Response to Commerce Commission's request for views on ensuring our energy regulation is fit for purpose

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Electrifying the economy

The electricity industry is entering an almost perfect storm of change. That change includes:

- New technology, such as solar, batteries and smart control at the household and distribution level, that makes demand appear a lot more elastic.
- The electrification of the economy, resulting in an increase in electricity demand of 50-100% by 2050 depending on factors like population growth.
- A substantial growth in inverter-based technologies (wind, solar) which reduces power system inertia.
- Two way power flows at the distribution level.
- A massive increase in batteries and smart control that enables power system stability to be managed much more effectively nationally (i.e. the flip side of reducing inertia) and at the distribution level.
- The potential to use new technology to flatten demand and therefore substantially increase the deployment of capital in the electricity sector.
- An increased demand for reliability of electricity, particularly in rural communities as people move to places like Queenstown/Upper Clutha/Coromandel/Northland for lifestyle reasons and demand urban-levels of reliability in order to run their businesses.

A new era of innovation is needed in the electricity sector. Globally, regulators are beginning to recognise the challenges facing the electricity sector and are responding in different ways. The Commerce Commission together with the Electricity Authority has the opportunity to draw from the learnings in other jurisdictions and apply those learnings to New Zealand.

Attached is a paper solarZero has prepared for the upcoming Electricity Engineers Association annual conference. The paper explores the challenges the industry faces.

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A new era of innovation in the power system

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Abstract

Distributed energy resources, smart control and the electrification of the economy will combine to create a perfect storm of change for the electricity industry. To successfully navigate through this period of rapid change and to create an efficient power system a new era of innovation in the power system is needed. This paper outlines some of the main challenges, proposes some ways forward and presents a case study that gives a glimpse into the future.

Introduction

The electricity sector is going to go through a substantial change in the next couple of decades. While a couple of decades may sound like a long time, it is well within the infrastructure planning and timelines that everyone in the electricity system is working within so planning for this new future needs to begin now. The perfect storm of changes include:

- The increase in distributed energy resources, such as solar, batteries and smart control. Much of this new technology will be "behind the meter"
- A substantial growth in inverter based technologies, such as solar and wind which means that inertia reduces.
- The electrification of transport, certainly the light fleet via batteries and the heavy fleet via a combination of batteries and possibly hydrogen, which will be generated from electricity.
- The demand for increased reliability in the electricity including in rural areas as people take advantage of the internet to run businesses in remote locations and rural economic activity becomes increasingly dependent on sensing and algorithms.
- The overall electrification of the economy resulting in a growth in demand of between 50 and 100% by 2050, depending on a range of factors such as population growth.

The combination of these challenges will require a substantial step up for the entire electricity sector. New technologies and new management frameworks will be deployed. Most in the sector will not have training in how to use, encourage, support and manage the new technologies and how to implement the new management frameworks. Rules and regulations will need to be rapidly changed to enable new technology. The whole industry will be learning as it goes. Innovation, pilots and sharing of learnings will be a key part of developing an electricity system in the coming few years as the electricity sector steps up to provide a key solution to addressing the climate change challenge.

The benefits of navigating this perfect storm well are significant for the whole economy. The power system does not use capital particularly efficiently. The system is built to meet peak demand which occurs for relatively short time spells. In the past very little could be done to increase the efficiency of the power system. Apart from ripple control for hot water and some variations in industrial demand, electricity has been too valuable and useful to alter demand patterns. Cost-effective technology did not exist to improve the overall capital efficiency of the electricity sector.

The approach of building infrastructure to meet supply at almost any cost can now change. New technology enables the power system to operate at a much higher level of efficiency. The productivity of the power system increases and because the power system becomes fundamental to powering the economy, the efficiency and productivity of the whole economy increases.

Using a motorway analogy, new technology and management techniques enable a constant flow of cars 24/7 avoiding the morning and evening peak. The result is that a substantial amount of traffic can be accommodated and the motorway network much more efficiently enables the capital deployed to be used at a much higher level of efficiency.

