RELATIVE PROGRESS OF SMART GRID DEVELOPMENT IN NEW ZEALAND

NEW ZEALAND SMART GRID FORUM

21 August 2016

The Smart Grid Forum

The Smart Grid Forum brings together relevant parties from business, scientific and academic circles, along with policy makers, regulators and consumers, to advance the development of smart electricity networks in New Zealand

The Forum has been commissioned by the Ministry of Business, Innovation and Employment, with the support of the Electricity Networks Association.

Members of the Smart Grid Forum are:

Paul Atkins (Chair), *NERI, replaced by Janet Stephenson in February 2016*

John Hancock (Secretariat)

Lynda Amitrano, *BRANZ*

John Carnegie, *Business NZ*

Neil Cheyne, *Fisher & Paykel*

John Clarke, System Operator, *Transpower*

Rogan Clarke, *Vector*

Simon Clarke, *Trustpower*

Stephen Drew, *Enernoc*

Richard Manaton, *Countdown and Major Electricity Users Group, replaced by Leon Jarden in September 2015*

Jason McDonald, *Meridian Energy*

Allan Miller, *University of Canterbury and GREEN Grid Project*

Matt Olde, *Mercury*

Jaun Park, *Unison Networks*

Ralph Sims, *Massey University*

Derek Todd, *Delta Utility Services*

Ryno Verster, *Powerco*

Gareth Wilson, *MBIE*

Hamish Wilson, *Consumer NZ*

Observers:

Craig Evans, *Electricity Authority*

Terry Collins, *EECA, replaced by Eddie Thomson in February 2016*

John Hamill, *Commerce Commission, replaced by John Groot in February 2016.*

This report has been completed by Bridget Moon on behalf of the New Zealand Smart Grid Forum

EXECUTIVE SUMMARY

A smart grid is *"an electricity network that can intelligently integrate the actions of all users and equipment connected to it, in order to efficiently deliver sustainable, economic and secure electricity supplies."*

At the request of the Minister of Energy and Resources, the New Zealand Smart Grid Forum has considered how New Zealand's smart grid developments are progressing relative to those in other countries – especially technologies and arrangements that support or facilitate new services for consumers. It has also considered what, if anything, could be done to accelerate developments in New Zealand that provide consumer benefits.

Smart grids provide new options for sourcing, transporting and using electricity. These new options can benefit consumers in a variety of direct and indirect ways, and will give them the most meaningful opportunity they've had to shape the electricity industry so that it better reflects their needs and values. The Forum has assessed New Zealand's "progress" based on its relative success in providing consumers with new options they value, as indicated by news articles, studies and surveys, including a number of materials prepared by the University of Otago's Centre for Sustainability.

New Zealand has approached smart grid development in a different way to many other countries. While some have chosen to provide broad subsidies for new technologies, New Zealand has largely relied on an organic, market-led approach to development. The Forum's investigation concludes that New Zealand hasn't seen the same *scale* of smart grid development activity as a result of this different approach. However, there is broadly the same *type* of activity underway, driven by a fairly healthy cross-section of local governments, electricity industry participants, and consumers themselves.

Furthermore, New Zealanders harbour an inherent interest in new technologies, and a strong desire for independence and control that will drive substantial uptake of technologies like solar PV and electric vehicles as costs come down. It is merely a matter of time.

However, the Forum has identified that there are real difficulties for parties in evaluating the various options available, and justifiable confusion about the benefits they provide. As a result, there is a real risk that good projects won't be pursued, and that decisions could be made that aren't in the best interests of all consumers.

Therefore, to accelerate developments that provide consumer benefits, New Zealand should identify ways to cut through the complexity associated with new technologies, and ensure their potential value is better signalled in a number of contexts. There may also be opportunities to help bring people together to jointly realise this value.

1. INTRODUCTION

This report considers how smart grid developments are progressing in New Zealand

The New Zealand Smart Grid Forum (Forum) was established in 2014 to advance the development of smart electricity networks in New Zealand. The Forum's vision is that:

> *"In 2050, New Zealand will have leveraged the opportunities made available from emerging smart grid technologies and practices to the benefit of electricity consumers and New Zealand's prosperity and productivity as a whole".*

The Forum presented a report to the Minister of Energy and Resources (Minister) in June 2015. That report set out the Forum's views as to:

- how to make the most of market led innovation and minimise risk of stalling due to lack of coordination between different stakeholders
- how to anticipate and proactively manage any risks to power quality and reliability that might emerge from smart grid technologies and applications.

In responding to the report, the Minister requested the Forum's views on two further issues:

1. How are New Zealand's smart grid developments progressing relative to those in other countries – especially technologies and arrangements that support or facilitate new services for consumers – and what, if anything, could be done to accelerate developments in New Zealand that provide consumer benefits?
2. How might smart grid developments assist in meeting New Zealand's greenhouse gas emission reduction targets?

This report addresses the first of these issues.

The Forum addressed the second issue in its report: "How Smart Grid Developments Can Support Emission Reductions" ('Emissions report').

Structure of this report

The following sections outline:

- The Forum's overall findings and observations ***(section 2)***
- The Forum's approach to assessing progress, which has been to draw on experiences, rather than rely on metrics ***(section 3)***
- An outline of the state of smart grid developments world-wide ***(section 4)***
- An high-level outline of the context for smart grid developments in NZ ***(section 5)***

- The development activity that the Forum has identified in NZ ***(section 6)***
- What the Forum has inferred about NZ's current and likely progress from this activity ***(section 7)***
- What could be done to accelerate developments that provide consumer benefits ***(section 8)***

2. RESULTS AND FINDINGS

There are opportunities to improve benefits from smart electricity grid developments

New Zealand consumers are benefiting from an electricity grid that continues to evolve and respond to opportunities presented by new technologies. Consumers will see further benefits from smart grid development as the capability of new technologies improves and costs decline.

There are things we, as a country, can do that would help electricity consumers see benefits from smart grids in a faster and more efficient way. We should:

- ensure that consumers see prices that properly reflect the value of the services they receive, so that they can avoid making decisions that might increase costs for other electricity consumers. To this end the Forum encourages the Electricity Authority's current review of pricing for distribution services
- investigate how to reduce barriers to effectively using the flexible response of distributed generators, energy storage devices and consumer demand
- facilitate relationships between the electricity industry, and businesses and agencies that can help to catalyse valuable smart grid developments
- find ways to break down the complexity associated with new technologies that are supported by smart grids, and make it simpler for consumers to identify the best options.

Smart grids are providing new options of value to consumers

The Forum has previously defined a smart grid as *"an electricity network that can intelligently integrate the actions of all users and equipment connected to it, in order to efficiently deliver sustainable, economic and secure electricity supplies"*[1]

Developing a smart grid – by applying electronic controls, computing, and communication technologies to electricity infrastructure - opens up new options around sourcing, using and transporting electricity.

These new options can benefit consumers in a variety of direct and indirect ways, and provide the most meaningful opportunity that electricity consumers have had to shape the industry so that it better reflects their needs and values. Smart grid development can put

[1] This is an internationally established definition. Ref: European Technology Platform Smart Grids, Strategic Deployment Document for Europe's Electricity Networks of the Future, September 2008. Also see the Forum's terms of reference

more of us in control of our energy outcomes, and has the potential to help New Zealand become more prosperous and competitive.

Interest in smart grids is growing internationally. Governments, utilities and consumers are funnelling billions of dollars into smart grid development opportunities and the new options they support, as well as research efforts to better understand the potential of smart grids.

Smart grid development is being driven from two directions:

- from the top:
  - national, state and local governments are investing in smart grids because they can support various policy initiatives. In particular, smart grids help to integrate renewable energy and electric vehicles, which will help meet greenhouse gas emission targets. Smart grids can also support smart cities, which can create economic and competitive advantages.
  - electricity industry participants are investing in smart grids because they provide new options for serving customers or managing their networks, which allow them to be more efficient and competitive
- from the bottom:
  - consumers and communities are investing in new technologies like solar PV, batteries and electric vehicles, in pursuit of self-sufficiency, control over their energy costs, and to help in the fight against climate change. This technology uptake is driving the need for a smarter grid to accommodate it. An individual consumer can drive significant change, because they can catalyse uptake by other consumers in their neighbourhood or social circles.
  - consumers are becoming more engaged with electricity – including how it is produced and used, and how it can serve their lifestyles and benefit their communities. This is opening doors for new business models and opportunities such as peer-to-peer trading, and the establishment of micro-grids.

In some instances, top down and bottom up development is starting to meet somewhere in the middle:

- Consumers are responding to the new opportunities that smart grid developments made by governments and industry have made available to them. This reinforces the decisions of investors, and encourages further evolution of the grid. For example, smart meters have allowed new approaches to electricity retailing that some consumers have found valuable. Businesses and households are also exploring opportunities to control loads in response to the real-time price signals they're starting to receive.

- In some jurisdictions where subsidies have been provided, the pace of consumer-led development has outstripped the ability of the electricity industry to meet them half-way. For example, in Queensland and Hawaii, the uptake of solar PV has been so swift, that network owners haven't been able to upgrade their networks fast enough. As a result, they're battling system security issues, and have had to limit uptake to keep on top of it. Subsidies have also caused problems with budget shortfalls, social inequality issues, and back-lash from consumers when trying to address these challenges.

New Zealand's organic approach to smart grid development is resulting in broadly similar activity as is happening overseas – albeit at a lower rate of development, given the different investment incentives that exist. So far, we've been able to realise some of the benefits, while avoiding most of the negative outcomes that others have experienced. For example, the Forum has previously reported on the contrasting outcomes between New Zealand's market-led roll-out of smart meters and the mandatory roll-out in Victoria, Australia. New Zealand will benefit from having been able to observe some of the negative outcomes experienced elsewhere, and from having more time to plan and prepare, knowing what *could* happen.

However, this does not justify complacency.

In general, there aren't yet enough financial benefits from new technologies like solar PV and electric vehicles to drive significant uptake in New Zealand. However, the global uptake of solar PV demonstrates how powerful financial benefits can be in mobilising technology uptake, and how swift the change could be when those sorts of benefits materialise here. Given the rate that technology costs have been declining, this might not be far away.

Furthermore, New Zealand consumers are keenly interested in new technologies, and embrace the benefits they can bring. Surveys indicate that many of us have a strong desire for independence and control over our energy outcomes. As costs fall, a groundswell of uptake of technologies like solar PV is surely inevitable.

In time, a smarter grid will support us all in using new technologies to generate electricity more efficiently, cleanly and at lower cost. We'll be able to trade electricity with our neighbours, and use it to support our local institutions and communities. Our homes will be more comfortable, our cars more environmentally-friendly, and our businesses more productive and efficient. The potential benefits from new technologies, for individuals and New Zealand as a whole, could be significant.

Consumers will have little sympathy for the electricity industry if it can't keep pace with their desire for change.

There is a risk of some poor outcomes if we do nothing

The Forum identifies that there are some undesirable outcomes that might arise if we, as a country, don't make changes to what we're doing.

1) **Consumers could make decisions that will not be in the best interests of New Zealand as a whole.**

   It is generally important that consumers see prices that reflect what it costs to provide them with the services they receive. If they don't, then they can't properly take those costs into account when making decisions about their behaviour or investments.

   A decision made by an individual consumer in order to reduce their own costs or pursue benefits can affect the costs and benefits for consumers more broadly. For example, an electric vehicle might lower a consumer's fuel costs; it could also lower public health costs because of reduced particulate emissions. Economists often refer to costs and benefits as being "private" or "public". Private costs and benefits should line up with the public costs and benefits, so that when people do things that make sense to them individually, it also makes sense from a wider perspective.

   The prices that New Zealand consumers currently pay for electricity distribution services don't reflect the cost of providing those services to them. Under current pricing structures, consumers see greater financial benefits from reducing their electricity use at certain times than they should, given the underlying costs that are actually avoided. Similarly, they see greater costs from increasing their electricity use at certain times than actually arise from that decision.

   Because network owners are subject to regulation, any costs associated with providing distribution services to an individual consumer that the consumer doesn't fully pay for will instead be recovered from other users of the network. The uptake of new technologies can create a feedback loop that keeps growing this issue, and can have socio-economic implications.

2) **We could leave a lot of value 'on the table'**

   For a number of reasons, we may miss a lot of opportunities to benefit from smart grid developments if we take a 'do-nothing' approach:

   - If consumers do not see prices that accurately reflect the value of the services they receive, they could be dis-incentivised to invest or change their behaviour in ways that might be beneficial for New Zealand. This particularly relates to electric vehicles; some existing distribution service pricing structures may make electric vehicles unnecessarily expensive to charge overnight, when using the network doesn't actually cost much. This could inhibit uptake, despite the positive impact that electric vehicles could have on our greenhouse gas emissions, which the Forum identified in its Emissions report.

- In some cases, we are not providing any clear signals about the value that certain assets and behaviour can provide to the power system. Parties that can be flexible, by increasing, decreasing or moving their generation or load over time play an important role in ensuring system stability and helping to minimise system costs. However, the current arrangements for valuing flexibility and deciding when and how to use it have been established over time, with the result that they are somewhat ad-hoc and under-developed. This means that we're unlikely to fully utilise what flexibility we have, use it in a way that is most valuable, or invest efficiently in additional flexibility and the smart grid infrastructure that might support it.
- To some extent, early smart grid development relies on certain parties to catalyse activity by others. Some state and local governments have been effective at catalysing smart grid development overseas, through their pursuit of smarter cities. While New Zealand agencies share the same smart city vision, we don't yet seem to have established strong relationships that will foster collaborative change.
- There is a lot of complexity associated with new technologies. Understanding the new options available and how they work, and determining how to best integrate them into our homes or businesses takes time, effort and resources. This kind of complexity can be a barrier to uptake, which may mean we don't pursue investments or make changes in our behaviour, even though we'd find them beneficial.

Consumers will benefit more if the issues are addressed early

There is a lot of value in promptly addressing the issues of prices that don't reflect the value of services, arrangements that don't signal when and how to best use flexibility, and complexity that presents an unnecessary barrier.

The longer the delay in addressing the issues, the greater the likelihood that:

- we'll make investments that have greater costs than we understand
- we'll miss the benefits from investments and changes in behaviour we ideally *should have* made
- there will be resistance to the eventual changes, based on the decisions we made in the interim

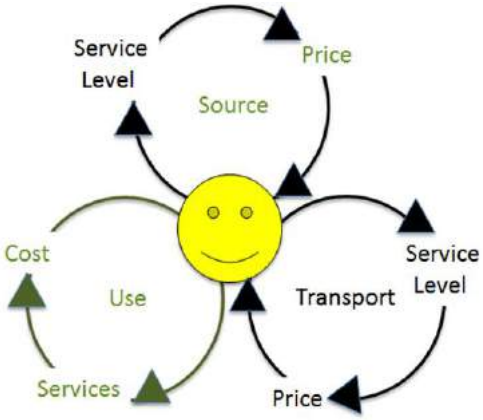
There is no single, perfect or enduring solution to the issues, and they will require a dynamic response. However, improving capability and declining costs of new technologies means that change is inevitable. Getting the incentives right now, provides the best opportunity to ensure we all make decisions that are in the long-term benefit of consumers, both individually and collectively.

3. ASSESSING PROGRESS BY RELAYING EXPERIENCES

Smart grid progress is about providing options[2]

Traditionally, consumers haven't had many options when it comes to the supply of electricity. Production and transportation of electricity has been centrally controlled, providing one standard of service for all consumers. Electricity has been transported at a regulated price, and while the competitive generation and retail markets have provided consumers with some ability to influence the price of sourcing electricity, the main way consumers have been able to influence their cost outcomes has been by varying their own use of electricity. This is illustrated in Figure 1.

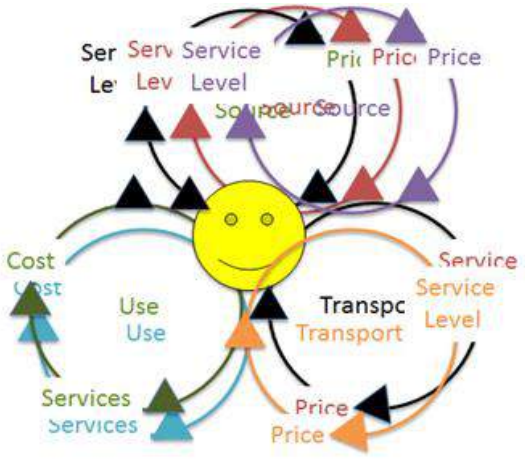
Figure 1: Consumers' traditional options for electricity



However, smart grids – i.e. electricity infrastructure bolstered by electronic controls, computing, and communication technologies - have the potential to change this dynamic, giving consumers a level of control and influence that they've never had before.

Smart grids can better integrate new sources of supply, such as solar PV and battery storage, which provide options around service level and price. Uptake of new technologies like these might affect how parties use the existing network for transporting electricity – including whether they use it at all – and the cost of doing so.

