held in mid 2008 as well as the start of a trial of the Thin Air micro wind turbine at a Blueskin site.

At around this time those involved in the community energy project realised that some structure was needed to support and manage the various initiatives, which up till this point had been run by a small group of volunteers living in and around Waitati, with no formal membership or contractual arrangements, nor any formal elected positions. This led to the development of the Blueskin Resilient Communities Trust (BRCT), a climate change focussed charity that could provide the members with a governance structure as well as a legal body suitable for securing funding and entering into formal agreements.

A presentation to EECA in early 2009 led to Blueskin becoming a pilot zone for the Warm Up NZ scheme. The insulation retrofit pilot ran later in 2009, and was facilitated by the BRCT. Over 400 homes were kitted out with subsidised insulation in just 4 months. Through this work BRCT learnt a lot about the insulation industry and the nascent government programme, as well as the power of community networks, energy and retrofitting, and simultaneously established a large subscriber email list of those in the community interested in becoming more energy efficient.

The Hikurangi Foundation (now called the Akina Foundation) came on board with funding and support in 2009, and further funding that same year was obtained through a successful bid to EECA's Distributed Generation Fund for a feasibility study into local wind generation. Generation had always been a project that the BRCT was keen to develop, but had seemed like a distant hope until this funding, along with connections to a group of students at the university, led them to conduct their first feasibility study into the viability of a single wind turbine for the settlement of Waitati. Earlier on BRCT had done some pre-feasibility assessment of micro-hydro (which seemed to be somewhat problematic) and solar (which compared unfavourably with wind because of price); wind seemed to make the most sense in terms of a community scale solution to build greater security of supply and greater resilience.

The feasibility report revealed not only that a small wind farm was more viable, but also revealed much more detailed information about the local grid and best placement. More wind data measurement and community engagement followed, with a company formed and lease secured for the site. BRCT's charitable company Blueskin Energy Ltd is currently involved with a number of potential customers and market participants to design the best market arrangement. At the time of writing this report the Blueskin Wind Farm resource consent application was being processed. Despite considerable community engagement from the outset, the application drew opposition from a number of submitters

concerned about issues such as visual impact, noise and bird strike. If consented, the BRCT aims to establish the three-turbine wind farm within the next 2 years, to generate approximately 7GWh annually.

In addition to the wind project, a piece of research conducted by a student at the University of Otago revealed a growing interest for solar within the community. Although the BRCT had no plans to develop a solar project beyond demystifying and promoting the technology, they advertised for a volunteer to support a solar programme, which involved the preparation of a request for proposals, sent to three different solar companies, for bulk purchase of PV panels. In parallel, a local engineer/entrepreneur was invited to put forward an alternative bulk import proposal. A public meeting was held to get feedback from the community, and while there was substantial interest, at the time only a few people signed up and these people shunned the commercial offers in favour of participation in direct import of solar PV, organised by the local engineer/entrepreneur. This individual, through his own research and household activities (including being an early adopter of solar PV, solar thermal, micro-wind, battery technology and developer of retrofitted electric vehicles), had developed links with manufacturers overseas, and was able to provide community members with both better prices and trusted advice about the purchase and installation process. In parallel one of the commercial Solar PV companies maintained contact with BRCT and several months later offered a concessionary deal, which had some success (solar panels were donated to community buildings for every $1000 spent with the company on a solar installation). This arrangement led to the BRCT office and its host, the Waitati Enviroschool, being fitted with a 1.5kW solar PV installation in 2014.

As at November 2015 there were 28 DG connections with a total capacity of 104.8 kW in the Blueskin area. Blueskin represents only 6% of the OtagoNet network, and over the whole OtagoNet network (including the Balclutha, Palmerston and Ranfurly areas) there were in Nov 2015 a total of 69 small scale DG connections with a total capacity of 250.8 kW. Blueskin remains a hot-bed of PV installations within the OtagoNet network.

Research has been a core component of all initiatives undertaken by community. In an iterative process, which involved close collaboration with the University (particularly via student projects in the early days), and industry, and a willingness to spend personal time reading technical and academic literature, members of the BRCT have built a knowledge base that has supported the varied projects. While some of the key members of BRCT have no formal qualifications in the energy industry, the informal pathways and hands on learning has afforded a unique opportunity to develop skills and knowledge well adapted to the local environment, incorporating a community approach. As advances have been made, pro bono support further 'powering up' BRCT has grown. Through this on-going journey of rich learning and a desire to create a lasting legacy, the BRCT has achieved substantial results despite limited resources, staff and time.

Key drivers, barriers, and enablers

A clear driver for action within the community can be seen to date back to 2006 floods, in which residents were stranded, roads were cut off, and stock and property were washed away. During the clear up that followed the some members of the community observed how powerful their informal networks has been during the response to this severe weather event, particularly compared to the centrally co-ordinated Civil Defence which was much less effective at taking charge. This seeded the desire for greater community resilience.

In addition, there was a growing frustration with the lack of response to climate change from central and local government, and a growing determination from several key individuals that residents would just need to get on and do things themselves.

Further drivers for action have been spurred on by changes in the energy sector starting with the re-regulation of the electricity sector beginning in 1998 (and the subsequent reshaping of a service for community benefit towards a service for profit), and followed by performance improvements and cost reductions in smart grid edge technologies, and new market participants. Residents are no longer just blind consumers at the whim of the entrenched energy incumbents, but instead are motivated to take greater control over their future.

The major barriers encountered by the BRCT in their efforts to become an energy resilient community have related to a lack of resource, time, funding, or support. While many residents greatly appreciate BRCT's many services and projects, this does not translate into on going funding, and volunteer support must be managed with care. Finally, some residents have come out actively against the proposed Wind Farm development and this opposition is suspected to be caused by fear of change.