Distributed energy resources and smart control

In this paper we focus on four aspects of distributed energy and smart control:

- The technology itself.
- The rules enabling DER
- Software development
- Management frameworks for DER

DER technology – solar, batteries and smart control

By far the most common form of DER is solar, batteries and a computer that manages the batteries and key loads in the house, such as hot water heating and EV charging. The computer at the heart of the battery system views the battery as just another device to be managed, along with hot water, EV charging and other appliances.

The battery charges during the night and discharges during the morning and evening peaks. The result is a substantial change to household energy demand profile as seen by the network (Figure 1). In addition the battery can discharge or charge very quickly, providing power system stability services (Figure 2).

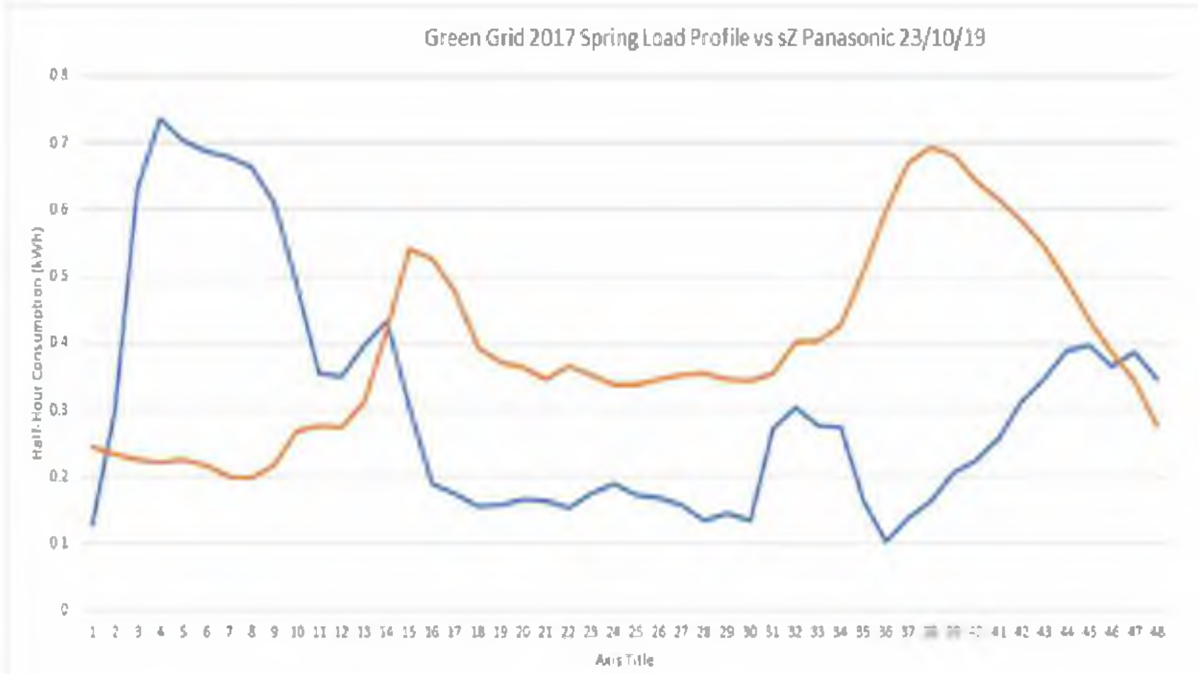

Figure 1: Average household profile (orange) and profile of an average solarZero house, over the 48 timesteps of the electricity day. The average household electricity demand profile is from the Green Grid Programme.