Figure 2: Options provided by the smart grids



Additionally, smart grids support new ways for consumers to use electricity, such as in electric vehicles, smart appliances, and by using home energy management systems[3]. These new technologies will in turn influence how electricity is sourced and transported. This is illustrated in Figure 2.

In essence, smart grids provide options.

2 'What the smart grid is really about'

3 'Home energy management system' is a commonly used term to describe systems that allow a consumer to automatically control their energy use. While this term suggests energy management is the primary objective of these systems, the Forum uses the term broadly to cover any smart control system that interacts with appliances that use or produce energy, in service of various consumer objectives (e.g. security, comfort, convenience etc.).

Consumers don't have to be the ones investing in new options in order for them to influence outcomes and see benefits. For example, consumers can benefit from:

1) **Investments made by governments in support of policy objectives:** Smart grids provide policy makers with new options to:
   - meet goals around greenhouse gas emissions, energy efficiency, and renewable energy
   - support economic growth and competitiveness
   - support energy security and self-sufficiency goals.

2) **Investments made by existing and prospective energy sector participants:** Smart grids provide new options for sector participants to:
   - meet increases in energy demand
   - serve and compete to supply electricity consumers
   - innovate to better meet consumers' changing needs and priorities, through new and improved services
   - drive efficiencies and automation into their operations
   - address reliability concerns, transmission and distribution constraints, or the need for supply in remote areas.

3) **Investments made by their peers and communities:** For example:
   - Communities may engage with new options provided by smart grids to support their local economy, or efforts to reduce greenhouse gas emissions. This activity may also provide social benefits to the members of those communities.
   - Investment in new technology by a few households could help to defer network upgrades, affecting a whole neighbourhood.
   - Investments made by a small number of consumers could place sufficient competitive pressure on electricity industry participants to affect outcomes for consumers more broadly.

4) **Investments they choose to make themselves:** The smart grid provides consumers with an improved ability to influence how they use and interact with electricity, to better reflect the benefits they derive from it – including 'lifestyle' benefits - and hence the value they place on it.

New options can influence energy security, equity and sustainability

The new options that smart grids provide have the potential to improve energy security, equity, and environmental sustainability. What is more, they allow more people to influence

these outcomes, because new options are open to governments, industry participants, communities, and individuals.

The World Energy Council captures these three measures– energy security, equity, and environmental sustainability – in its Energy Trilemma Index, which it uses as a way of assessing the overall quality of different countries' energy systems. It states:

> *"Balancing the three core dimensions of the energy trilemma is a strong basis for prosperity and competitiveness of individual countries. Secure energy is critical to fuelling economic growth and social development. Energy must be accessible and affordable at all levels of society, and the impact of energy production and energy use on the environment needs to be minimised in order to combat climate change and maintain good air and water quality."*[4]

Therefore, by providing new options that can improve energy security, equity and environmental sustainability, smart grid development has the potential to help New Zealand become more prosperous and competitive overall.

The Forum has drawn on experiences to assess "progress"

Drawing on people's and businesses' experiences with the new options provided by smart grids is the best way to understand how New Zealand's smart grid developments are progressing, in terms of providing benefits to consumers.

The Forum does not consider that using common metrics and statistics of technology uptake (such as the proportion of homes with PV or smart meters), or of the funding directed toward smart grid developments would be an effective approach. This is because:

- **The incentives to invest in new technology options can be drastically different between jurisdictions.**

  A given technology may currently be economic in one country, but not in another. For example, solar PV could be more economic in a country with a sunnier climate, simply because it has a higher yield. Where a technology is not yet economic for consumers, a lack of uptake would be an efficient outcome.

  Additionally, some countries have improved the economics of various technologies for investors by providing subsidies. Where a technology is supported by subsidies, uptake has generally been quite strong, and metrics would show this as good progress. However, subsidies distort the economics, and make it challenging to determine the actual extent of benefits arising.

[4] See the WEC's Energy Trilemma Report for 2015

It would therefore be difficult to make meaningful comparisons of smart grid development progress based on the uptake of new technology options for which parties in different countries experienced very different investment incentives.

- **Measuring inputs doesn't provide much information about the consumer benefits of a development.**

  As the Forum discussed in its first year report, virtually all consumers in Victoria, Australia have had a smart meter installed. Smart meters can lead to benefits for consumers in terms of reduced retailer cost-to-serve, more options over tariff structures, improved consumption data, and improved ability to integrate smarter in-home technology. However, the mandated roll-out of smart meters in Victoria was heavily criticised because it was poorly governed, came at significant cost to consumers before they could realise any benefits, placed technology risks on the consumers themselves, and did not engage or consult with consumers effectively.

  This contrasts with the market-led roll-out of smart meters in New Zealand. While New Zealand's smart meter rollout has been slower and has not yet reached the same level of penetration as Victoria, consumers have not seen any direct increase in their costs, and they have not borne the technology risks, which have instead been carried by competitive retailers and metering service providers. New Zealand consumers are also starting to benefit from new retail products and business models that are emerging off the back of smart metering.

  This highlights that measuring the uptake of new technologies, or the funding provided to smart grid developments would not necessarily translate into a consistent story about the benefits being realised by consumers. There is a need for richer context than metrics alone can provide.

- **Metrics would be unlikely to give a complete picture of the consumer benefits.**

  Some consumer benefits are abstract, cannot readily be quantified, and will differ from consumer to consumer.

  Consumers might invest in a home energy management system because they appreciate the comfort and convenience that these technologies can provide; they might purchase an electric vehicle because they personally place a high value on its lower emissions impact relative to a petrol or diesel vehicle; or they might invest in solar PV to save money, but see lower financial benefits than their neighbour who is home during the day, and hence better able to use the solar PV output.

  Therefore, the benefits that consumers ultimately receive from smart grid developments are better understood by relaying experiences.

The Forum considers that *availability* of new options from smart grids, and the *ability* to take them up if desired, is more informative of smart grid development progress than whether those options have actually been adopted. For example, if parties can choose to invest in a new technology when they want to – whether the benefits they see are real and tangible or not – without facing barriers, then this would suggest the smart grid was developing well.

The Forum has used a variety of sources to inform its work

The Forum has primarily drawn on three sources that the University of Otago's Centre for Sustainability prepared in support of its work. These are:

- a literature review of 'prosumer collectives' [5]
- case studies of New Zealand communities, mass market consumers, and businesses that have engaged with new options provided by smart grids.[6]
- a survey of New Zealand mass market consumers about smart home technology.[7] A similar survey has been run in the USA and, although those findings had not been published at the time of writing, results between the two jurisdictions will be directly comparable.

These sources have been supplemented by a number of other sources that have given the Forum more context and insight into some of the issues identified, including:

- reports from the GREEN Grid Project[8] into early adopters of solar PV[9] and electric vehicles in NZ[10]
- news articles, including various international news articles, Energy News articles,[11] and an Otago Daily Times article into a community development in Blueskin Bay in Otago[12]
- international reports into new technologies and smart grid developments, including a report on the uptake of electric vehicles produced for the UK Department for

5 Link to the Centre for Sustainability's report: Prosumer Collectives: A Review

6 Link to the Centre for Sustainability's report: Smart Grid Edge Technologies – Case Studies of Early Adopters

7 Link to the Centre for Sustainability's report: Smart Homes: What New Zealanders think, and want

8 Gathering Renewable Energy in Electricity Networks Project

9 Link to GREEN Grid Project report on early adopters of Solar PV

10 Link to GREEN Grid Project report on early adopters of electric vehicles

11 Energy News is a subscription news website based in New Zealand www.energynews.co.nz

12 'Blowing hot and cold', Otago Daily Times, 14 March 2016

Transport,[13] and a report on making the electricity system more flexible, produced by the Office of Gas and Electricity Markets in the UK[14].

The Forum is also grateful to have benefited from the wisdom of various international collaborators – particularly John Scott from the British Smart Grid Forum - who have shared their insights into smart grid developments with the Forum, and at a number of public lectures throughout the year.[15]

13 Link to UK report: Uptake of Ultra Low Emission Vehicles in the UK

14 Link to OFGEM report: Making the electricity system more flexible and delivering the benefits for consumers

15 Many of the presentations that the Forum has received over the past couple of years are available as video recordings on the Forum's 'Publications' webpage

4. THE INTERNATIONAL SMART GRID EXPERIENCE SO FAR

The potential of smart grids is still being understood

Smart grids are a relatively new concept, and no country would yet claim to have implemented 'a smart grid'.

This reflects that today's 'smart grid' is tomorrow's 'dumb grid', and the term itself represents an ongoing pursuit for a contemporary and more capable grid, rather than some pre-determined end-state.

It also reflects improving technology capability, declining technology costs, and an increasing focus on climate change mitigation issues, which mean that the benefits of smart grid development are becoming increasingly real.

Interest in smart grids has been ramping up internationally. Governments, utilities and consumers are funnelling billions of dollars into smart grid development opportunities and the new options they support, as well as research efforts to better understand the potential of smart grids.

Some of this investment is easily observed: smart meters are becoming near ubiquitous in mature economies, there are now over 1.5 million solar PV installations in Australia[16], and there are nearly 100,000 electric vehicles in Norway[17].

There is also less visible smart grid development activity going on: research, planning and preparation is aiming to understand and front-foot the broad impacts of future technology uptake, and ensure a smooth transition towards a more modern grid.

In outlining how smart grid development has been progressing overseas, in terms of providing options that consumers can benefit from, the Forum has summarised development as being either:

- top down – i.e. led by governments or the electricity industry
- bottom up – i.e. led by consumers and communities.

In some instances, uptake of new technologies by consumers is encouraging parties to offer new services and develop new business models, and affecting grid operation and security in a way that is prompting 'smart' action from utilities. Similarly, some investments made by industry are resulting in positive changes in consumer behaviour, which is reinforcing the investment decision, and encouraging further evolution of the grid These sorts of outcomes are effectively where top down and bottom up development is meeting in the middle.

16 Australian Energy Council, Solar Report, March 2016

17 Energy News Article

Smart grid development is occurring from the top-down

GOVERNMENTS ARE HELPING TO DRIVE SMART GRID DEVELOPMENT

Many national, state and local governments are helping to drive smart grid development activity. For example, some governments:

- **have mandated the roll-out of smart meters.** For example, the roll-out of smart meters was mandated in Victoria, Australia, as discussed earlier.
- **are providing funding for smart grid developments.** For example, the United States government directed $US 3.4 billion of stimulus funding toward grid modernisation investments as part of the American Recovery and Reinvestment Act 2009.[18]
- **are supporting various working groups and technical studies into smart grids** and how a more modern grid might operate. For example, much like the New Zealand Smart Grid Forum, a similar forum in the UK is being supported by the Office of Gas and Electricity Markets and Department of Energy and Climate Change.
- **have subsidised new technologies that smart grids support, like solar PV and electric vehicles**. For example, feed-in-tariffs have supported uptake of solar PV in a number of countries, including Germany, the UK and Australia. Germany's feed-in-tariffs for a range of renewable energy technologies have reached a cost of over €10 billion per year.[19] Electric vehicles are also subsidised in Japan, China, France, and most prominently, Norway.
- **are driving smart grid development so as to deliver their aspirations for a 'smart city',** which uses data, sensors and other smart technology to make cities more functional, resource-efficient, and generally more desirable to live in. For example, Barcelona has sought to transform itself into a model of modern urban systems, as part of its recovery from the 2008 recession. The city's authority has identified 12 areas for 'smart' intervention, including transportation, water and energy. The city installed 19,500 smart meters that monitor and optimize energy consumption in targeted areas of the city. It is also driving a move to have electric vehicles as its standard mode of public and private transport, providing 300 free, public electric vehicle chargers across the city, and establishing electric vehicle taxi and car sharing schemes.[20]

THE INDUSTRY IS 'SMARTENING' UP THEIR ACTIVITIES

Energy sector participants are also investing in smart grid development, and the new technologies they support, to the ultimate benefit of consumers. For example:

18 U.S smart grid investment grant program webpage
19 According to the Solar Energy Industries Association
2020 See Barcelona's Smart City webpage, and this Harvard University article

- utilities have invested in smart meters to reduce their cost-to-serve and improve their offering to consumers
- network owners have invested in advanced switches, sensors, and communication equipment in order to improve reliability, enhance system efficiency, and reduce operation and maintenance costs
- utilities are engaging with the new options that smart grids provide. For example Origin Energy in Australia sells solar PV systems, including as part of a $0 up-front electricity retail offering. Similarly, utilities are using smart meters to reduce the cost of serving consumers, and to provide more innovative products
- new participants and business models are emerging, leveraging the opportunities provided by new technologies and a smarter grid.

GOVERNMENTS AND INDUSTRY ARE WORKING TOGETHER

Governments, energy sector participants, and technology developers are working *in partnership* on various projects. For example:

Figure 3: Parties contributing to European Union-funded smart grid project *(Source: Grid4EU)*

- The European Union has contributed around half the cost toward a €54 million series of smart grid demonstration projects, undertaken by a consortium of European energy distributors, in partnership with 27 utilities, suppliers, manufacturers and research institutes (Figure 3). The projects aim to test the potential of smart grids, while promoting joint research and results-sharing between the parties involved.[21]
- The Australian government contributed $AUS 100 million to a ~$AUS 500 million project to develop a commercial-scale smart grid. The project was undertaken and further funded by AusGrid (distributor), EnergyAustralia (generator-retailer) and various consortium partners, as a way to gather information about the costs and benefits of smart grids, to inform future policy and business decisions.[22]

21 Grid4EU webpage
22 Smart Grid, Smart City webpage

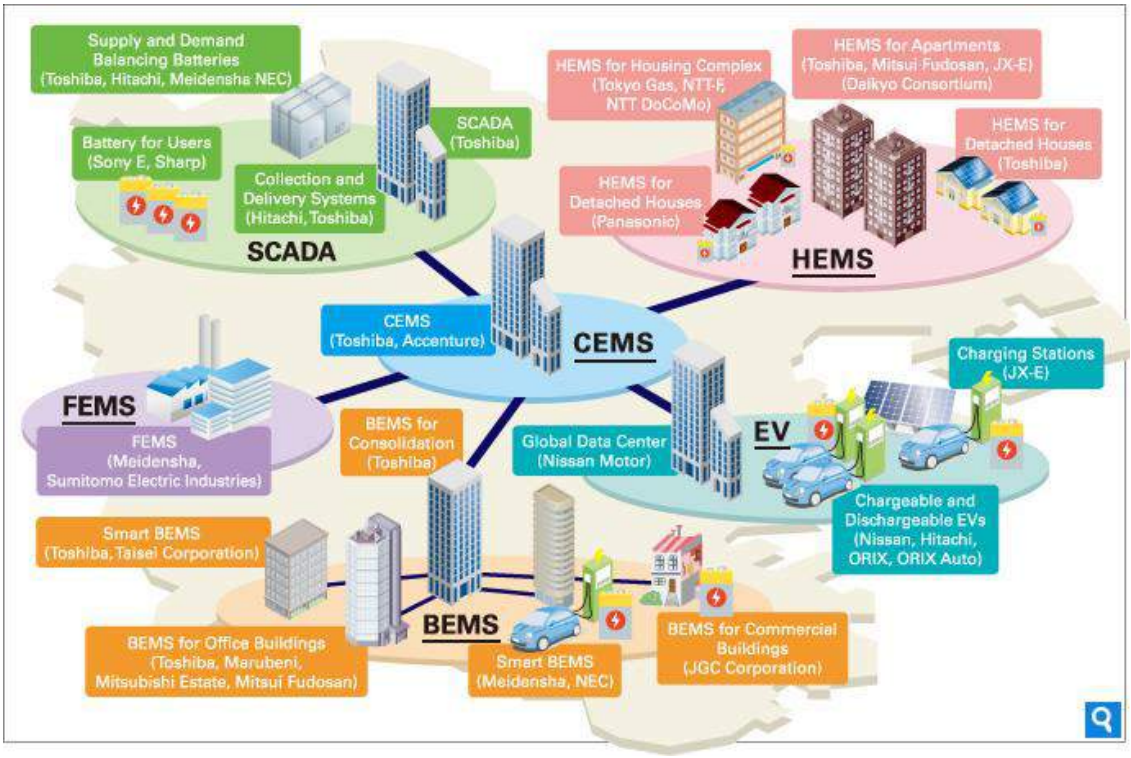
- Governments, property developers and technology companies are working together to develop smart cities. For example:
  - A consortium headed by Panasonic, have been working with Fujisawa City in Japan to develop Fujisawa Sustainable Smart Town. It is a 1,000 household development that evolved from a series of experiments for smart technologies, to now focus on using technology to enrich people's lives in terms of energy use, security, mobility, healthcare, and community. The development includes LED lighting, solar panels, batteries and fuel-cell cogeneration systems in each home, and electric bicycle and vehicle sharing services. The development is essentially an opportunity for Panasonic and its consortium partners to showcase and experiment with their own technology products.[23]
  - Yokohama City in Japan is collaborating with a number of private companies (e.g. the Tokyo Electric Power Company, Accenture, Toshiba, Nissan Motor, Panasonic, amongst others) to work on various projects such as introducing renewable energy, energy management systems for homes, buildings and local communities, and next generation transportation systems (Figure 4).[24]
  - The Singapore government is embarking on an ambitious urban development program to address issues arising from its aging population, and the stresses on its limited resources. It is encouraging technology companies and entrepreneurs from around the world to leverage Singapore's 'smart' infrastructure, and use the nation as a 'living lab' to test new ideas and solutions that might have international potential.[25]

[23] See Panasonic's Fujisawa SST webpage, and this media release

[24] Yokohama smart city project website

[25] See the Smart Nation Singapore website

Figure 4: Yokohama Smart City Project schematic
(Source: Yokohama Smart City Project website)



SMART GRID DEVELOPMENT IS SUPPORTING BUSINESS AND POLICY OBJECTIVES

Some industry participants have been incentivised to support smart grid development because of regulations – as in Victoria, Australia.