Given these barriers, perhaps unsurprisingly the main enablers of change occurred through funding success; initial funding from TaskForce Green and the Otago Community Trust enabled the employment of a staff member for 30 hours a week, and further funding success (through Task Force Green) secured a second staff member for a fixed term. The Hikurangi (now Akina) foundation's support was also key to the BRCT's ability to develop the major energy projects, as was the time and effort donated to the BRCT by trustees and volunteers.

Establishment of the Trust a legal entity was critical to these successes; it not only provided greater legitimacy to the community's vision and enabled funding applications to be made, but was an essential ingredient to establishing collaborative relationships with industry, local government and government agencies, university, NGOs, business and landowners.

Finally, certain individuals within and external to the community have been identified as key enablers of action; Janet Stephenson at the University of Otago has been a powerful catalyser in providing the BRCT with connections to like-minded individuals and organisations as well as research resources.

Others experts within the community have also been pivotal to the success of energy projects, providing technical know-how and trusted advice, and facilitating access to solar, storage, and retrofit electric vehicles. These experts, along with those members of the community who were early adopters of solar PV, have helped to publicise the projects and vision of the BRCT, and support a shift in community perceptions around energy.

What the future might hold

Blueskin Bay is seen as being part of a rapidly changing energy environment, and one of the BRCT's key goals is to develop an islandable energy community, inclusive of electricity generation, storage, and micro-grid functionality, within the national electricity network. The various Blueskin energy projects are seen to contribute towards the development of a modular energy community, whereby the community can manage electricity supply, in a peer-to-peer grid and independently at the community scale, whilst still remaining part of the grid. This independence, or micro-grid functionality may include the use of real time feedback on supply and demand at the local level to inform and support better decision-making by households and by smart appliances, as well as autonomous and painless transactions between households in the community to ensure balanced operation of the grid at a local level. While household level micro-generation is seen as important, it is viewed as contributing to a community level smart energy eco-system, rather than something that could enable individual families to go off grid completely. There is the expectation that this example will also lead to a more resilient national network supported by a spider's web of distributed generation and storage (solar and wind power primarily, with battery banks and EVs) supporting the national grid.

A price on carbon and positive regulatory shifts to bring about real time pricing on electricity are seen as key in making the distributed generation and storage technology already available even more important for households and communities, further supporting the viable development of New Zealand's electric vehicle fleet and opportunities for peer-to-peer trading of power.

While the BRCT sees themselves as a leader in the change process that needs to happen to decarbonise New Zealand, they believe that Government and industry should also be recognising the emerging 21st century reality and playing a role to support transition out of the 20th century; they need to recognise the technological improvements in wind, solar and battery technology as well as the advancement of Internet capabilities across the country, the positive economics afforded by renewables, and the harsh reality of climate change. The interviewee suggested that Green Development banks should be created to finance loans for renewables, and the Government should be removing subsidies that the fossil fuel industry has been receiving for the past 50 years and putting this into renewables and electric mobility solutions (EVs, eBikes, and eBus), as well as developing a carbon tax that can be used directly to support changes at the household level.

Although the future isn't certain, and there is the risk that Government and industry won't support New Zealand's transition to a sustainable energy future, the progress to date by the BRCT has already gone a long way to enhancing relationships within the community and supporting their vision of local energy security and resilience.

Conclusion

The drivers for action in the energy generation and management space seem to be quite different between early movers in each of the three groups. Ideas around resilience and sustainability were most strongly expressed by the communities, particularly around being able to access power in situations where the distribution system is down (e.g. due to a severe storm). Interestingly, their actions do not necessarily support this bigger motivation; in Blueskin Bay where the community is investing in a focal site wind-turbine, the system would add no more resilience in such a localised event than the existing grid structure. The arrangement – in which the power from the turbines is sold to retailers through a power purchase agreement, with the profits being recycled through a trust – doesn't provide power direct to the community and thus doesn't support or further ideas around resilience. Even arrangements at the household level fail to provide this type of support with typical inverter structures; when the grid goes down so does the PV system.

The two households also mentioned values around resilience, but their main motivators of action appeared to be more around having fun and trialling new technologies. For the businesses too, resilience may well have been an overarching value, but their main drivers were related to cost, scalability, and alignment with existing business mandates (internal focus) or the markets within which hey operate (external focus).

Despite the different drivers of action, there are some key barriers emerging across all three cases, particularly those relating to the lack of information and the complexity/lack of interoperability of the space. The two households who were highly motivated to take action spent a lot of time investigating different options and creating their own solutions, but both realised that others wouldn't want to or be able to do this. Within the communities the technological complexity was aided by having local experts, but other complexities (e.g. around setting up the necessary legal structures) was overwhelming due to the lack of expertise internally, and lack of funds to outsource this. Even the businesses mentioned issues around being unable to engage in some behaviours due to a lack of information about the technology, or because existing systems and infrastructure were not set up in the right way to make it easy for them to.

Thus the case studies illustrate that while cost is emerging as a clear barrier, the projects that have been successful are those in which the value propositions are clear for all actors (and aligned with their existing mandates and values), and in which solutions are easily implementable. This ease of implementation covers all stages in the users journey, from initial information and knowledge gain through the purchase, install and operation. This raises questions around how to further develop the "smart" market, and suggests that "plug and play" options will need to be clearly promoted and easily integrated into homes and businesses without the need for technical experts. Furthermore, to be able to leverage these additional "smarts" to support grid flexibility means that these systems need to be able to communicate with signals from the system operator. These are challenges that the industry must consider if such technologies are to be more widely adopted, and to ensure they do not negatively impact the grid, but instead can be harnessed to improve its resilience.

SMART GRID EDGE TECHNOLOGIES
CASE STUDIES OF EARLY ADOPTERS

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