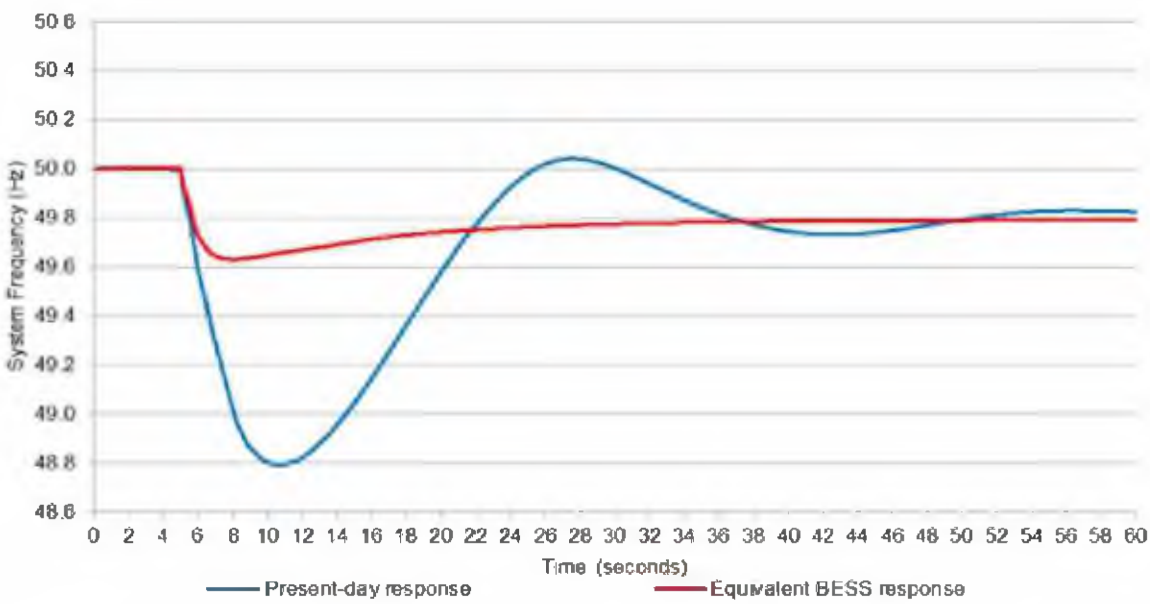

Figure 2: Under-frequency event comparison between a present-day system response and an equivalent battery response. Source: Distributed BESS in NZ, Transpower (2019).

As has been identified in Whakamana Te Mauri Hiko and other reports, a value stack can be created for distributed batteries and smart control. The stack will vary regionally and in time. For example, at certain times playing the batteries and smart control into the reserves market may generate the most value. At other times meeting distribution benefits may generate the most value.