However, for the most part, industry participants are investing in smart grid developments because of traditional commercial drivers that motivate them to minimise costs, seek out new streams of revenue, and ensure they remain competitive. Some are also subject to regulation that incentivises resource efficiency (e.g. CPI-X regulation).

For these parties, investing in new technology options and smart grid developments is no different from investing in any energy-efficiency or research / development initiative. These parties could be expected to invest in new options and smart grid developments when and wherever they present an apparent financial opportunity, which will increasingly be the case as technologies develop and mature.

For governments, smart grids are contributing to a range of policy issues. Table 1**Error! Reference source not found.** indicates some of the factors driving smart grid development in various countries. Environmental goals – particularly in terms of supporting greenhouse gas emission reductions - are a notable driver for most.

Table 1: Drivers for smart grid development in selected countries[26]

Country	Government Policies/ Mandates	Environmental Goals	Electric Vehicle Integration	Renewable Integration	Reliability Concerns	Financial Incentives	Energy Efficiency Goals	Increasing Demand	Economic Competitiveness	Geographic Grid Constraints	Energy Security Goals	Energy Theft Reduction
Australia	●	●		●	●	●	●					
Canada		●					●	●		●	●	●
China		●		●		●	●	●	●	●		
Denmark	●	●	●	●								
Germany	●	●		●		●		●			●	
India					●		●	●	●	●		●
Japan		●	●	●		●						
South Korea		●		●		●	●					
Spain	●		●	●		●		●				
United Kingdom	●	●				●			●		●	

Source: Smart Grid Around the World, 2011, Science Applications International Corporation

Policy-driven smart grid developments and research initiatives may not be intended to provide immediate benefits to consumers. However:

- there are indirect benefits for consumers. For example, consumers will benefit from smart grid developments if they help to mitigate climate change.
- some consumers might benefit directly; for example, if they can profit from feed-in tariffs by installing their own renewable generation.

However, some policy initiatives have had unintended consequences that may mean they have not been in the long-term benefit of all consumers. Specifically, some of these developments have contributed to:

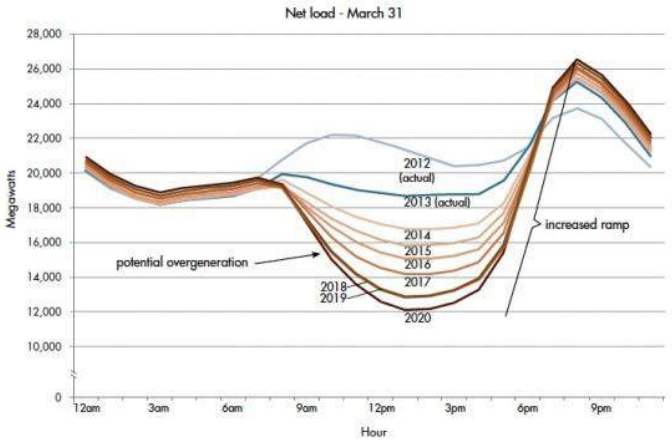
- **high costs to consumers.** For example, as discussed, the State of Victoria's mandatory smart meter roll-out had a number of negative outcomes for consumers, including higher than anticipated costs. Victoria's experience influenced other Australian states to choose a market-led approach to rolling-out smart meters.
- **network security issues.** Subsidy-driven uptake of solar PV in some jurisdictions has occurred at a pace that network operators and owners have been ill-prepared to respond to, creating impacts for the secure operation of networks. For example:
  - Australia and Hawaii have had to deal with over-voltage issues on local networks. Most low-voltage networks have not been designed to feed power back into higher voltage networks, or to accommodate huge swings in net load. High volumes of solar PV on these networks can hence result in voltage fluctuations. If voltages go beyond design limits then household appliances and equipment can be damaged, solar PV systems can trip in and out, and there are potential safety risks. The network owners have been unable to react fast enough to upgrade

26 Smart Grid Around the World

their networks and make them 'smart' enough to overcome the issues, which comes at a significant cost. Instead, they have had to limit the rate and extent to which consumers can connect solar PV to their networks, and how much excess power consumers can export to the grid. This has caused frustration and distrust in the network owner, and been challenging for local solar PV businesses.[27]

- California has identified risks arising from what has commonly become referred to as the 'duck curve', in which uptake of solar PV results in net load dropping significantly in the middle of the day and ramping up sharply as the sun goes down and everyone returns home. California's generation fleet consists of a lot of plant that takes a long time to ramp up its output, or that has to run for network security reasons. The network operator has identified that, if the pace of solar PV uptake continues without any other response, there may not be enough flexibility in the system to meet both the daytime trough and sharp evening ramp-rate. This could mean that the amount of electricity that can be injected from some renewable generation would be curtailed at certain times of the day. This would reduce the income of the people who owned that generation, which could undermine their investment decision as it may have been based on an assumption of greater financial benefits.[28]

Figure 5: The 'duck' curve – daily load profile



- **concerns about social inequality issues, and cross-subsidies between parties owning and not owning new technology.** For example:
  - Norway's electric vehicle subsidies led to the Tesla Model S (which normally retails at over $US 100k) becoming Norway's top-selling car for a time, prompting calls to end subsidies for wealthy buyers.[29]
  - Norway's exemptions for electric vehicles from road tolls has meant that owners of non-electric vehicles may have to be charged more to cover the lost revenue.[30]

27 Scientific American article on Hawaii, and The Australian article on Australia
28 As discussed in a National Renewable Energy Laboratory report
29 Wall Street Journal article about Norway's electric vehicle subsidies
30 ibid

  - A reduced contribution from solar PV owners to the fixed costs of networks has been an issue discussed in countries including Australia and the United States. Utilities are driven to increase their tariffs in order to recover the lost revenue, disproportionately affecting consumers that don't have solar PV, who are more likely to be lower-income.

- **spiralling costs that can be challenging to control**. Norway had a projected tax shortfall of 2 billion krone (~$NZ 350 million) in 2015 because of electric vehicle subsides, which saw them meet uptake targets earlier than expected.[31] Similarly, the UK's renewable subsidy scheme was designed based on a set allocation of funding, which was expected to last until 2020, but was instead fully utilised in 2015. To avoid big impacts for electricity bill payers (from whom the subsidies are recovered), the government proposed changes to the scheme, but had to scale these back following criticisms from environmentalists, businesses facing job losses, and parties that had invested in renewable technologies assuming subsidies would continue.[32]

Bottom-up smart grid development is also occurring at pace

CONSUMERS ARE DRIVING A LOT OF SMART GRID DEVELOPMENT ACTIVITY.

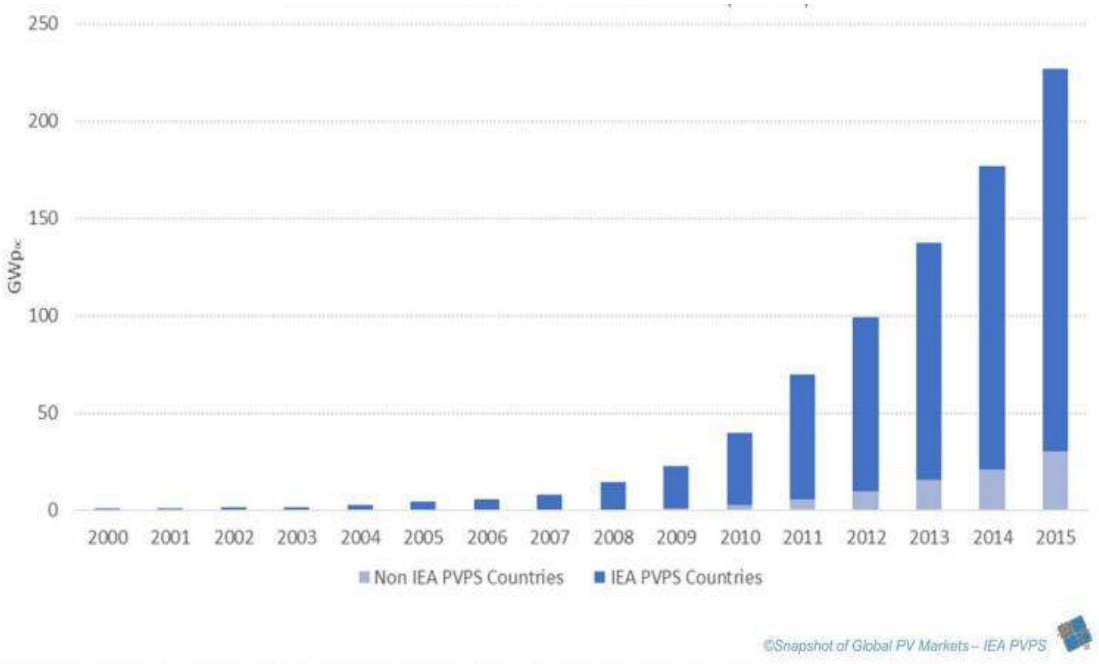
Consumers are engaging with new options provided by smart grids, for their own direct benefit.

As the costs have fallen, consumers have increasingly invested in new technologies that smart grids support - like solar PV and electric vehicles. A lot of this investment is primarily driven by financial benefits – being strongest where there are subsidies - or the perception of financial benefits. The global uptake of solar PV demonstrates how powerful financial benefits can be in mobilising technology uptake by consumers: uptake has grown exponentially, consistently exceeding industry forecasts.

31 Automotive News Europe article

32 The Guardian article and Department of Energy and Climate Change press release

Figure 6: Global uptake of Solar PV since 2000 in GW[33]



Source: International Energy Agency, Photovoltaic Power Systems Programme, 2015 Snapshot

Any financial benefits from new technologies are also supplemented by unpriced benefits like energy-independence, environmental concerns, or personal interest in the technology. For some, these unpriced benefits are a sufficient motivator to adopt a technology. Because consumers aren't limited to investing based on financial benefits, the potential for them to drive uptake can be unpredictable.

Technology uptake by consumers drives smart grid development because it can necessitate a 'smart' response from utilities. For example, the high uptake of solar PV in Hawaii has required Hawaii Electric Power Co to upgrade its network so that the midday solar output can flow from low-voltage parts of the network into higher-voltage parts. It has also prompted it to investigate energy storage options, and the potential of smart inverters, which would receive information from grid operators and regulate the amount of solar power flowing into the grid.[34]

The University of Otago's Centre for Sustainability identifies that technology uptake has not necessarily occurred uniformly, and can be adopted in clusters – potentially placing pressure on the existing grid in concentrated areas. It has reviewed a large number of international examples of 'prosumer collectives' (a 'prosumer' being a producer-consumer) to understand what drives this clustered activity. It summarised its findings in its report; "Prosumer collectives: a review" ("Prosumer Report").

33 Link to IEA-PVPS report

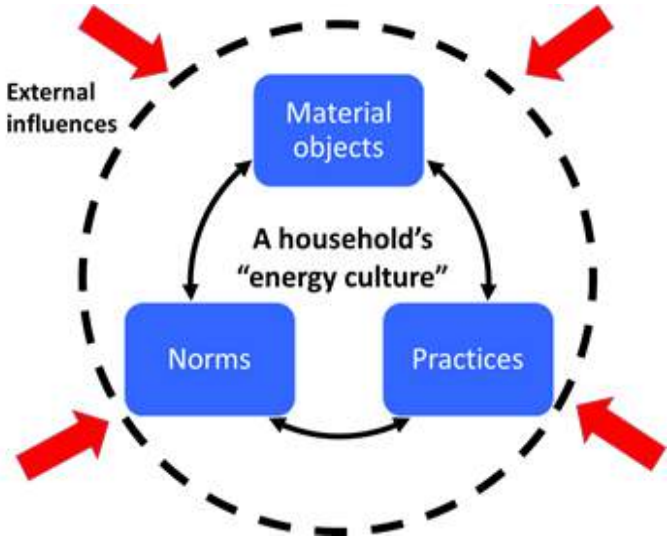
34 Wall Street Journal: "Hawaii Wrestles With Vagaries of Solar Power", 28 June 2015

The Prosumer report cites the 'energy cultures framework'[35], which explains how a consumer's single decision to invest in new technology ("material objects") can catalyse a wider change in their behaviour ("practices") and attitude towards energy ("norms"):

"…they may start to shift their timing of activities in line with their energy generation, they may install additional smart grid edge technologies (e.g. storage or energy management systems), or they may be inspired to get involved with other prosumers (or aspiring prosumers) on collective energy projects."

Figure 7: University of Otago Centre for Sustainability's Energy Cultures Framework

(Source: Centre for Sustainability's Prosumer Report)



By way of this framework, a single person can initiate technology adoption and a change in the energy culture of their friends and neighbours. For example, a consumer may be inspired to invest in new technology from seeing that their neighbour has solar PV on their roof, or from talking about it with them. The Prosumer report discusses how this can lead to clusters of uptake within a close geographic region, which in turn can potentially lead to community-based activity, such as development of community-owned generation.

It's possible to envision how, over time, this sort of 'collective prosumerism' might necessitate a response from the network owner in order to manage the change in load at a particular feeder; how clusters of prosumers might eventually spread and capture local institutions (e.g. local governments, schools, libraries etc.) and businesses; and how these clusters might merge into smart cities, and eventually, a smart grid.

From its research, the Centre for Sustainability identified four different models of collective prosumerism that have emerged overseas. The four models differ based on how they have been initiated, and their ownership structures. Specifically, it identified developments as being:

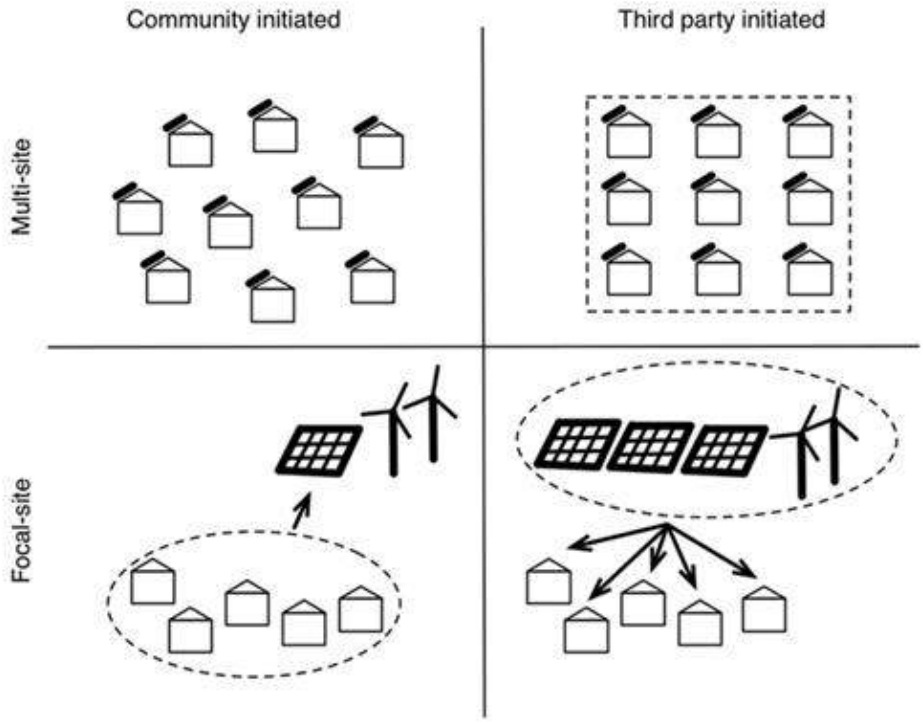
- initiated by communities, with electricity being produced at multiple sites
- initiated by communities, with electricity being produced at a single site

[35] Link to Journal Article: Energy Cultures - A Framework for Understanding Energy Behaviours

- initiated by a third party (e.g. a property developer), with electricity being produced at multiple sites
- initiated by a third party, with electricity being produced at a single site, to the direct benefit of a select group of consumers.

