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Smart Grid in a New Zealand Context

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Andrew Lapthorn* [1], Neville Watson[1]

[1] Electrical and Computer Engineering, University of Canterbury

* Presenting

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1 INTRODUCTION

Early in 2011 a report was commissioned by Transpower New Zealand Limited and the Ministry of Science and Innovation into Smart Grid in a New Zealand context. In New Zealand, plans for a Smart Grid will likely differ from those in other countries. This is because New Zealand is starting from a different position than the rest of the world. For example, the generation mix in New Zealand is fairly unique compared with other countries, with New Zealand having a large renewable base compared with many countries having a large thermal base capacity.

In addition, many countries see load management as an area Smart Grids could improve their system. In the New Zealand context direct control is already widely used via ripple control of hot water heating and contracted interruptible load. However, it must be said that ripple control system would now be considered low spec by today's standards and regulatory and market drivers have over recent years resulted in a general erosion of capabilities. Thus there is a need for the industry to become pro-active in this and other Smart Grid areas.

The purpose of this paper is to provide an overview of the main findings of the report and to present this information to a wider audience than might otherwise see it. For those who are interested, the full report can be found in [1]. The paper begins by examining what progress has been made toward Smart Grids in other countries and the progress of smart grid standards. This is followed by an overview of some of the significant steps towards a smart grid that have been made in New Zealand. The paper then finishes with some concluding remarks.

2 SMART GRIDS AROUND THE WORLD

The scope of Smart Grid progress throughout the world is vast. Even in [1] where a lot more space is given to the topic and 80 pages are dedicated to examining Smart Grid progress in North America, Europe, Asia, and Australia, the report barely touches the surface of what is happening.

There are however, a number of common trends appearing. In most countries looked at, there has been some sort of Smart Grid task force or committee established [2-6], usually by government, to oversee and direct the Smart Grid implementation in their country or region.

There have also been a considerable number of pilot or demonstration projects funded either publicly and/or privately, showcasing a wide variety of Smart technologies ranging from in home smart appliances and metering, distribution level Energy Management Systems and Distributed Generation (DG) including wind and PV, and transmission level Automated Load Control, Active Volt-Var Control, Fault Detection, and Wide Area Measurement.

Another area that has seen a lot of attention is in Advanced Metering Infrastructure (AMI) or smart meters. Globally there have been mass rollouts of smart meters and a significant portion of world smart grid expenditure has been allocated to this. Some notable examples include the Telegestore project in Italy [6], the State Grid Corporation of China [7], and the National Smart Metering Program in Australia.

3 STANDARDS DEVELOPMENT

It is apparent that to achieve a fully functioning Smart Grid will require a large investment in a variety of devices and systems throughout the entire electricity system. A key element to interconnecting these devices and systems is interoperability. Standards development will play a key role in ensuring interoperability and assisting the uptake of new technologies by the various users of the electricity network such as utilities and consumers.

The IEC is based in Europe and produces a large number of standards and technical reports related to the electric power industry. The IEC is aware of the role standards have on Smart Grid development and have already identified a number of IEC standards relevant to Smart Grids. These are;

- IEC/TR 62357 – Framework of power automation standards and description of the SOA (Service Oriented Architecture) concept.
- IEC 61850 – Substation automation and beyond
- IEC 61970 – Energy Management System – CIM and GID definitions
- IEC 61968 – Distribution Management System – CIM and CIS definitions
- IEC 62351 – Security

In 2008 the IEC created a Smart Grid Strategic Group, SG3, tasked with developing a framework for Smart Grid Standardisation. IEC SG3 has produced a Smart Grid Standardization Roadmap [8] covering general topics such as communication, security, and planning as well more specific applications including smart transmission systems, renewable energy generation, distributed automation, demand response, and electric storage, as well as many additional topics.

In the United States, the Energy Independence and Security Act of 2007 assigns to the National Institute of Standards and Technology (NIST) the "primary responsibility to coordinate development of a framework that includes protocols and model standards for information management to achieve interoperability of Smart Grid devices and systems" [9].

In response to the urgent need to establish interoperability standards and protocols for the Smart Grid, NIST developed a three-phase plan:

1. To accelerate the identification and consensus on Smart Grid standards.
2. To establish a robust Smart Grid Interoperability Panel (SGIP) that sustains the development of the many additional standards that will be needed.
3. To create a conformity testing and certification infrastructure.

In January 2010 the NIST published the *NIST Framework and Roadmap for Smart Grid Interoperability Standards, Release 1.0* in which 75 existing standards were identified that were applicable to Smart Grid development. In addition, there were 15 high-priority gaps identified which required new or revised standards. Since 2010 progress had been made on Phases 2 and 3 of the NIST plan leading to the publication of NIST Framework and Roadmap for Smart Grid Interoperability Standards, Release 2.0

In the context of a New Zealand Smart Grid, the work carried out by the IEC and the NIST will play a significant role in how the grid will develop.