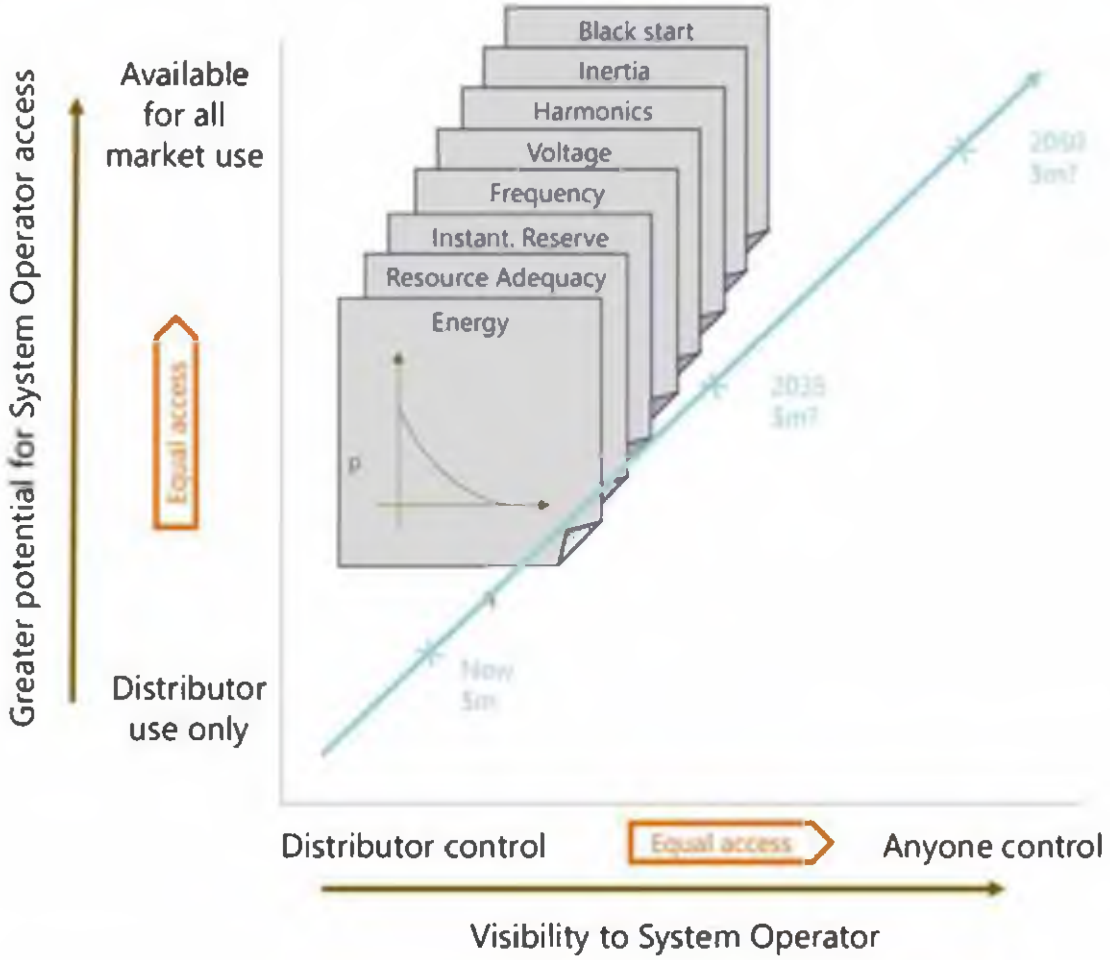

Figure 3: Range of values for distributed energy resources. Source: Distributed Energy Resources – Understanding the potential, Sapere for the System Operator, July 2020

From an economics perspective, batteries and smart control make household demand much more elastic. This change in elasticity alters the paradigm of electricity management. To date household demand has been regarded as inelastic with the exception of hot water control.

Increasing the elasticity of household demand means that pricing signals will need to be set correctly at the national and distribution level. Aggregators/flexibility service providers can now choose how electricity profiles can be played into different markets. Household load and generation will be played into different markets, at times down to the millisecond scale. In the future there may be competition between distribution networks and the grid owner, system operator and retailers for access to household flexibility at certain times. There may even be competition between different markets. Pricing regimes by distribution networks and at the national level will need to be tuned and refined to ensure that the much more flexible household load and injection responds optimally to pricing signals.

Rules enabling DER

The Electricity Code needs a substantial overhaul to address DER. The Code has been developed on three fundamental premises:

- There is a discrete set of technologies that perform certain functions in the electricity system. These are identified in the code. Tail-water suppressed hydro generation and partially loaded hydro generation are examples.
- Electricity demand is fundamentally inelastic.
- Generation is from large power plants pushing power in one direction.

While adding interruptible load (IL) into the Code was a good step forward, adding IL was essentially a "hack" of the existing Code. The fundamental premises of the Code were not changed.

As outlined above household load can now be considered fairly elastic. As solar and batteries proliferate, small commercial and then large commercial load will also appear increasingly elastic. The Code needs to reflect the increasingly elastic nature of demand.

DER are distributed. The power system of the future will have millions of devices all responding to different signals and playing their part in overall power system management. The Code needs to reflect this new future. This new future requires two related developments; software development and new management frameworks.

Software development

Power system management software at the transmission level reflects the code and visa versa. Reserves is an example, where the software reflects the technology that is available. Updating the Code will require an update to the Reserves Management Tool (RMT). The two go hand in hand – any change to the Code is likely to require a change to software and enhancements in power system management which are enabled by development of software is likely to require a change to the Code.

Similarly at the distribution level, increased DER is likely to require adoption and enhancement of software. Around the world there are various initiatives to develop software solutions for integrating DER into distribution management systems. Key is greater visibility and control potentially at a very small scale, for example, potentially down to the individual distribution transformer level where demand from the uptake of EV may cause issues for the network.