Figure 8: Two-by-two prosumer collectives taxonomy

(Source: University of Otago Centre for Sustainability)



The Centre for Sustainability also identified a fifth, slightly different model, involving business models like peer-to-peer trading of electricity. These have emerged in some countries as platforms to support collective prosumerism.

Peer-to-peer trading is similar in concept to 'Airbnb'. While it ostensibly allows for trading of electricity between prosumers and consumers, the examples that have emerged overseas are financial trading arrangements only – they do not extend to physical trading.

5. CONTEXT FOR SMART GRID DEVELOPMENT IN NEW ZEALAND

New Zealand has so far relied on organic smart grid development

To date, smart grid development in New Zealand has largely relied on the raw merits of the various development options and new technologies available.

Electric vehicles will enjoy an exemption from Road User Charges until they comprise two per cent of the light vehicle fleet. However, with this exception, there are no subsidies available for smart grids, or the new technology options that they support. Any person or business that has so far invested in smart grid developments or the new options they support has largely been left to identify and act in response to their own drivers.

This approach reflects two things:

1) **A preference for market-led solutions.**

   The New Zealand government generally supports an open economy based on free market principles[36]. The Electricity Authority also prefers market-led development, where it is efficient, and looks to facilitate this by:

   - reducing barriers to entry, exit and expansion
   - facilitating consumer participation
   - providing efficient price signals
   - promoting a flexible and resilient market.[37]

   This preference for market-led solutions has generally worked well for New Zealand in terms of smart grid development to date. The rollout of smart meters is a specific example where consumers have been able to experience the benefits of smart grid development, with few negative outcomes.

   As the Forum concluded in its first-year report, the fast pace of technology change means that it is appropriate to use market forces to drive smart grid development. It stated;

   > *"The nature of these technologies means they require a 'trial and error' approach and there is a risk that a particular approach could be a technological dead-end. A market-led approach places the technology risk with participants… Given uncertainty and rapid change, where practicable*

36 As it states on its 'New Zealand Now' website

37 Electricity Authority, Strategic Directions for Market Development

there are advantages in relying on market forces to allocate risk and enable on-going incentives for providers to provide value to customers."[38]

The Forum considers that the continued fall of technology costs, and improvements in technology capability over the last year, has confirmed the wisdom of this approach.

Furthermore, as long as consumers and participants face appropriate incentives, a market-led approach is most likely to reach an efficient balance between the costs of investing in smart grid developments, and the benefits that are received from those developments. Some of the overseas examples of subsidised technology uptake appear to have resulted in a somewhat smarter grid, but at a very high cost.

2) <u>It is not clear whether we need to support smart grids, and if so, how best to do it</u>

Smart grid development will help us improve our energy equity, security and environmental sustainability (discussed in section 3).

However, New Zealand hasn't yet identified an urgent problem that new technologies or smart grid developments present a clear answer to. Rather, smart grids are currently seen to provide opportunities to do some things better and more efficiently, and to seek additional benefits over time.

Furthermore, some features of New Zealand's electricity sector make it different to other countries. In its Emissions report, the Forum discusses how New Zealand's mostly-renewable electricity supply means that smart grids present a different opportunity to reduce greenhouse gas emissions than in countries with a mostly-fossil-fuelled electricity supply.[39] Other features of our electricity industry that may influence how we can best benefit from smart grid developments might include:

- the overall size of the industry here, including our relatively small and sparse population, and the small size of electricity consumers and industry participants compared to many other countries
- our long-stringy network, and large number of network owners with different approaches to pricing for distribution services
- the fact that we already have some ability to control peak loads (using ripple control systems)
- the fact we have a fully competitive retail market model, and deregulated approach to metering.

38 Link to the Forum's first year report

39 Link to the Forum's Emissions report

Ultimately, New Zealand is still at the point of working out whether there is benefit in supporting any specific technology options or smart grid developments, and if so, how best to do it. The Forum believes that this period of assessment and consideration is important and should continue. The Forum notes that, to date, its findings have supported a market-led approach, though it made some recommendations about how to support the market's progress in its first year report to the Minister.

6. SMART GRID DEVELOPMENT ACTIVITY IN NEW ZEALAND

New Zealand's organic approach to smart grid development is resulting in broadly similar activity as is happening overseas – albeit at a lower scale, given the different investment incentives that exist.

Generally, the Forum has not identified any sorts of activity going on overseas that there aren't examples of in New Zealand, including:

- bottom up development – with consumers and communities engaging with various new options opened up by smart girds
- top down development – with local governments and industry participants supporting, planning around, and investing in smart grid developments.

Consumers are driving activity from the bottom-up

CONSUMERS ARE TAKING UP NEW OPTIONS WHERE THERE ARE APPARENT FINANCIAL BENEFITS

Smart grids provide new options that can present consumers with opportunities for financial benefits, and New Zealand consumers appear to be looking to capture these benefits where they exist. For example:

- Record numbers of residential electricity consumers switched their retailer in 2015 in pursuit of cost savings and innovative services.[40] At the end of 2015, 120,000 residential consumers were on a retail plan that offered different prices at different times of day – made possible by smart meters. This was an increase of over 10,000 from 2014. Switching activity and greater retail efficiency and innovation helped to see the average cost of residential electricity reduce in the year to March 2016, for the first time in 15 years.[41]
- The Centre for Sustainability's two case studies of businesses highlight that adopting new technology is part of 'business-as-usual' activity for these parties. Specifically:
  - Countdown stated that it has been pursing various energy efficiency initiatives for several years. It said that the main driver for these initiatives is financial, and that an initiative has to provide a net positive financial benefit for the company if it is to proceed – either by reducing energy costs, or by improving revenue by providing a better retail experience for customers.

    To date, the initiatives that have gone ahead have been focussed on energy efficiency, rather than 'smart' technologies per se - specific developments

40 See the Electricity Authority's Residential Electricity Market Performance 2015 report

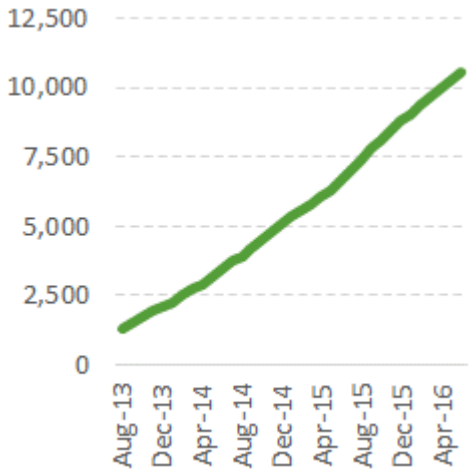
41 Energy News, 'Household power prices fall – MBIE', 17 June 2016

include LED lighting and lids on freezers. However, Countdown has automated store lighting, and it is exploring opportunities for solar PV, electric vehicle charging, dynamic load management of its refrigeration systems, and battery storage to provide back-up supply and reduce peak load.

- EnerNOC is an aggregator of electricity loads, which it manages as responsive demand, in order to make money in various ways from the electricity market. It is currently investigating how to overcome various challenges so it can grow its range of offers. In particular, it would like to offer its responsive demand into the wholesale energy market. It says that its customers are typically large industrial consumers that are motivated to participate by the financial benefits available, which can be greater if their demand is aggregated with others, than if they tried to go it alone.

- Solar PV uptake has been increasing in NZ, and is driven partly by financial benefits. The falling cost of the technology means that it is likely economic for a small number of consumers, borderline economic for others, and that some also perceive it to be economic even though it actually might not be. The GREEN Grid Project's 2014 report on solar PV uptake in New Zealand noted that a reduced power bill was the most important driver of uptake.[42] However, the financial benefits are still somewhat murky here, so unpriced benefits are probably still important drivers.

Figure 9: NZ solar installations



- New electric vehicles are generally not yet economic in New Zealand. However, new but second-hand Nissan Leafs are being imported into New Zealand and make up a significant share of our electric vehicle registrations. The Energy Efficiency and Conservation Authority's cost of ownership tool[43] suggests these vehicles may be cost competitive with a similar-specification Toyota Corolla over the lifetime of the vehicles[44]. Furthermore, some electric vehicle owners place a high value on the reduced operating costs of electric vehicles[45], even though the higher upfront costs may make them more expensive overall than a petrol or diesel vehicle.

- While uptake of home energy management systems is very low in New Zealand, the smart-homes survey run by the Centre for Sustainability highlights that financial

42 Link to the GREEN Grid Project's PV report
43 EECA's Vehicle total cost of ownership tool
44 "Stop Press! A Leaf is cheaper than a Corolla" – Energy News, 1 December 2015
45 Link to the GREEN Grid Project's EV report

benefits, and opportunities to save energy are key perceived benefits of smart homes.

Larger industrial and commercial electricity consumers are likely to be among the first to identify the potential for financial benefits from the new options provided by smart grids. This is because they have the scale and technical expertise to investigate the opportunities in depth, and because the financial benefits are most substantial for them, given the contribution that electricity use makes to their overall costs.

Uptake of the new technology options that smart grids support is building in New Zealand. For example, despite a lack of subsidies, solar PV had been installed by over 0.5% of grid connections by mid-2016[46]. However, this is low when contrasted with other countries that have increased the financial benefits by providing subsidies. Uptake is over 20% in some states in Australia[47] where up-front subsidies and feed-in-tariffs have been provided.

Similarly, there were over 1,500 electric vehicles in New Zealand in mid-2016. However, this compares to nearly 100,000 in Norway, which has a similar population but has provided generous subsidies and other incentives.

CONSUMERS ARE EXPLOITING NEW OPTIONS BECAUSE OF UNPRICED BENEFITS

As discussed, consumers identify unpriced benefits from the new options that smart grids provide, and consumers in New Zealand are pursuing these unpriced benefits. For example, in addition to any financial benefits, unpriced benefits are helping to drive uptake of:

- **solar PV and storage.** The GREEN Grid's 2014 report on solar PV uptake in New Zealand identified that, in addition to seeking to reduce their power bills, early adopters of the technology were driven by:
  - a strong desire to be independent and self-sufficient
  - lack of trust in power companies
  - a desire for greater financial control
  - environmental concerns
  - a desire for resilience in the face of power cuts
  - a drive toward a more energy efficient home.

  New Zealanders tend to view solar PV very positively, and as costs fall, consumers' desire to take back control over their energy outcomes has the potential to drive a significant groundswell of solar PV adoption – alone, or in combination with battery storage.

[46] Data sourced from the Electricity Authority's EMI web portal

[47] According to the Australian Energy Council's March 2016 Solar Report

- **electric vehicles.** There were over 1,500 electric vehicles in New Zealand in mid-2016, owned by both fleet owners and individuals. Unpriced benefits are supporting uptake of electric vehicles here, and include:
  - a desire to showcase or support the technology. For example, Mighty River Power is converting its vehicle fleet to electric in hopes of encouraging wider uptake.[48]
  - reduced greenhouse gas and particulate emissions. For example, Air New Zealand is electrifying its vehicle fleet where possible to cut its carbon emissions, as it wants to take "a leadership position in carbon management".[49]
  - the performance of electric vehicles. A GREEN Grid Project report into early adopters of electric vehicles in New Zealand[50] noted this as a driver particular to parties with high net-worth.
  - the novelty of new technologies. The GREEN Grid Project report also identified the desire to be an early adopter as a driver for some parties.
- **Smart home technology.** Smart home systems are an emerging technology, and the Centre for Sustainability's Smart Homes Survey highlights that we have a low awareness of these technologies. Unpublished results from a similar survey in the US suggest that only 35 per cent of NZ consumers are reasonably familiar with the concept of a 'smart home', compared to 75 per cent of our US counterparts. We are also much less familiar with various smart home products, including smart thermostats and appliances.

  This – at least in part - reflects differences in the availability of products: the Google Nest Thermostat is a home energy management product developed in 2010 that is proving popular in North America and the UK, but is not yet supported in other countries including New Zealand. It also reflects that New Zealanders have a different mindset about home heating (and cooling); while consumers in some other countries tend to rely on continuous heating, New Zealanders tend to heat their homes on an as-needed basis, and would hence see quite different value in products like smart thermostats.

  There are a couple of providers of smart home products in New Zealand, and smart appliances, wi-fi capable electric plugs, and smart lighting options are available in stores. However, these are generally expensive; and complicated and time-consuming to purchase, install and use. As a result, smart homes in New Zealand are mostly in the realm of hobbyists and innovators at the moment. For example:

48 Energy News Article, 'MRP swapping to EV fleet', 07 November 2014
49 Energy News Article, 'Air NZ switches ground fleet to electric, 17 March 2016
50 Link to the GREEN Grid Project's EV report

- The Centre for Sustainability's first household case study notes that the subject had a strong technical background, and for 'fun' explored and played around with the opportunities that their household appliances, solar PV system, and hot water system presented for automation and demand management. This included writing their own computer code.
- The subject of the second household case study also had a technical background, and was driven by the desire to generate a proof-of-concept for residential demand response, which was relevant to their job.

However, the Smart Homes Survey highlights an underlying interest in smart homes amongst New Zealand consumers (around 60 per cent of respondents were somewhat or very interested). In addition to financial benefits, the Smart Homes Survey identifies that New Zealanders perceive comfort and security as advantages of advanced energy monitoring and control abilities, which might drive future uptake of smart home technologies.

COMMUNITIES ARE ENGAGING WITH NEW OPTIONS FROM SMART GRIDS

There is some of the same 'clustered' uptake of new technology options in New Zealand that has been identified overseas. With reference to the Centre for Sustainability's prosumer collectives two-by-two taxonomy, New Zealand ticks off examples of each. Specifically:

- **Blueskin Bay (north of Dunedin) and Otaki (north of Wellington) are both examples of community initiated developments across multiple sites.** As discussed in the Centre for Sustainability's community case studies:
  - Blueskin Bay is a community of around 1,000 homes, with 28 distributed generation connections. While representing only 6% of the OtagoNet network, it comprises 40% of the network's distributed generation connections and installed capacity.
  - Otaki has engaged with 'clean' technology in a broader sense than just that relating to smart grid development. However, it has installed solar PV on the town's Clean Tech Centre and local high school, and is investigating further opportunities for solar PV and wind generation.
- **Blueskin Bay is also an example of a community initiated focal site development**. Its recent application for resource consent for a three-turbine wind farm sited near the community was rejected by the Dunedin City Council. However, the community has said it will continue to explore related initiatives that will contribute towards their energy resilience.[51]

[51] Energy News article, 13 July 2016, "Blueskin rejected; trust considers options"

- **The St Kilda property development in Cambridge is an example of a third-party initiated project covering multiple sites**. It is a 130-section residential development – the majority of sections having been sold - where all homes are required to have a minimum 3 kW solar PV system, and houses that meet certain energy-efficient design specifications. It will also include some services and a cafe.[52]
- **There are multiple examples of third parties investing in small-scale renewable electricity generation in New Zealand**, and this prosumer model is only a slight extension of that general activity, in the sense that the output of the development benefits a select community. A specific example of this in New Zealand might be Pioneer Generation, which is a generator-retailer that has developed a number of distributed wind and hydro projects in the South Island, and is owned by the Central Lakes Trust, with profits being directed to the trust for use in the community.

The third-party developments are based on a commercial proposition, so are primarily driven by opportunities for financial benefits, and will succeed or fail on that basis.

However, the community-initiated developments have a more diverse range of drivers, and have been experiencing some challenges to date. Specifically:

- **The drivers for community developments are not homogenous**

  Blueskin Bay first started to engage with new options supported by smart grids after they lost power for several days because of flooding in 2006. This sparked the community's interest in climate change issues, and energy resilience and security, which lead to its interest in developing small scale renewable generation.

  There is general agreement across the community about the importance of renewable energy and sustainability, with community support for edible gardening projects, home insulation, solar PV and electric vehicles. However, it became divided over its potential wind project, because the proposed development:

  - wouldn't help to offset residents' power bills as some had anticipated. Rather, a retailer would purchase the output, with proceeds going to the Blueskin Resilient Communities Trust for use in the community and for dividends to investors in the wind project
  - wouldn't provide the community with any resilience benefits since they would still be connected to the grid
  - has been based on ecological impact assessments and wind assessments that some consider were not done as thoroughly as they should have been
  - has largely become a symbol of the community's commitment to sustainability

[52] Link to the St Kilda website

  - is on a 'class II' wind site, and the South Island is largely renewable already. Some residents consider that it would be more responsible from a sustainability perspective, and more profitable for the Trust, to support a project that would have a greater electrical output, and greater impact on emissions.