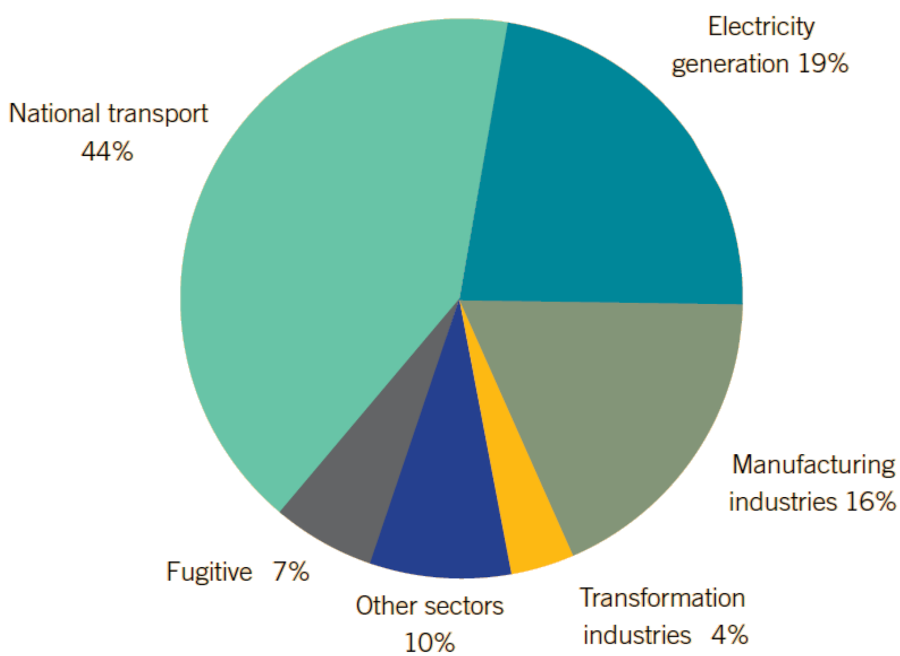
4 Smart Grids In New Zealand

Current Smart Grid progress in New Zealand has been happening over the entire electricity sector. Some highlights are presented below.

4.1 Government

Unlike in most other countries examined in this paper, at this stage, there is no specific policy on Smart Grids from the New Zealand government. However, general policy regarding the electricity sector is found in New Zealand's Energy policy, which is set by the Ministry of Economic Development. In August 2011, the government released the New Zealand Energy Strategy 2011-2021 (NZES) [10]. The New Zealand Energy Strategy 2011-2021 sets out four priority areas:

- **Diverse Resource Development** This priority area has three main focus topics; develop renewable energy resources, develop petroleum and mineral fuel resources, and embrace new energy technologies. As part of the renewable energy resources focus, the government has set a target that 90% of electricity generation should be from renewables by 2025, providing this does not affect security of supply.
- **Environmental Responsibility** This priority area has two main focus topics; best practice in environmental management for energy projects, and reduce energy-related greenhouse gas emissions, see Figure 1. The Government has set a target for a 50 percent reduction in New Zealand's greenhouse gas emissions from 1990 levels by 2050.



- Figure 1: New Zealand Energy Emissions by Sector in 2009 [10]

- **Efficient Use of Energy** This priority area has four main focus topics; warm, dry, energy efficient homes; an energy efficient transport system; enhance business competitiveness through energy efficiency; and better consumer information to inform energy choices. This priority area touches upon AMI technology. *"As smart meter technology is installed by companies, the Government will ensure consumer rights are protected, and will monitor the effect on consumer energy use and electricity bills. The Government will encourage industry participants to explore the opportunities offered by smart meter, grid and appliance technologies in providing consumers with better information and options for their energy management."*

- **Secure and Affordable Energy** This priority area has three main focus topics; competitive energy markets, reliable electricity supply, oil security and transport. In 2009 and 2010, the review of the electricity market resulted in significant electricity market reforms. The reforms make it easier for more electricity retailers to operate across New Zealand, so customers will have more choice in providers. The Government has also established a three-year $15 million fund to promote customer switching. The Electricity Authority estimates that residential customers could save on average about $150 a year – or $240 million a year across all customers – by switching to the cheapest available retailer. The Government's major electricity market review in 2009 also resulted in a broad suite of proposals to increase security of supply. New measures to promote secure electricity supply include phasing out the reserve energy scheme and ensuring that market participants have clear incentives to manage risk. These incentives include a proposed floor on spot prices and requiring companies to compensate consumers during conservation campaigns.

4.2 Generation

The mix of generation in New Zealand consists of hydro, geothermal, coal, gas, and wind, with around 77% of the generation coming from renewables. This puts New Zealand third in the world for renewable generation as a percentage of total electricity as shown in Figure 2.