Management frameworks for DER

Both Transpower and lines companies will need to make calls on the relative effort spent on supporting DER and traditional solutions to electricity demand growth and changes. DER development needs an enabling environment, for example, Transpower and lines companies need to support DER as compared to just building more infrastructure.

Electricity sector management frameworks will need a comprehensive review if DER are to be better enabled. Under the current management frameworks it is generally easier for lines companies to build more infrastructure than look at DER solutions. For a start, electricity sector professionals have very limited experience in DER solutions – these are new and were not part of the training and education programme when electricity sector professionals were doing their engineering degrees. Even today, DER are not a significant feature of electrical engineering degrees – we are not yet equipping our future electrical engineers with the skills they will need in a very different electricity sector. In addition, an attitudinal change to contracting for solutions rather than engineering and owning solutions may be required.

At a national scale some kind of collective approach is needed to better enabling DER. The Network Transformation Roadmap is a good start, but an action plan is needed to support the deployment of DER at a distribution level. Sharing of information and learning are key to supporting the evolution of management frameworks for DER. Standardised communication protocols and/or communication standards are likely to be a key enabler.

Reducing inertia – the role of batteries

As the New Zealand power system moves closer to 100% renewable generation, inertia is likely to reduce. In addition, geothermal general, wind generation and solar generation cannot provide reserves, i.e. they cannot quickly offer a sustained injection of energy. Globally the challenge of power system stability due to increasing renewables is an increasing focus of attention[1].

Distributed batteries can provide an injection of power in response to a reduction in frequency. Currently the inverters will follow frequency so power system stability still relies on some spinning generation to anchor the frequency. But distributed batteries have the potential to provide much more finely tuned frequency management than the relatively blunt approaches currently used in the New Zealand power system; increasing hydro output and interruptible load.

Batteries can respond not just to thresholds in frequency reduction, but also to rate of change of frequency. Further, batteries can assist with managing a decline in frequency and the resulting over frequency which currently occurs during a frequency event. Frequency events in the future are likely to be much more effectively managed as DER proliferates, provided that the management frameworks are in place to enable DER to participate in ancillary services markets.

Electrification of transport – is a massive increase in electricity network infrastructure needed?

With smart charging of EV a massive increase in electricity infrastructure for EV charging may not be needed – at least for the light fleet. For example, on the Orion network there is enough spare capacity to enable charging of some 300,000 EV at off peak times (Figure 4).

The challenge with ensuring EV charging at the right time is likely to have a strong social aspect. EV owners need to be encouraged to charge at certain times. Smart home technology will assist. But aggregators/flexibility service providers who will manage household demand will optimise EV charging and other household loads to maximise value for customers. Pricing regimes therefore become critical.

[1] https://www.greentechmedia.com/squared/dispatches-from-the-grid-edge/solving-the-renewable-powered-grids-inertia-problem-with-advanced-inverters