  This highlights that the wind project has a mix of drivers. There is a clear interest in some form of financial benefit, as well as drivers that are very similar to the unpriced benefits for solar PV uptake discussed earlier. However, for some members of the community, the reality of the project is such that it does not satisfy any of their drivers particularly well.

- **They have limited resources and experience to support developments**

  Both Blueskin Bay and Otaki community developments rely largely on the enthusiasm and goodwill of volunteers. These volunteers are not necessarily experienced with the processes and associated issues involved with investing in energy projects – including technical, legal and consenting processes. Working through these can take considerable time, money and energy, and there is a limit to how much volunteers can reasonably commit to a project.

  Blueskin Bay has benefited from the advice and experience of a few experts and professionals that have lent their support, and their progress to date reflects this.

- **Accessing funding can be a challenge**

  The community developments have to compete with other initiatives for grant money to support their projects. Blueskin Bay has had some success with this. Otaki has had some set-backs, and its progress and approach to its initiatives has been affected as a result.

Smart grid development is being driven from the top-down

INDUSTRY PARTICIPANTS HAVE BEEN PLANNING AND PREPARING FOR CHANGE

Industry participants have recognised the significant potential for disruption that new technologies present. They are engaged in considering and planning for what smart grids could mean for their businesses – both in terms of risks and opportunities. For example:

- **Transpower has produced an update to its 'Transmission Tomorrow' publication**. It is primarily an internal strategic planning exercise, which analyses scenarios of new technology uptake, behavioural change, and underlying factors such as population and economic growth. Based on plausible extremes, it identifies the stresses that might be placed on the system, and a 'least regrets' trajectory as a base case for how it will develop and operate the national grid.

- **Genesis Energy undertook an eighteen month 'tomorrow street' trial,** in order to understand how consumers would engage with new technologies and tariffs to inform future business decisions. The trials by Genesis provided fifteen households with a mix of time-of-use pricing plans, Wi-Fi enabled home energy management systems, solar PV panels, solar hot water systems, heat pump hot water cylinders and smartphone apps to manage home energy use.[53]
- **Meridian Energy has carried out a public survey into electric vehicles**, to help it shape any future electric vehicle offering to its customers.[54] It also commissioned a study by Professor Goran Strbac of Imperial College London, into the implications and opportunities of smart grids and the new technologies they support, from the perspective of the New Zealand electricity system.[55]
- **The Electricity Networks Association, with support from the Forum, commissioned the development of the Transform Model.** The model helps network owners to understand the potential implications of new technologies for their networks, and how they can best upgrade and develop the network through both smart and 'conventional' investments.[56]
- **Network owners are undertaking their own individual modelling** to understand the impacts of new technologies for their businesses, and to help them plan future network investment. For example, Orion has modelled impact scenarios from uptake of solar PV, batteries and electric vehicles, for their low and medium voltage networks. It has used its modelling to identify the risks and opportunities for its business from these technologies.[57]

INDUSTRY PARTICIPANTS ARE ENGAGING WITH NEW OPTIONS

In addition, electricity industry participants have already been engaging with smart grids and the new options they support. These parties already see the potential for private benefits from these new options, or want to pre-empt or pro-actively manage the likely impacts for their businesses. For example:

- **Electricity retailers and network owners have been rolling out smart meters** through-out the country, in order to lower their cost-to-serve and allow for

53 Smart Grid Forum, "A catalogue of smart grid standards, publications, trials, case studies and activities in New Zealand"
54 Energy news Article, 19 February 2016, "Meridian tests public's view of EVs"
55 Smart New Zealand Energy Futures: A Feasibility Study
56 Presentation from electricity distributors on the impact of new technologies and business models on lines businesses
57 Presentation from electricity distributors on the impact of new technologies and business models on lines businesses

innovation in the services they provide to consumers. Seventy-one per cent of residential consumers had a smart meter by December 2015.[58]

- **Some network owners are supporting the uptake of solar PV** on their networks. For example, Vector have been leasing solar pV systems to customers. An earlier offer also included battery storage, which it programmed to discharge over the evening demand peak. It is partnering with Tesla to offer Powerwall batteries to consumers in the near future. Vector's interest is in avoiding investment in lines for its growing network, and in exploiting growth opportunities to improve its financial performance, given the potential disruption that new technologies present to its traditional business.[59]
- **Various network owners, such as Unison, 'smartening up' their networks.** Between 2011 and 2015 example, Unison installed 1,200 smart network assets, allowing it to set line ratings dynamically, optimise its asset replacement and maintenance, and isolate faults and restore power remotely. This is resulting in better outcomes in terms of outages, and is forecast to reduce capital expenditure.[60] Network owners are also engaged in 'business-as-usual' network upgrades and maintenance that includes adding 'smarter' functions to devices, equipment, and software applications.
- **Various network owners, such as Scanpower and Powerco, are using solar PV as part of off-grid systems in rural parts of their networks**, as a more economic alternative to supplying remote areas through conventional grid investment. Scanpower sees this as an opportunity to front-foot the risk of grid defection by being an 'energy solutions' provider.[61,62]
- **Mighty River Power bought What Power Crisis**– a solar PV supplier - in January 2016. Its aim was to add solar expertise into its business and give it opportunities to position solar PV within its retail brand, given consumers' growing interest in the technology.[63]
- **A number of industry participants are helping to install fast and standard electric vehicle chargers throughout the country,** working in partnership with other groups, including local and district councils, the Electricity Networks Association, Drive Electric, and ChargeNet. For example:

58 Electricity Authority: Residential Electricity Market Performance 2015
59 Vector website and 2014 news article
60 Presentation from electricity distributors on the impact of new technologies and business models on lines businesses
61 Energy News Article, 11 September 2015, "Scanpower to install solar-diesel micro-grids next year"
62 Presentation from electricity distributors on the impact of new technologies and business models on lines businesses
63 Energy News Article, 19 January 2016, "Mighty River to buy What Power Crisis"

- Northpower has worked with ChargeNet to install a number of fast chargers around its network[64], and it has installed chargers itself that it makes free for public use.[65]
- Unison has partnered with four councils to roll our fast chargers around Hawkes' Bay and the central North Island 2016.[66]

NEW BUSINESSES AND BUSINESS MODELS ARE EMERGING

New Zealanders are known for their entrepreneurial spirit, and have been busy identifying and creating opportunities from the new options provided by smart grids. A number of new businesses are emerging that are providing employment and export opportunities. Specifically:

- **New entrant electricity retailers have been capitalising on new opportunities presented by smart meters**. For example:
  - Electric Kiwi has a retail offer where consumers have one hour each day during which their electricity use is free.[67]
  - Flick Electric offers retail tariffs based on spot prices. It started in 2014, and now has over 10,000 customers. It's retail offer can encourage uptake of other smart grid technologies, such as electric cars and smart appliances, because of the strong time-of-use signal. It has also developed an app that provides information about the fuel-mix of electricity being generated in a half-hour, to encourage consumers to reduce their carbon footprint by using electricity at times when there are fewer generators operating that create emissions.
- **Businesses are providing innovative solar PV offers**. For example:
  - SolarCity offers a $0 up-front arrangement, where a consumer can buy output of a solar PV system without paying the upfront costs.[68] Similarly, Vector offers solar systems with costs spread over time, rather than requiring payment in full up-front[69]. These sorts of offers are similar to offers that are available overseas.
  - What Power Crisis offers a device that helps consumers use more of their solar generation, by effectively using their hot water cylinder as a battery.[70]
- **Businesses are exploring different electric vehicle charging opportunities**. For example:

64 Energy News Article, 30 October 2015, "ChargeNet adds to Northland fast charger network"
65 Energy News Article, 05 December 2013, "Northpower to install free EV charging station next year"
66 Energy News Article, 2 June 2016, "Unison, councils to roll out fast chargers"
67 Electric Kiwi 'Hour of Power' webpage
68 SolarCity's SolarZero payment option
69 Vector Solar webpage
70 What Power Crisis' solar power diverter webpage

  - JuicePoint supplies and installs a range of different electric vehicle charging units and associated controls, for both public and private purposes[71]
  - ChargeNet is developing a network of chargers through-out the country. Electric vehicle owners can sign up to ChargeNet, which gives them access to the chargers, with their consumption tracked and billed monthly.[72]
  - Spark is piloting electric vehicle chargers in its phone boxes.[73]
  - Various other businesses are installing fast and slow chargers – for example, in shopping centre car parks and petrol station forecourts - or exploring how electric vehicle charging can complement their existing businesses.

- **Vehicle sharing schemes are emerging in parts of the country**. A vehicle sharing scheme using plug-in electric vehicles has started operating in Wellington[74]. In 2015, Auckland Transport sought proposals from parties that could establish an electric vehicle sharing scheme in Auckland.[75]
- **A 'peer-to-peer' solar trading platform has started**. P2 Power ostensibly gives consumers an opportunity to purchase the excess generation from solar PV owners. As with peer-to-peer platforms overseas, this is just a financial trading arrangement that operates around the traditional market – it doesn't avoid the need to trade electricity through the wholesale market, or to transport it through the grid. Nor does it avoid the underlying cost or complexity associated with doing so - it simply masks that complexity for its customers.

  There may be potential for peer-to-peer trading to extend into more physical trading of electricity. However, the approach to network pricing and wholesale market access may need to evolve before that can occur. This would be necessary for consumers to continue to benefit from system balancing and reserve requirements, and contribute to the sunk costs of transmission and distribution networks.

New Zealanders are also benefiting from new business models developed overseas. For example, the Plugshare app helps electric vehicle owners find compatible chargers in their area, and is actively used in New Zealand.

LOCAL GOVERNMENTS ARE SUPPORTING SOME 'SMART' DEVELOPMENTS

Local governments have been involved in supporting new smart technologies, including some that relate to smart grids and the new options they provide. However, where changes have been made, they have so far been modest, incremental developments, rather than the

71 See JuicePoint's website
72 See ChargeNet's website
73 Energy News Article, 17 February 2016, "Spark trials EV chargers"
74 Energy News Article, 31 May 2016, "EV car share programme eyes fleet market"
75 Energy News Article, 13 April 2015, "Auckland Transport eyes EV car-sharing scheme"

transformational change that is being supported in Japan, Barcelona and Singapore through their smart city projects. For example:

- **numerous local and district councils are partnering with industry participants and other businesses** to install electric vehicle chargers in their regions, as discussed
- **councils are envisioning a smarter and lower carbon future.** For example, the Auckland Council has developed a 'Low Carbon Auckland Action Plan', which outlines its vision and high-level approach to reducing the city's greenhouse gas emissions by 40 per cent by 2040. It includes consideration of how it can facilitate and stimulate uptake (non-financially) of electric vehicles, renewable generation and demand response technology. It has already been installing solar PV on various council-owned buildings.[76]
- **the Wellington City Council runs a 'Low Carbon Challenge' programme**, in which it supports entrepreneurs with projects that achieve smarter energy use within Wellington.[77] The vehicle sharing scheme in Wellington, mentioned previously, was supported as part of that programme.
- **some councils have begun, or are planning to install LED streetlights with smart communications,** which allow for streetlights to be digitally controlled, monitored, and metered. As well as being able to digitally control the brightness of street lights, these 'smart' systems can, for example track how far away a rubbish truck is, located, track a micro-chipped dog, direct motorists to available car parks, and signal a property where emergency services are required. Some electricity network owners have identified the potential for them to leverage off these systems. For example, Wellington Electricity has suggested that these systems could give them the ability to communicate with consumers about shifting load, and have been in discussions with councils about the opportunity.[78]
- **Land Information New Zealand (LINZ) is working with Auckland, Wellington and Christchurch councils on a 'Smart Cities - Smart Nation' project[79]**. It has received some funding from the central government to invest in projects that use sensors and other new technologies to better understand – and ultimately improve – how the cities function.

  As part of the project, Christchurch City Council is trialling an IT platform that mulitple types of sensor can plug into, laying the foundation for more smart-cities work in the future. Christchuch City Council intends to work with various other

76 Low Carbon Auckland Action Plan

77 See the WCC Low Carbon Challenge webpage – previous iterations of the programme have been called the 'Smart Energy Challenge' and 'Smart Buildings Challenge'

78 Energy News: NZ Bus conversion avoids $20m Wellington investment, 24 June 2016

79 Beehive announcement, LINZ project website

agencies, including the University of Canterbury, Environment Canterbury, and central government to help Christchurch become a smart city.

Other aspects of the LINZ project are focussed more on using sensors and data to help address traffic congestion and water quality issues. There is some suggestion that the projects will ultimately support improvements in energy use, though the extent to which the projects will support, or be supported by the development of smart grids is unclear.

7. WHAT CAN BE INFERRED FROM DEVELOPMENTS SO FAR?

There are three key things the Forum has distilled out of the activity that is occurring overseas, and what has been observed so far in New Zealand. They include that:

1) **the pace of development in New Zealand reflects that the benefits are currently quite low:**
   - the financial benefits of new technologies aren't yet sufficient to drive significant uptake
   - unpriced benefits don't generally provide enough benefit on their own to drive uptake of new technologies
   - international experience suggests the consumer-led uptake of new technologies could be swift once benefits materialise
2) **some of the investment made in new technologies is inefficient from a national perspective:**
   - if the private and public costs and benefits do not align, consumers might make decisions that have inefficient outcomes
   - consumers may make inefficient decisions because of complex, incomplete or inaccurate information
   - investment that is inefficient from a national perspective could catalyse a wider response that is efficient
3) **there should possibly be more activity than we're seeing, particularly at the mid-scale level where benefits should be most substantial:**
   - there is a lot of complexity associated with the various new options, which creates a barrier to development
   - uncertainty due to changing prices may be dissuading investment
   - we are missing price signals of the value of flexibility
   - there aren't parties catalysing transformational change here, as there has been in Japan, Barcelona and Singapore.

1) The level of development in New Zealand reflects that the benefits are currently quite low

THE FINANCIAL BENEFITS AREN'T YET SUFFICIENT TO DRIVE SIGNIFICANT ACTIVITY

While consumers in New Zealand are starting to invest in the new technologies that smart grids support, uptake rates are still relatively low, probably because the financial benefits are limited here.

The financial benefits in New Zealand from smart grid developments and the new options they support are currently affected by:

- **High upfront costs.** Many of the new technologies that smart grids support are currently too expensive for a lot of potential investors. For example, solar PV systems and batteries each cost at least $5,000; new electric vehicles come at a significant price premium to petrol or diesel vehicles, and although slow recharging can be carried out at home, rapid electric vehicle chargers cost around $50-70,000 to install[80].
- **Returns that are too low to offset the upfront costs:**
  - The returns from solar PV are affected by the relatively poor solar resource in parts of New Zealand.
  - New Zealand's existing ripple control system is already used in some areas to reduce peak demand through load management – a capability that other countries don't generally share. This may mean there are reduced benefits from investing in new forms of energy management and demand response.
  - Most heat pumps, home appliances and electric vehicles have delay functions that allow them to be run at times when prices are likely to be lower. Consumers can therefore already attain some of the value of a home energy management device, albeit with more effort and risk than if these appliances were controlled automatically. This means that the uptake of home energy management systems will rely on them being low cost, or providing significant unpriced or non-energy related benefits (such as convenience). In California where home energy management systems are more common, there are more opportunities for financial benefits from load management. For example, California has more load from swimming pool pumps and air conditioning, which can be moved or curtailed to avoid periods of high prices.
  - New Zealand's electricity system already benefits from a large amount of flexibility, because the hydro lakes allow us to store energy. New Zealand's main

[80] According to JuicePoint, a supplier of rapid chargers

storage issue is seasonal, so storage would ideally would allow us to move supply from summer into winter when demand is higher. This limits the potential income that can be gained from energy storage devices like batteries.

- **Their reliance on interacting with other costly assets. For example:**
  - a home energy management system has limited value if it cannot interact with household appliances. These can come at significant cost, and will generally only be replaced once every ten years or so – even with the potential benefits from connecting them up to a home energy management system. Furthermore, the technology capability needs to align: the fast rate of technology improvement means that an appliance purchased now might not interact with a home energy management system purchased two years ago. Until the technology is more mature, it is likely that there will be limited inter-operability between brands and specific technologies.
  - rapid electric vehicle chargers can only make money if consumers invest in electric vehicles.

Furthermore, it may be that there are other investment opportunities that provide *greater* financial benefits, and are hence a higher priority for consumers at this stage – for example, LED lighting or home insulation.