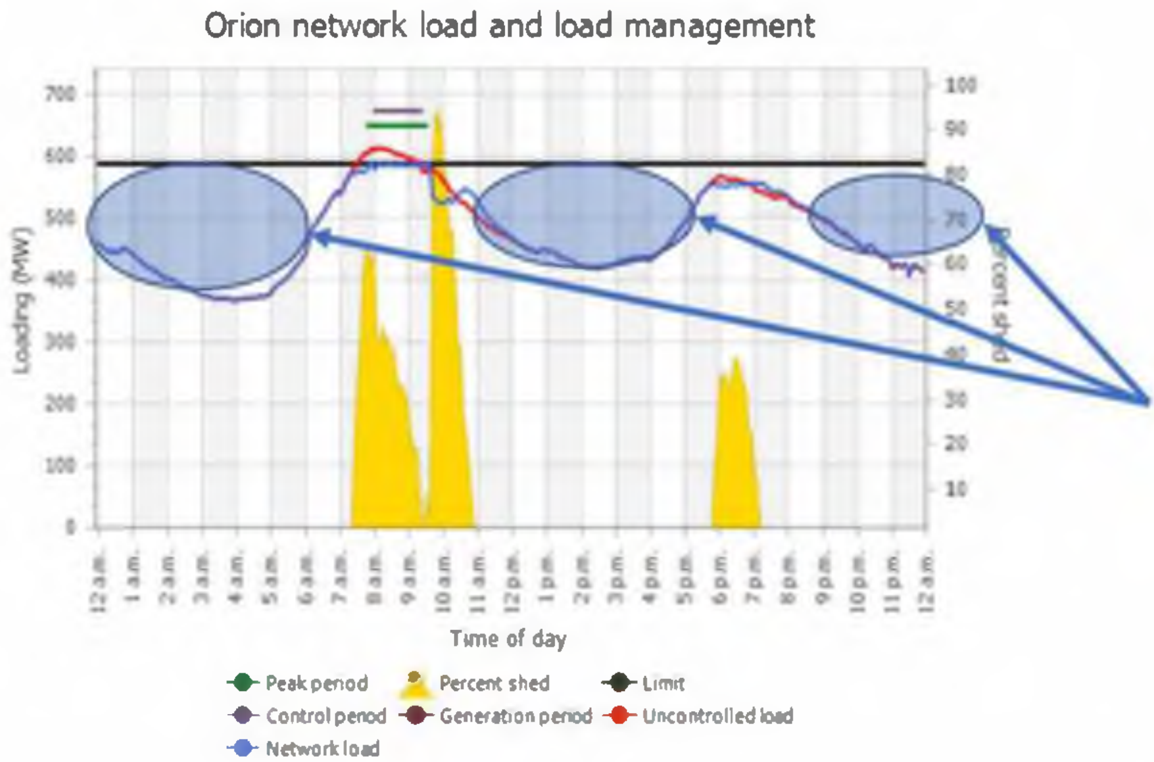

Figure 4: The blue shaded oval areas represent charging 300,000 EV travelling 50km. Network peak is not exceeded if the EV are charged at the right time

Increased reliability

In some rural area of New Zealand households are demanding increased reliability of the electricity system, for example, in the Upper Clutha and Queenstown areas[2]. Businesses that rely on the internet can require very high levels of reliability. In some rural areas achieving urban-levels of reliability may be prohibitively expensive. Households and businesses that do not need ultra high levels of reliability should not be expected to pay the infrastructure costs to those who value ultra-high reliability.

DER provides a solution for those requiring ultra-high reliability in rural areas. Lines companies should work with customers needing ultra-high reliability and encourage those customers to adopt DER technology. The Commerce Commission together with the Electricity Authority should update policy around reliability. That policy update should acknowledge that technology now exists enabling ultra-high reliability for householders and in the near future for commercial businesses. Part of the policy refresh should include promotion of technology enabling ultra-high reliability and an explanation that achieving ultra-high reliability via networks in rural areas is not always financially possible.

Meeting the growth in demand

Electricity is going to power the economy – it will take the place of oil, gas and coal. DER, mostly solar, are likely to provide an important source of generation, alongside other forms such as wind

[2] Based on anecdotal evidence – see Upper Clutha case study later.

generation. The solar potential in New Zealand is massive. For example, covering half the area of Rangitoto Island[3] in solar will enable New Zealand to reach 100% renewable electricity generation[4].

Globally, solar is now the largest and the fastest growing form of new generation[5]. Hopefully the electricity industry in New Zealand has now come to recognise that solar, as part of a DER revolution, will play an important part in the electricity future of New Zealand.

New Zealand electricity industry attitudes to solar will need to change. As recently as 5 years ago the perception in the industry was that solar was a "problem" as compared to a key solution to the climate change challenge (Figure 5). It is indeed ironic that the electricity industry challenged the value of solar at a time when solar was the only climate-friendly new generation being installed in New Zealand.

Figure 5: Headlines on the Stuff website between 2016 showing a change in attitude towards solar generation

Case study – Upper Clutha Non-network solution

The Upper Clutha area (Wanaka, Hawea and Cardrona) is growing rapidly. The electricity supply to the area is nearing capacity. Aurora Energy, the lines company in the Otago area, sought tenders for cost-effective solutions that could defer the network upgrade. Non-network solutions are increasingly being used internationally, with the most well known being the Brooklyn-Queens substation deferral in New York, which began in the later 2000s. The substation has not yet been upgraded.

solarZero was chosen as a supplier by Aurora Energy for the non-network solution using household solar and batteries to reduce morning and evening peak demand. The project got underway in earnest in mid April 2021, following the final Commerce Commission announcement on the

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[3] Not that we are in any way suggesting installing large scale solar on Rangitoto Island.