The limited financial benefits from new technologies affect uptake across the board:

- **commercial and industrial customers, and industry participants will be most prominently affected** by a lack of financial benefits. Given their traditional commercial drivers, these parties are unlikely to invest in new technologies or smart grid developments unless they see a financial benefit.
- **financial benefits are also a key driver of uptake by mass-market consumers**. While unpriced benefits are sufficient for some consumers, and will get a technology over the line for others, widespread uptake is unlikely until there are obvious financial benefits.
- **community developments also rely on some level of financial benefit to be viable.** This is highlighted by the Blueskin Bay and Otaki developments. Communities will generally coalesce around a variety of unpriced benefits. However,
  - new technologies are generally high cost, and the communities rely on funding from businesses and other agencies, who are more likely to fund projects that are well-resourced and reasonably economic
  - the members of communities have limited time and resources that they can volunteer to initiatives

  - there is ultimately some level of self-interest, which may not be completely satisfied by unpriced benefits, particularly if there is a need to compromise in order to get agreement on a project.

- **development by national and local governments is limited because of the many competing uses for their resources.** Any development would have to pass a cost-benefit assessment before it went ahead. Governments will focus on a wide range of social benefits – which they will generally attempt to price where others mightn't - as well as pure financial benefits. However, financial benefits may make the assessments more straight-forward and compelling.

UNPRICED BENEFITS DON'T PROVIDE ENOUGH BENEFIT ON THEIR OWN

Unpriced benefits have been key in driving much of the uptake in new technologies to date, given the limited financial benefits, and the barriers that high upfront costs present for many. While they're significant, unpriced benefits have not been sufficient to mobilise significant investment either. For example:

- **The environmental benefits of some new technologies may be limited in New Zealand.** Some prosumers have invested in solar PV in support of environmental goals. However, as the Forum discussed in its Emissions report, some new technologies may not have a significant impact on New Zealand's emissions. That finding is not intuitive, and is different from the experience in most other countries. It appears that engaging in the community generation project may have helped Blueskin Bay residents' come to an improved understanding of these sorts of complex issues. For example, one resident of Blueskin Bay stated that she was reviewing her support for the community wind development, in part because she was not convinced that it would have significant emission benefits.[81]
- **Distributed generation does not necessarily provide any resilience benefits.** Some prosumers are driven to invest in distributed generation to provide resilience against power cuts. However, most solar PV systems won't generate electricity if there is a power cut[82]. Similarly, storms or other isolated issues affecting distribution networks cause most power cuts, and distributed generation cannot overcome these. The Blueskin Bay wind farm is unlikely to have provided the community with the resilience it sought, irrespective of whether it was connected to the distribution network or transmission network.

81 'Blowing hot and cold', Otago Daily Times, 14 March 2016

82 According to: the Sustainable Electricity Association of New Zealand's Small Scale Renewable Energy Standards Guide (section 5.2.1) which suggests that most inverters will incorporate a grid protection device to disconnect the inverter from the grid if there is an outage, in order to comply with installation standards. Also see the draft EEA "Connection Guideline for Connection of Inverter Based SSDG", by the EPECentre.

- **Being 'independent' and 'self-sufficient' comes at a cost.** A desire to be independent from the grid has driven investment by some prosumers. However, as Otaki identified in the early stages of its community engagement, being off-grid is expensive because it would mean no longer benefiting from the balancing and reserve generation that the grid provides, and the cost of energy storage is generally prohibitive. As a result, Otaki changed their goals over time from being off-grid to be more broadly about 'big picture' sustainability issues, which has resulted in a focus on reducing wasted energy and their reliance on fossil fuels.

Environmental goals and/or renewable integration are drivers of smart grid development for all but one of the countries that were included in Table 1. The need to reduce emissions has been a key driver for countries to provide the financial incentives to invest in smart grid technologies.

It is useful to compare how these drivers stack up in the New Zealand context. Table 2 highlights that, absent financial benefits, and noting financial barriers, there isn't yet a sufficiently compelling driver for many smart grid technologies in New Zealand.

Table 2: Relevance of overseas drivers for New Zealand smart grid development

Overseas smart grid driver	Relevant?	Explanation
Government policies / mandates	-	New Zealand has no policies or mandates specific to smart grids. A strategic target of 90% renewable electricity is achievable without smart grid tech.
Environmental goals	●	Reduced emissions a driver for some technologies. As per the Forum's Emissions report, emission savings are possible from electrifying thermal processes – including electric vehicles and industrial processing. May influence some households.
Electric vehicle integration	●	Near-term focus on public charging infrastructure. In the future, load control and network capacity issues may be a focus, and are things we should be planning for, but uptake is not at a level that necessitates investment at the moment.
Renewable integration	-	Large hydro resources already allow for integration of renewables – at least for the foreseeable future.
Reliability concerns	◖	Demand response used as reserve (i.e. interruptible load), but private financial benefits for that. New 'smart' HVDC controls have improved reliability. May drive some business-as-usual network investment. Distributed generation doesn't provide reliability benefits.
Financial incentives	-	As discussed – few financial benefits available at the moment.

Overseas smart grid driver	Relevant?	Explanation
Energy efficiency goals	◖	Energy efficiency largely driven by financial benefits. May influence some households, but lower hanging fruit for most such as efficient lighting, insulation etc.
Increasing demand	◖	Will drive business-as-usual investment by some networks. May influence some households.
Economic competitiveness	◖	A desirable goal, but new technologies are not economically competitive yet in NZ.
Geographic grid constraints	◖	Will be a business-as-usual driver for some networks.
Energy security goals	-	NZ an islanded system so always had to manage energy security – not a pressing concern. However, electric vehicle uptake will support our current account balance.
Energy theft reduction	-	Not a significant issue in NZ. However, smart meters will improve visibility of energy theft and help to reduce it further.

THE INTERNATIONAL EXPERIENCE SHOWS HOW FAST CHANGE CAN BE

Consumers in New Zealand are not driving the same pace of smart grid development through new technology uptake, as consumers in many other countries. However, in all cases, high rates of new technology uptake in other countries have been a result of subsidies and other incentives.

Subsidies haven't just supported uptake by individuals and businesses; basically all of the international examples of prosumer communities have also been subsidised – either through specific grants to those communities, or because of general technology subsidies and feed-in tariffs that they benefit from.

Other countries' experiences with subsidies shows that uptake of new technologies can be rapid when consumers see clear incentives to invest.

Furthermore, overseas subsidies are supporting new technologies in achieving economies of scale and reduced costs, which New Zealand consumers will ultimately benefit from, and which will fuel uptake here.

Surveys by the Centre for Sustainability and GREEN Grid project in electric vehicles, solar PV and smart homes respectively found that at least 60% of respondents:

- would at least consider buying an electric vehicle if it cost the same as a petrol vehicle
- would be willing to purchase solar PV in the future
- are 'somewhat' or 'very' interested in having a smart home.

This suggests there is a significant potential market for new technologies. As technology costs fall over time and financial benefits materialise, New Zealand consumers are primed to respond, and this could happen very quickly.

2) Some investment may be inefficient from a national perspective

IF PUBLIC AND PRIVATE COSTS / BENEFITS ARE NOT ALIGNED, CONSUMERS MIGHT MAKE DECISIONS THAT HAVE INEFFICIENT OUTCOMES

Consumers will invest in new technologies to satisfy a variety of values and needs. While some investments may not seem to be efficient from a purely financial perspective, and may not stand up to the scrutiny of a commercial investor, unpriced benefits may mean that they are efficient investments overall.

Obviously it is a consumer or community's prerogative to spend their own time and money in whatever way they choose, and they should not be prevented from doing so.

However, if the prices that any consumer sees for a service are not reflective of what it costs to provide them with that service, then they cannot effectively assess the merit of certain investments and behaviour, in order to make efficient decisions.

If consumers do not have to pay costs that might arise as a result of decisions they make, then their choices may increase the costs that others have to pay. This could have detrimental outcomes for wider consumers.

An important example where New Zealand consumers do not currently see prices that are reflective of the value of the services they receive, is for distribution services.

The non-cost-reflective nature of pricing for distribution services has caused concerns in Australia, following the high uptake of solar PV there, and New Zealand could potentially head down a similar path. Australia's experience provides a useful case study to understand why it is so important to send cost-reflective signals. Specifically:

- The costs of networks are mostly fixed, and mostly sunk, but network owners in Australia (and New Zealand) have generally charged consumers for use of the network on a variable basis, reflecting the historic limitations in measuring consumption using conventional meters.
- Australian consumers that invested in solar PV reduced their energy consumption, and this reduced how much they contributed to the costs of the network – even though their actual use of the network was more-or-less the same.
- Because the network owners in Australia are subject to price regulation, the reduced revenue from solar PV owners affected their ability to recover their costs. To address this, the regulator changed the price regulation regime. The revised regime was

more reflective of the networks' cost drivers, and controlled the total amount of revenue the owners could earn, rather than the prices they charged.

- The revised regime also required the network owners to change how they charged consumers: If they continued to charge on a variable basis, the increasing number of solar PV owners would mean an increasing number of consumers reducing their contribution to the regulated revenue. Non-solar PV owners would then increasingly have to make up that share of the costs. This:
  - would incentivise more and more people to invest in solar PV to avoid paying higher and higher costs, which would become increasingly removed from the actual costs that the solar investment genuinely saved
  - would have socio-economic implications, because solar PV owners tend to be wealthier than consumers that don't have solar PV.
- However, the network owners have been given some latitude around the transition to more cost-reflective prices. There have been suggestions that, since their private concerns about recovering their costs have been resolved, the network owners are being complacent about making the necessary changes. Changing price structures could be a highly contentious issue, since the large cohort of solar PV owners would see the benefits of their investment reduced, which makes it an undesirable and challenging change to make.

INDUSTRY PARTICIPANTS AND CONSUMERS MIGHT MAKE INEFFICIENT DECISIONS BECAUSE OF COMPLEX, INCOMPLETE OR INACCURATE INFORMATION

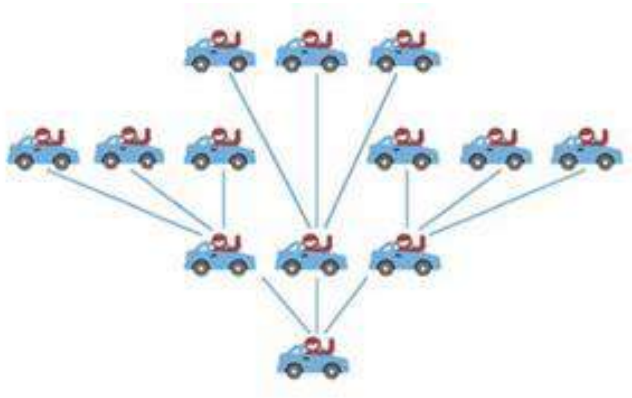
Even if the private and social costs and benefits were more aligned, industry participants and consumers might still make decisions that are inefficient. This could happen for two reasons:

- **they have incomplete or inaccurate information.** For example, people might assume that solar PV will help to reduce New Zealand's greenhouse gas emissions, and might support investment in solar PV because of it. However, the Forum's Emissions report suggests that solar PV might actually have a negligible effect on our emissions. Similarly, some consumers may have gained false impressions about the capabilities of new technologies, or about how much money they can save by investing in them.
- **they may not properly process complex information**, resulting in decisions and outcomes that are sub-optimal. There are numerous psychological reasons why this occurs. For example, people:
  - tend to have a strong preference for the status quo and an aversion to change
  - will avoid loss more than pursue an equal gain

- value immediate rewards more than bigger rewards at a later time
- place a heavy emphasis on the first piece of information they receive, or on reference points that are familiar

Figure 10: Impact of a single electric vehicle owner

(source: Norwegian EV association)



INEFFICIENT DEVELOPMENTS CAN CATALYSE A WIDER, EFFICIENT RESPONSE

While an individual investment might be inefficient from a national perspective, it could catalyse a wider response that resulted in efficient outcomes overall.

This is explained by way of the Centre for Sustainability's Energy Cultures framework (Figure 7).

The Centre for Sustainability's research suggests that many prosumers change other aspects of their energy culture once they adopt new technologies, and these changes may be efficient. For example, they might invest in solar PV, and subsequently change their behaviour by moving their demand away from times of network peak demand. They might be encouraged to invest in energy efficient lighting, or an electric car.

Furthermore, the changes made by one household might inspire change in another, that in turn inspires change in another, and so on. According to a 2015 Norwegian survey of electric vehicle owners, the average electric vehicle owner considers that they have inspired three further people from their social circle to purchase an electric vehicle.[83]

These investments can also help to establish and prepare the associated industries and infrastructure (e.g. installers, technical standards etc.). This could facilitate faster and smoother uptake of new technologies in New Zealand, once cost declines and improvements in capability make them more beneficial.

Therefore, the potential for a development to catalyse a wider efficient response may mean that an inefficient project can produce efficient outcomes.

83 The Norwegian EV Success, Christina Bu, Norwegian EV Association president

3) There should possibly be more activity than we're seeing

It appears that there are smart grid opportunities that are not being exploited because of various barriers to action.

At this stage, the Forum would expect smart grid development to be most apparent where the potential benefits are particularly material – being where energy use is of significant scale, or a major contributor to a party's overall costs or revenues.

There will be diminishing returns from smart grid developments - the last 20 per cent of potential benefits may come at 80 per cent of the cost and effort. While bigger opportunities exist, the Forum wouldn't expect much activity on things like smart control of household appliances, since residential consumers are small-scale, and household appliances make a relatively small contribution to their energy bill.

The biggest opportunities for residential consumers come from smarter management of space and water heating, as these are major contributors to energy bills. Furthermore, there is significant scope for greater efficiency in these areas, both at an aggregate level (e.g. through systems like ripple control), and at an individual level - which might justify supporting consumers in making 'smarter' technology decisions when space and water heating assets come up for replacement or renewal.

THERE ARE A LOT OF CHALLENGES TO ENGAGING WITH NOVEL TECHNOLOGIES

New technologies present issues for investors that they haven't had to deal with before. This creates barriers to uptake, because resolving the issues takes time, money and effort that is in short supply. Challenges for investors – big and small - include:

- **investigating and understanding the new technologies**. To invest in new technologies, investors need to:
  - know about them and know what benefits they provide
  - be able to choose between the various different brands and/or suppliers
  - figure out what size / power/ capability they require for their particular circumstances, which might require professional advice
  - determine the right time for them to invest, given how fast technologies change and improve.

  The Centre for Sustainability's smart homes survey identifies that just accessing the information to sort through these issues is a barrier for some consumers.
- **figuring out how to manage any new risks that new technologies can present**. Specifically, new technologies can introduce data security issues that would be new to many investors. The Centre for Sustainability's smart homes survey highlights that

data security issues were a concern for over 40% of the potential target market for smart homes.

- **figuring out how to integrate new technologies with existing equipment**. Any 'smart' control technology would need to integrate with existing appliances and machinery. Getting everything set-up and working properly together would be a challenge for many consumers. This is particularly true because new technologies may not be at the point of having plug-and-play solutions, which is a significant barrier to uptake for consumers, who value convenience[84].
- **figuring out the implications of new technologies for their electricity purchasing arrangements**. For example, new technologies can change a consumers' load profile, and give them new abilities to control their load. This could change the value of any hedge contracts they have or might enter into, or make purchasing at spot prices a more attractive option – all of which they'd need to consider in making a decision to invest.
- **getting the necessary approvals to invest**. This generally applies to businesses, who may need to get sign-off from management to invest in new technologies, and have to be able to present a compelling business case. However, it can also affect consumers. For one of the consumers in the Centre for Sustainability's case studies, a barrier to developing their smart home was their wife's concerns about the time involved, and the potential for something to go wrong.
- **installing new technologies**. Installing some new technologies – for example, solar PV – involves modifications to buildings or land. In some instances, this can necessitate engineering reports or consents. There can also be challenges if a consumer does not actually own their premises, and the landlord needs to get involved.

New technologies can also require investors to engage with markets that they haven't been involved in before, or in ways they haven't before, and to work around regulations that they've previously had no experience with. This introduces new challenges for them that they need to work through. For example:

- Establishing a formal structure around their community engagement has been a barrier for the Otaki community's initiatives. The community group found it difficult to attract funding and progress initiatives without a formal structure. Setting up a co-operative was something the volunteers had not done before, and involved a lot of learning. It also required legal advice, the cost of which was also a barrier. Blueskin Bay similarly had to go through the process of establishing a community Trust so that it could secure funding and enter into formal agreements with various businesses.

84 Scientific American article, 1 July 2016, "The "Internet of Things" Needs a Fix"

- EnerNOC considers that one of the main barriers to aggregating small loads, is in making it simple and easy for consumers to participate, and appreciate the contribution they can make to system security
- Solar PV owners that generate more electricity than they use may want to trade electricity with their neighbours, or sell it directly through the wholesale market. However, there are numerous regulatory hoops to jump through to do this, which makes it too challenging for most consumers.

UNCERTAINTY DUE TO CHANGING PRICES MAY BE DISSUADING INVESTMENT

It is likely that uncertainty about the financial benefits of new technologies is affecting uptake by consumers. A number of developments may have contributed to this uncertainty, including:

- In 2014, a number of electricity retailers reduced the price they would pay to prosumers for any excess generation exported to the grid. Those retailers stated that they were reducing the price to make it more cost reflective.[85] However, the GREEN Grid Project's 2014 report on solar PV uptake in New Zealand suggested that the lack of certainty about these prices was a barrier to uptake for some potential investors in solar PV.[86]
- In 2016, Unison introduced a new pricing regime for consumers wanting to install distributed generation. It suggested the change was intended to give consumers "*a good idea of the real cost of providing an electricity network*". However, some commentators strongly oppose the change, and have labelled it a 'solar tax' in the media.[87]
- The Electricity Authority has indicated that it expects distributors will transition to more service-based pricing structures in coming years.

These sorts of developments – particularly given the level of media attention they can attract – likely contributes to reasonable uncertainty in the near-term about the financial benefits consumers can expect from investing in technologies like solar PV, which may be dissuading investment.

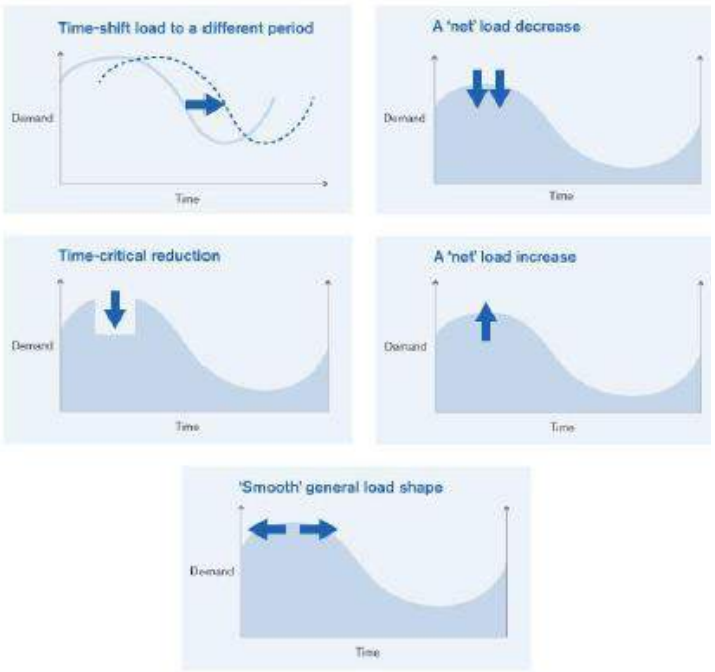
85 Energy News article, 6 November 2014, "Meridian ends 'unfair' solar subsidy"
86 Link to the GREEN Grid Project's PV report
87 Radio NZ article, 1 April 2016, 'New solar panel charge kicks in'

WE MAY BE MISSING SOME SIGNALS OF THE VALUE OF FLEXIBILITY

Because electricity supply and demand need to be matched from moment-to-moment, and both can vary over time, there is a need for a flexible response from either or both. Smart grids provide opportunities to utilise:

- **new sources of flexibility** – such as household or large-scale battery storage
- **unused flexibility that already exists on the system** - such as demand response from small consumers
- **existing flexibility more effectively –** for example, by having it respond automatically to price signals.

Figure 11: How flexibility can help manage the electricity system



Source: UK Office of Gas and Electricity Markets, Making the Electricity System More Flexible and Delivering the Benefits for Consumers

There is the potential for significant changes in the availability and providers of flexibility, as the uptake of new technologies such as batteries, solar PV, electric vehicles and energy management systems builds.

There are multiple existing and potential providers of flexibility, including:

- grid generation
- industrial and commercial consumers
- domestic consumers
- energy storage providers
- distributed generation
- load aggregators
- owners of ripple control systems (i.e. retailers and distributors).

We already benefit from flexibility from some of these providers.

There are also multiple potential *users* of flexibility, including:

- generators – who use it to gain revenue from the wholesale electricity market, and balance their generation/ retail portfolios.

- distribution and transmission network owners – who can use it to manage congestion on their networks, and potentially to defer or avoid investment in new network assets
- the system operator – who relies on it to balance supply and demand and maintain system security
- retailers – who can use it to manage their exposure to wholesale electricity prices, and balance their generation/ retail portfolios
- consumers – who can also use it to manage their exposure to retail electricity prices.

Currently, the arrangements for using and valuing flexibility are limited.

This is demonstrated by Table 3, which shows the various providers of flexibility down the left-hand side, and the ways to use that flexibility – including the costs that it avoids – along the top. The ticks indicate where providers are able to trade their flexible response with users.

Table 3: Current arrangements for using and valuing flexibility

		Ways to monetise flexibility							
		Wholesale electricity market*	Hedge contracts	Ancillary services provision	Avoided cost of transmission (ACOT) payments	Transpower demand response programme	Management of private costs	Bilateral contracts	Management of private costs
Users		Generators & Retailers		System operator	Grid owner		Distributors		Consumers
Relevant costs		Capacity & Energy		Balancing	Transmission		Distribution		Electricity retail costs
Supply	Grid generation	✓	✓	✓					
	Distributed generation	✓	✓	✓	✓			✓	
	Behind-the-meter generation								✓
Storage	Generator/ retailer owner	✓	✓	✓		✓			
	Network owned	✓	✓	✓		✓	✓		
	Consumer owned	✓	✓	✓		✓		~	✓
Demand	Ripple control	✓	✓	✓		✓	✓	~	
	Aggregated load	✓	✓	✓		✓			
	Commercial/ industrial load	✓	✓	✓		✓		~	✓
	Domestic load								✓

**including dispatchable demand*

This highlights that:

- **most flexibility can be used to influence capacity and energy costs** (i.e. avoid costs or receive income). This is done through the organised wholesale market, and contracts for which some price information is transparent to the market. Therefore, providers of flexibility are able to determine the value of their response in terms of reducing energy and capacity.
- **there are numerous opportunities to use flexibility to minimise balancing costs**. Some balancing services are provided under contract, while others are priced and provided by participation in an organised market. The ability for some forms of demand to fully participate in balancing markets is a developing area. Scale and sophistication are currently barriers to providing flexibility in support of system balancing.

- **there are some opportunities to use flexibility to avoid transmission costs**, largely because the grid owner has been developing its demand response programme.[88]

  Distributed generators currently receive some signal of the value of their output in avoiding transmission costs. However, the Electricity Authority has indicated its preference for removing the current arrangements for rewarding avoided transmission costs, as it does not consider the payments reflect avoided *economic* costs. The Electricity Authority has suggested that distributed generators should instead negotiate payment directly with Transpower, through some extension of its demand response programme.

  In its current form, Transpower's demand response programme would not be the ideal vehicle for this, because it has a short-term focus (six months to a year), whereas distributed generation consists of long-life assets that would value income certainty over multiple years.

- **flexibility mostly only helps manage distribution costs if it is owned by distributors themselves**. Furthermore, there is no transparency as to the costs that could be avoided from a more flexible response on distribution networks. Some distributors might contract with others to use their flexibility at times. [89]

- **flexibility owned by domestic consumers is currently only valued by those consumers themselves for reducing their own electricity bills.** By reducing their electricity retail costs they avoid some mix of energy, transmission, distribution, and potentially balancing costs by proxy. However, because domestic consumers generally see a packaged price that doesn't accurately signal real-time costs, the extent to which their avoided costs represent genuine system cost savings will vary.

Overall it appears that there are sources of flexibility that aren't being used by some parties that would value it, suggesting there may be barriers to them doing so. This includes some sources that might see high levels of uptake in the future – such as battery storage and behind-the-meter generation – as well as latent sources of flexibility that already exist, but are not being utilised, or could be utilised more effectively, such as ripple control (in some cases) and demand response.

The inability to see the value of providing a flexible response, and receive any reward for doing so, is a particular barrier.

88 Link to Transpower's webpage about its demand response programme

89 See, for example, the "demand side management value for network development alternatives" on pages 237 and 238 of Orion's 2016 Asset Management Plan

The Forum discussed these issues in its first year report[90] with respect to ripple control. It identified the potential for benefits to be missed altogether, because no single participant sees enough of that benefit to justify chasing it.

The UK's Office of Gas and Electricity Markets (Ofgem) has identified a number of barriers to providing and using flexibility in the UK electricity market - many of which also apply in New Zealand. Ofgem summarises barriers as being cultural, regulatory, commercial or structural barriers – as shown in Table 4Table and Table 5 .

Table 4: Key barriers for providers of flexibility identified by Ofgem

	Non- dom consumers	Dom consumers	Storage	DG	Aggregators
Cultural barriers	- Difficult to understand the value of flexibility (£) - Difficult to gather information on the flexibility products/programmes available and how to participate in them - Perceived risk of disruption to their business if they provide flexibility	- Difficult to understand the benefits of flexibility - Perceived risk associated with automation may prevent uptake of flexibility offers			
Regulatory barriers (role of parties)	- Regulation re. role of these parties in the market (eg whether and how they could sell flexibility) may need to be clarified	- Lack of clarity in the regulatory framework over roles and responsibilities of different market actors (other than licensed suppliers) towards domestic consumers may cause detriment or limit benefits	- Lack of clarity on the legal status of these assets	- Connection regime needs to be clarified - Role and contribution of DG needs to be clarified in the FiTs regime	- Regulatory framework does not provide for a clarification of the role of these parties
Commercial barriers (incentives)	- Technical and commercial requirements of flexibility products may not fit with the characteristics of the providers - Providing flexibility not core business for many of these consumers so value (£) may not justify the effort to sign a contract and provide the service	- Terms of contracts of offers available may be difficult to understand - Perceived value (£) of flexibility may not be enough to incentivise uptake	- Technical and commercial requirements of flexibility products may not fit with flexibility that storage can provide	- Benefits of using DG for flexibility need to be correctly priced to incentivise investments	- Technical and commercial requirements of flexibility products may not fit with the characteristics of the providers
Structural barriers (costs)	- Ongoing perceived risk and associated costs of providing flexibility may be too high compared to perceived benefits	- Upfront costs of smart devices may be too onerous for some consumers	- High capital costs - Perceived limited reliability of storage could make it a second-best choice for providing flexibility	- If uncapped, flexible connection agreements may deter connection	- Perceived risk of 'outsourcing' control of own energy consumption may increase the costs of successfully signing a contract

90 Link to the Forum's first year report

Table 5: Key barriers for users of flexibility identified by Ofgem

	Suppliers	DNOs	TO	SO
Cultural barriers	- Using new flexibility sources not core business yet - Existing level of system changes (eg smart meter roll-out, switching programme, energy efficiency policies) could divert attention from flexibility	- Perceived higher risk of adopting new practices	- Perceived higher risk of adopting new practices	- Perceived higher risk of adopting new practices
Regulatory barriers (role of parties)	- Regulation to be kept under review to ensure licence obligations allow for efficient procurement of flexibility	- Future role of DNOs, including relationship with consumers and transition to a DSO role, needs to be clarified to better support the inclusion of flexibility in DNO business plans - Regulation to be kept under review to ensure licence obligations allow for efficient procurement of flexibility	- Regulation to be kept under review to ensure licence obligations allow for efficient procurement of flexibility	- Regulation to be kept under review to ensure licence obligations allow for efficient procurement of flexibility
Commercial barriers (incentives)	- Some reforms to industry processes necessary to further incentivise parties to use and contract for flexibility	- Price control regime needs to ensure that benefits of using flexibility can be fully captured - Charging regime needs to be in line with approach to using and valuing flexibility	- Price control regime needs to ensure that benefits of using flexibility can be fully captured - Inter-network management issues to be addressed and this may take time/not be priority for both parties	- If procurement of flexibility largely based on price (provided all requirements are met), traditional sources of flexibility preferred at times of low wholesale prices - Structure and length of incentives regime needs to 'capture' benefits of using flexibility (both in the short and in the long term)
Structural barriers (costs)	- Complexity of market arrangements may increase cost of entry for new actors	- High investment costs may not be justified if delivery of flexibility by providers is not guaranteed		

WE DON'T HAVE PARTIES CATALYSING TRANSFORMATIONAL CHANGE

Some countries have had businesses and agencies that have had a strong catalysing effect on smart grid developments. For example, governments and technology companies have been turning areas of Japan, Barcelona and Singapore, amongst others into smarter cities. These examples have seen significant investment in smart meters, sensors and communication technology, and electric vehicle infrastructure.

While New Zealand city councils do envision their cities becoming smarter, they have not yet had the same catalysing impact:

- **The Christchurch rebuild** provides an ideal opportunity to pursue smart city developments, and this has been recognised.

  "The Sensing City project was heralded by Canterbury Earthquake Recovery Minister Gerry Brownlee and Science and Innovation Minister Steven Joyce in December 2013 as 'a world-leading project to transform Christchurch into a smart city of the future and create opportunities for New Zealand's tech sector' and received $250,000 seed funding from Callaghan Innovation."

  However, the Sensing City initiative has not progressed to the extent intended, because restoring basic services became a higher priority.

"Stakeholders had under-estimated the complexity of rebuilding the city as quickly as possible, and 'complexities with insurance, central and local government has meant there hasn't been much of a focus' on intelligent infrastructure"[91]

- **Resistance from electricity distributors has been a barrier to councils adopting LED technology** - and hence the smart communications that they can incorporate - according to the Local Government New Zealand (LGNZ). LGNZ suggests that distribution pricing structures have been a key reason for this resistance, because the networks' total revenue would be affected by councils moving to LED lighting. [92]

  The Centre for Sustainability's case study of the Otaki community notes that they tried to engage with their community-owned lines company, but had not got any traction, and identified this as a barrier to action.

- **Cost may be seen as a barrier to smart city developments.** However, some smart city developments overseas have seen significant economic benefits. For example, Barcelona estimates that the changes it has made have helped save $58 million on water, increased parking revenues by $50 million per year, and generated 47,000 new jobs. It is also reportedly saving $37 million annually from smart lighting. Furthermore, it has reduced traffic congestion and greenhouse gas emissions, improved the quality of its own governance, and made the city a more desirable place to live, work and visit.[93] It may be that overall, the costs of smart city development are much less than expected, and it may even have net benefits.

- **Large technology companies have been instrumental in supporting development overseas**. New Zealand may not be able to benefit as much from large technology companies driving developments, as Panasonic and others have in Japan. There are some private companies helping to catalyse some development in New Zealand, but they may not be of sufficient scale to enact transformational change. For example:

  - ChargeNet has been working with a range of parties to install electric vehicle chargers around the country
  - Infratil have been able to help catalyse some smart grid developments through some of its shareholdings, such as Z Energy (electric vehicle charging), NZ Bus (hybrid electric busses) and Trustpower (distributed generation).

91 NBR: Pressing need for basic infrastructure overtakes Christchurch 'smart city' plan, 1 September 2015

92 Local Government New Zealand, submission on Electricity Authority's Implications of evolving technologies for pricing of distribution services consultation paper

93 Harvard University: How Smart City Barcelona Brought the Internet of Things to Life, 18 February 2016

8. WHAT CAN BE DONE TO ACCELERATE DEVELOPMENTS THAT PROVIDE CONSUMER BENEFITS?

Smart grid development in New Zealand will increase as technology improves and reduces in price. Consumers are likely to see increasing benefits alongside.

However, the Forum has identified four ways to accelerate developments and support consumer benefits:

1) ensure the value of services is properly signalled, to support efficient decision making
2) investigate how we could ensure flexibility can be used for its most valued purpose
3) make it as easy as possible to engage with new technologies and new markets
4) encourage relationships between the industry and potential catalysts of development.

1) Ensure the value of services is properly signalled

PROPER PRICE SIGNALLING WILL ENSURE EFFICIENT DECISION MAKING

The Forum considers that consumers should be able to spend their money on whatever they want. However, it is important that they see prices that reflect the value of the services they receive, so that they make decisions that do not increase costs for other consumers, and that are beneficial for the country as a whole.

Consumers themselves do not need to see infinitely detailed prices (e.g. a half-hourly breakdown of energy, transmission and distribution costs) in order to make good decisions and minimise their impact on others. It is the role of retailers to repackage costs into a price structure that consumers like and understand, and manage the complexity and risk inherent in doing that. As long as the underlying costs that result from consumers' decisions and behaviour are able to be made visible to them, via their retailer, then efficient outcomes should still be achieved.

The Electricity Authority has highlighted that distributors do not charge consumers – via retailers – in a way that reflects the value of the services they receive. In November 2015 it released a consultation paper: Implications of Evolving Technologies for Pricing of Distribution Services[94]. The paper stated:

> *"Distribution prices affect the way consumers invest in and use these evolving technologies. If prices are designed correctly, consumers' decisions will help all New*

[94] Link to Electricity Authority's Implications of Evolving Technologies for Pricing of Distribution Services consultation paper

> *Zealanders to benefit from the advances in technology. However, most distribution prices for residential and small commercial consumers are poorly designed for this purpose.*
>
> *Existing pricing makes it unnecessarily costly to operate electric vehicles and use battery storage systems to smooth electricity consumption, and encourages over-investment in solar panels."*

This work by the Authority is vitally important to ensure efficient outcomes. The longer it takes for distributors to transition towards more service-based tariffs, the greater the risk that:

- consumers will make decisions based on private costs and benefits that do not align with the public costs and benefits
- those decisions will increase costs for other consumers, potentially including those least able to afford them
- the transition to align public and private costs will become a contentious issue, because consumers that had made an investment would see the value of those investments eroded
- efficient uptake of new technologies will be impacted by uncertainty about the financial benefits they provide.