[4] After allowing for wind and geothermal generation under construction or announced to be completed.

[5] https://www.carbonbrief.org/exceptional-new-normal-iea-raises-growth-forecast-for-wind-and-solar-by-another-25

Customised Price Path for Aurora Energy at the end of March. We are working closely with Aurora Energy.

The most urgent issue for Aurora Energy is summer evening peak. Initially, installing around 200 household solar and battery systems per year will reduce the peak sufficiently to defer the upgrade. How much peak reduction is required in the future will depend on growth rates in the Upper Clutha area.

Non-network solutions comprise a mix of technology and social aspects and the Upper Clutha non-network solution is no exception. The technology aspects comprises a solar and battery system, coupled with smart control and communications. Peak demand in each house is managed collectively resulting in a reduction in the load across the network. At times the batteries can be “called” to provide electricity outside of the morning or evening peak.

The social aspects involve working with different groups and sectors across the Upper Clutha community, informing and educating them about the electricity supply challenge the area faces. The community is receptive to the issue and the “virtual power plant” solution being offered by solarZero. It is widely recognised that the growth in housing is substantial and that the level of growth will result in infrastructure challenges. Deferring the need for an electricity network upgrade by creating a virtual power plant is something that can be explained and understood by the community and a concept that the community is willing to engage with. At the time of writing this paper, sales of the solarZero solution to support the Upper Clutha virtual power plant have been strong.

An added advantage of a household solar and battery solution is increased household resilience. Some households require ultra-high electricity reliability, compared to the norm in rural areas. A number of people in the Upper Clutha area run national or even international businesses via the internet. In part the growth of the Upper Clutha area is a consequence of people being able to do business online. Households or businesses that require ultra-reliable electricity can install solar and battery systems, which also contribute to the community-level virtual power plant. Potentially the model of rural households that need ultra-reliable electricity adopting solar and batteries can avoid expensive upgrades of power systems in rural areas.

At the time of writing this paper the initial indications are that the concept of a virtual power plant is resonating with the community. The role Aurora Energy has played is enabling a 21st century solution for a community that appears ready to embrace it. As a flexibility trader, solarZero is able to add to the value stack for distributed batteries. Ultimately the customers - which are both solarZero and Aurora Energy customers - will have an improved power system.

Summary

Significant innovation in the power system is going to happen, possibly rapidly. Distributed energy resources are now available and are cost effective. The pace of change will be determined by the rules, regulations, the development of management frameworks and the development of software.

There are many upsides and few downsides of DER. One of the biggest upsides is that the use of capital and therefore productivity of the electricity system will increase significantly. That increase in productivity comes at a critical time - electricity will replace fossil fuels and will power the economy. The combination of this increase in productivity with the electrification of the economy is fortuitous

- national welfare will increase as a consequence of the more efficient deployment of capital in the electricity industry.

Electricity demand will appear increasingly price elastic. That is a substantial change. Electricity demand has always appeared inelastic. Consumers, or more likely aggregators/flexibility traders, will respond to price signals. Market signals will need to be created at the distribution level to which flexibility service providers will respond resulting in a much more efficient power system. But the pricing signals will need to be carefully developed to ensure the flexibility providers respond optimally.

The electricity industry will need to embrace DER solutions and quickly if the economy is to electrify cost effectively. Key will be exploring solutions that may not involve engineering but may involve pricing. The Upper Clutha non-network solution is an example of the kind of project that DER enables, resulting in a more efficient, effective and resilient power system. We look forward to the industry following Aurora Energy's lead, the vision set out in Whakamana Te Mauri Hiko and the work of the Electricity Authority's Innovation and Participation Advisory Group, all of which point to a future where DER plays a significant role in the power system.