COMMUNICATING CHANGES TO PRICING IS A SENSITIVE ISSUE

It is clear from media coverage of Unison's purported 'solar tax', that any move to more service-based distribution prices will have to be very carefully managed to aid understanding and maintain consumers' faith in the industry.

A strong driver of uptake of solar PV is a lack of trust in power companies. If the need to change to more service-based prices is not communicated clearly, any changes to pricing that reduce the financial benefits of new technologies are likely to play strongly into this kind of view. Any national conversation on these issues will need to be technology-neutral, and would likely be aided by having clear and consistent messages, including from parties that provide a neutral voice.

AVOIDING BROAD SUBSIDIES HAS BEEN THE RIGHT APPROACH

As the international experience shows, subsidies are certainly effective at driving uptake of new technologies, if that is the desired outcome. Therefore, New Zealand *could* accelerate smart grid development by providing broad subsidies for the new technology options that smart grids support.

Most countries have provided subsidies primarily to incentivise investments that help to reduce greenhouse gas emissions, and for the most part, that's been achieved to at least some degree.

However, the international experience also demonstrates the litany of unintended consequences from subsidy-driven uptake of new technologies. To reiterate, countries have variously experienced:

- poor technology choices, and/or investing at the wrong time in the technology lifecycle
- budget shortfalls from subsidies that have proven more popular than anticipated
- back-lash when trying to scale back or remove subsidies
- sunk costs being recovered from a shrinking pool of consumers that haven't invested in new technologies
- back-lash when trying to revise legacy pricing structures that are not service-based
- system security issues because network owners have struggled to upgrade their networks fast enough to support all of the distributed generation that consumers have wanted to install, and have faced back-lash for consequently preventing new connections
- the potential for future system security issues, because the existing assets connected to the system do not provide sufficient flexibility to accommodate the large swings in the output of the subsidised technology.

The Forum considers that New Zealand is fortunate to have avoided the potential pitfalls of broad subsidies, and does not consider that consumers are likely to benefit in the long-term from taking on that cost and risk.

2) Investigate how we could ensure that flexibility can be used for its most valued purpose

Flexibility in the electricity system is not only necessary to ensure stability, it also plays an important role in minimising costs, because moving or reducing generation and/or demand can:

- avoid or defer the need to upgrade or reinforce transmission and distribution networks
- avoid or reduce the need for generation to meet peak electricity demand, or to provide ancillary services.

It is likely that both the providers of flexibility, and how it is used, will change moving forward. However, it appears that there may currently be barriers to providing and utilising

flexibility in a way that is most valuable from a total-system perspective. The Forum considers that it is an appropriate time to investigate improved arrangements for valuing and deploying flexibility. In particular, because:

- The Electricity Authority has signalled its intention to remove Avoided Cost of Transmission payments for distributed generation.
- There could potentially be investment in a large number of energy storage devices in coming years, and ideally, the prices they see will incentivise parties that owned these devices to use them in a way that helped to minimise electricity system costs (rather than just private costs).
- There is a lot of latent demand response on the system, and the potential for much greater amounts of it in coming years from energy management technologies. It would be desirable to have arrangements in place that allowed us to fully utilise those resources.
- The system is losing some flexibility, because of the retirement of some large industrial loads that offer their responsive demand into the reserve market.
- The system operator may find it has a reduced ability, or a smaller role, in balancing the system in a future where local network issues become much more pressing – for example, because prosumers in low-voltage networks could be either generating or consuming electricity at different times. It may be that there will be a greater need for more a distributed approach to managing system security, and a greater focus on managing flexibility at a local level.

The Forum has developed a high-level 'vision' for what improved arrangements might look like in theory.

Firstly, Figure 12 illustrates the current arrangements, which were summarised in Table 3. It shows:

- the four uses (in orange), for which a flexible response could help to lower costs, and the price signal they send to providers (which is strong for energy and balancing, but non-existent for distribution)
- the various sources of flexibility, which are not fully utilised (textured arrows) and the parties that own them, and draw on them to sell their flexible response to the parties that value it
- the organised arrangements in the middle, where users and providers of flexibility are able to trade with each-other, directing resources to their most effective and valuable use, to the extent arrangements allow
- a number of ad hoc arrangements, where flexibility is not traded in an organised or transparent way, or in a way that makes it straight-forward for parties to participate

Figure 12: Current arrangements for providing and utilising flexibility

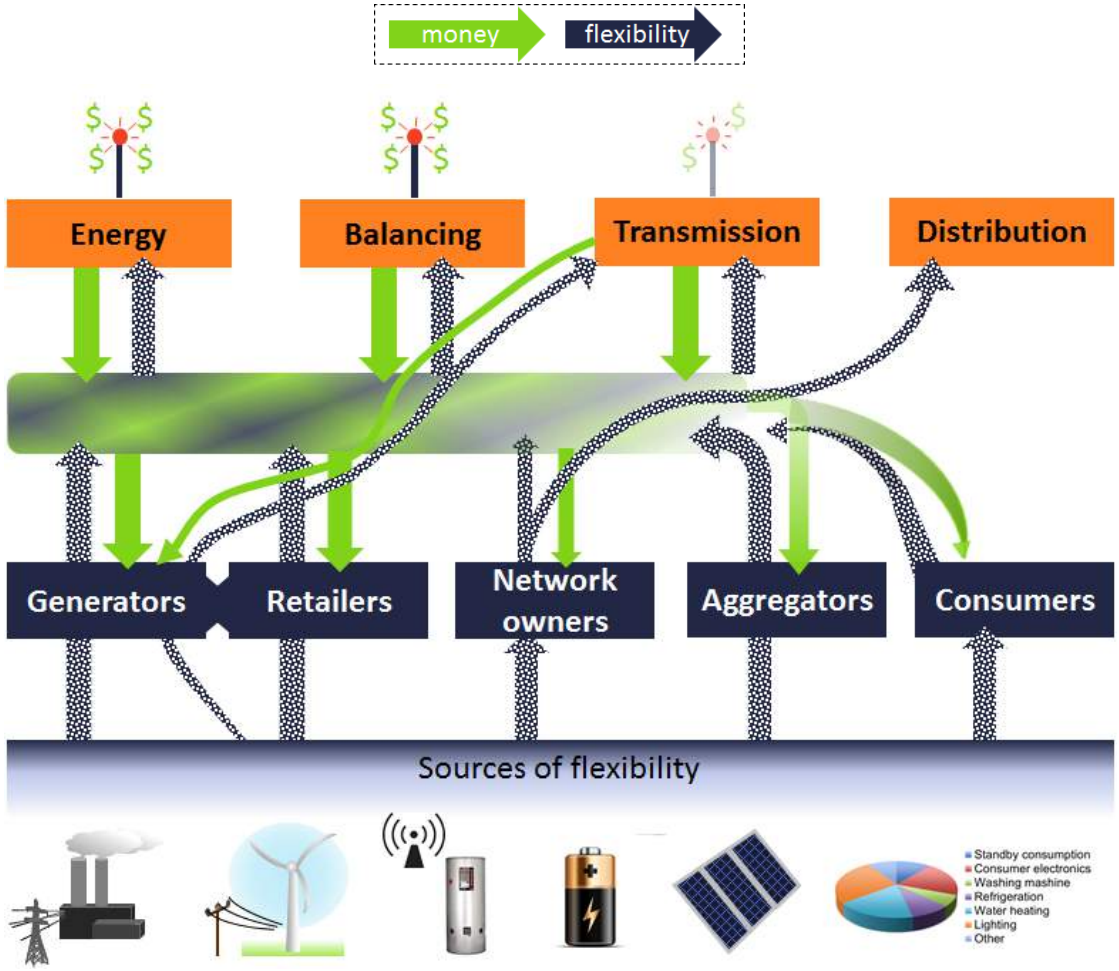
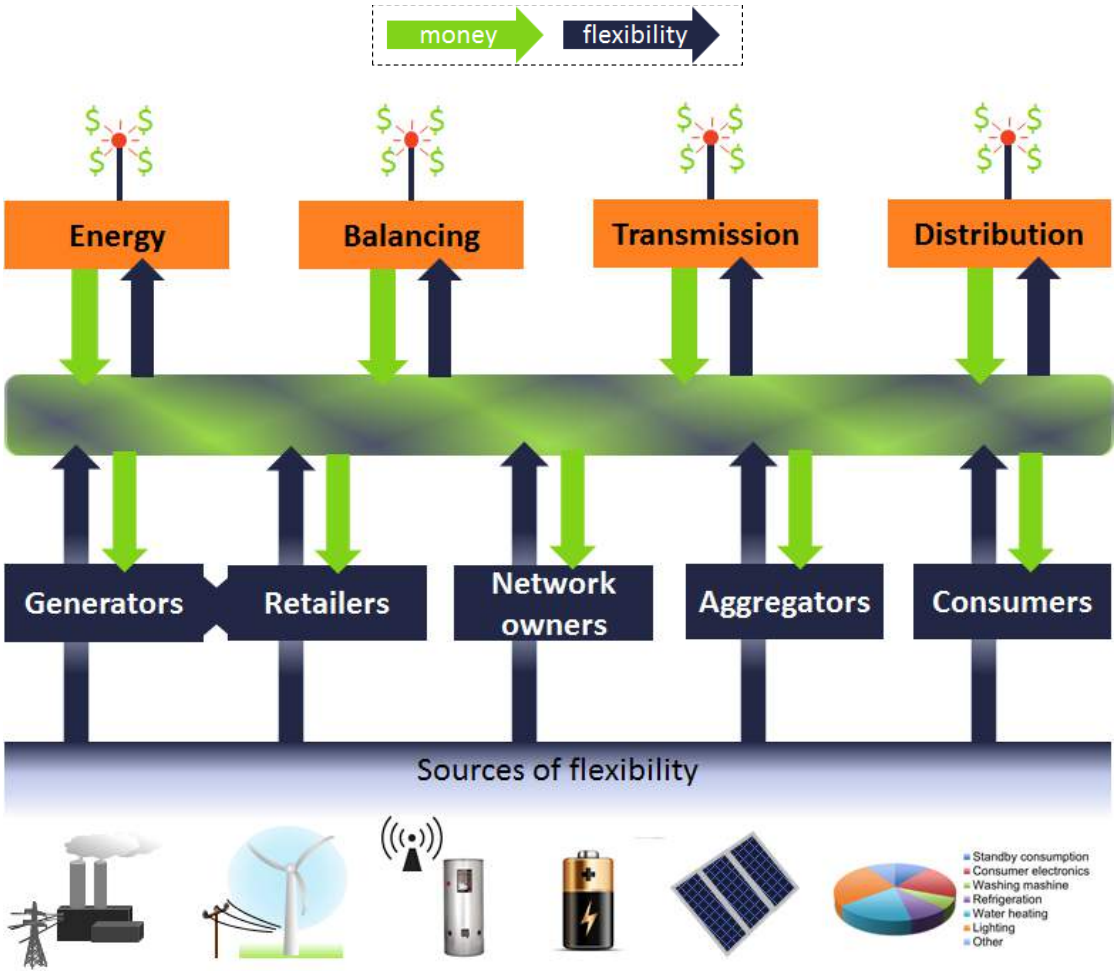


Figure 13 illustrates the vision for what ideal arrangements would achieve. Specifically:

- all parties that benefit from flexibility send a signal of the value they place on it, which all providers of flexibility can receive
- all sources of flexibility are fully utilised (bold un-textured arrows)
- there are organised arrangements that help to match providers and users of flexibility, so that it can be put toward its most effective and valued use, and all parties can easily participate.

Figure 13: Ideal future arrangements for providing and utilising flexibility



It may not be realistic to expect arrangements that are as straightforward and organised as this might suggest. The organised arrangements do not need to be competitive two-way markets like those that exist for energy, and should build on the existing electricity market foundations. The main requirements would be that they provide a way to:

- match providers of flexibility to the various uses, in a way that accounts for the different contributions they make
- establish a price at which parties will trade the flexible response
- ensure parties can confidently participate, knowing they're on a relatively level playing field.

The Forum considers that it would be appropriate for the Electricity Authority to undertake a project to investigate whether the arrangements for valuing and deploying flexibility could be improved in the direction the Forum envisions. More specifically, it could identify whether and how:

- commercial barriers to providing and using flexibility could be reduced, by:
  - helping users of flexibility to provide a clear signal of the value they place on it

  - better matching providers of flexibility with users
- cultural, regulatory and structural barriers to providing flexibility can be reduced
- cultural, regulatory and structural barriers to using flexibility can be reduced.

The Office of Gas and Electricity Markets in the UK is anticipating a future move toward a 'distribution system operator' model, rather than a 'distribution network operator' model. This essentially means that the network owners will take on a bigger role in procuring flexibility to manage security on their networks, and minimise network costs. The Commerce Commission could consider whether and how this type of model might appropriately fit within New Zealand's market arrangements.

3) Make it as easy as possible to engage with new technologies and new markets

ENSURE NO REGULATORY ROAD BLOCKS

The Electricity Authority is engaged in a project to identify any barriers that prevent participation from new technologies and business models. The Forum would like to emphasise the value of that work in supporting smart grid development progress.

Because technologies are changing so fast, and innovation is occurring all the time, getting the regulatory arrangements right so that they cover all eventualities may not be a one-off exercise. However, the Forum notes that the Electricity Authority has:

- strategic directions for market development recognise the need for the market to remain flexible in the face of change
- recently restructured its work programme, and has indicated it will re-focus its advisory groups and internal structures, to better reflect an industry that in future may be more decentralised and dispersed, with greater involvement by consumers[95]

Overall, the Forum considers that the Electricity Authority has established processes that can allow for a dynamic approach.

HELP TO BREAK DOWN THE COMPLEXITY ASSOCIATED WITH NEW TECHNOLOGIES

There may be opportunities to reduce some of the complexity associated with engaging with the new options provided by smart grid development. For example:

- The Otaki community found the process of establishing a formal structure around their community engagement to be a barrier to development. Both Blueskin Bay and Otaki now have experience in establishing community Trusts and co-operatives, and

[95] Energy News: EA refocuses work programme, advisory groups, 28 June 2016

working through various legal and accounting issues associated with community initiatives. It may be possible to work with these communities, so that their newfound wisdom can be shared, to reduce barriers for other communities that might like to engage in similar developments.

- There may be a role for the Energy Efficiency and Conservation Authority (EECA), potentially alongside partners such as Consumer NZ, in providing targeted information about the new options that smart grids provide. This could help consumers better understand the options and how to engage with them, to encourage more informed decision making.

The Forum notes that a number of parties provide online 'calculators' that help consumers who are considering investing in solar PV or electric vehicles to understand the financial costs and benefits, relevant to their individual circumstances. For example, EECA has worked with the GREEN Grid to develop a calculator that helps consumers understand the benefits they might gain from solar PV[96]. EECA also has a tool to help vehicle fleet owners calculate the relative lifetime costs of electric vehicles. [97] These sorts of developments are valuable in helping to reduce complexity.

4) Encourage relationships between the industry and potential catalysts of development

There may be opportunities to encourage parties to take a greater role in catalysing smart grid development. For example:

- It appears that there is room to develop stronger relationships between industry participants, and councils and communities.
- It may be possible to work more collaboratively with technology providers and private businesses in developing smart grids, by engaging with them more directly on specific proposals where there may be private benefits for them, and public benefits for cities and communities.
- For some applications, New Zealand has been seen as a good testing ground for new technologies, because we are a small market of fairly affluent, tech-savvy consumers. For example, Google, Microsoft and Facebook have used New Zealand as a test market for new mobile apps and software updates.[98] It may be possible to build on this position, in order to collaborate with technology companies on new opportunities for smart grid development.
- There may be opportunities to improve collaboration between the electricity industry and research institutions such as universities. This could support:

96 Link to EECA's website. BRANZ and NIWA also provide solar PV calculators

97 Link to EECA's vehicle total cost of ownership tool.

98 The Economist: Kiwis as Guinea Pigs, 23 May 2015

- effective tracking over time of consumers' knowledge of and appetite for new technologies, to help anticipate uptake and its potential implications
- opportunities for New Zealand businesses and consumers to benefit from innovative applications of new technologies – for example, through demonstration projects
- develop specialist expertise and innovative technologies within New Zealand that could be exported overseas.