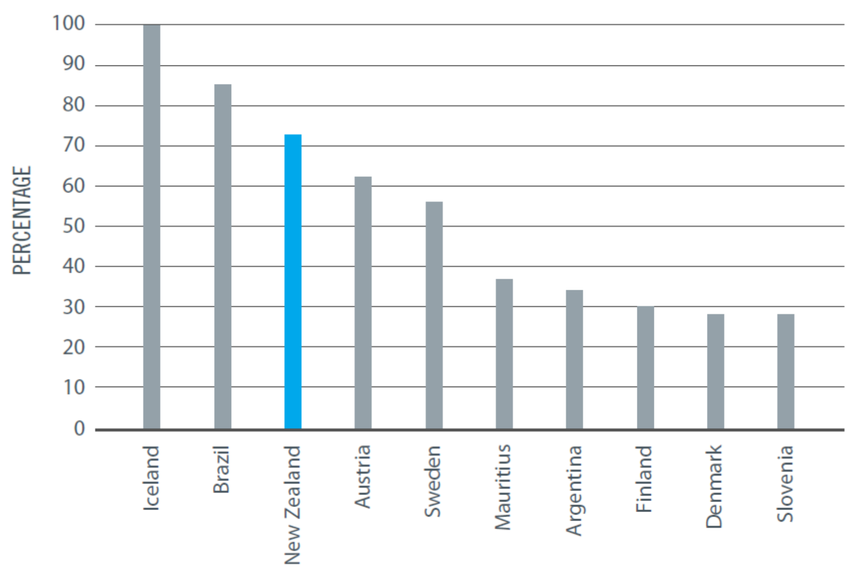


Figure 2: Top 10 Renewable Electricity Countries as a % of Total Electricity [11]

The control of these generation assets is quite advanced, with companies having invested in complex SCADA systems over the past couple of decades. These systems allow for remote control and monitoring of all of the generator's assets, exchanging data every few seconds. This means a high level of automation is possible, for example, whole stations can be given a set point for MW and MVAr and operated automatically or control can be done at the unit level. While automation algorithms are present, the generation systems are overseen by trained human operators.

The advanced control systems available to the generators should make possible Smart Grid style operations such as enhanced frequency and voltage control algorithms, and automatic generation control and dispatch. These systems will become more important with increasing amounts of intermittent renewable energy such as wind or solar. They will also require centralised control and communications, probably from Transpower as the System Operator. However, at this stage each generator has their own communication and control systems which are not compatible with each other as highlighted by the exchange between Meridian Energy and Genesis Power of Tekapo A and B power stations which needed to be controlled by MEL while Genesis put their own systems in place.

4.3 TRANSMISSION

The transmission network in New Zealand, known as the National Grid, is owned and operated by Transpower New Zealand Limited who is also the System Operator. Transpower has moved from a long period of very low investment, over the last 20 years, to a concentrated period of high reinvestment in the transmission grid. Between 1995/96 and 2004/05, capital expenditure on new build and asset renewal averaged around $100 million per year. However, over the next decade Transpower expects to spend $3 to $5 billion to meet future electricity demand.

A. Grid Upgrade Projects

Transpower currently has committed to over 20 upgrade projects throughout New Zealand with four major projects totalling $2 billion. These projects are:

- North Island Grid Upgrade - Building a new power link between Whakamaru and Auckland.
- North Auckland and Northland Grid Upgrade Project - Reinforcing the network with a new 220kV cable link and two new substations.
- HVDC Inter-Island Link Project - Replacing Pole 1 of the inter-island HVDC link with a new pole.
- Wairakei to Whakamaru Replacement Transmission Line Project - Building of a 400kV line.

B. Transmission Tomorrow

In 2008, Transpower began to look at the future of generation and the use of electricity in New Zealand as part of their Transmission 2040 strategy. They were aware that transmission is interlinked with a diverse range of stakeholders in the wider electricity system, including customers, landowners, distribution networks, retailers, generators and others. As such the changing face of the electricity sector would have a significant impact on the transmission network. The Transmission Tomorrow document describes Transpower's views about the future needs for New Zealand's electricity transmission. They see [12];

- An economy becoming increasingly reliant on electricity, with increasing expectations of a reliable supply.
- Transmission technology changing, enabling Transpower to utilise their existing assets better.
- Technology enabling far more interaction with and by consumers.
- Increasing amounts of remote and intermittent generation being built.

The major long-term planning concerns the high voltage backbone grid. Today, the backbone grid predominantly carries energy from south to north. This often reverses overnight, as South Island hydro generators conserve water, and periodically reverses in dry winters, when the southern hydro lakes run low.

Transpower has developed three strategies to deliver the grid of tomorrow. The three strategies are, Lifting Grid Performance, Lifting System Performance, and Improving Reliability and Resilience.

4.4 DISTRIBUTION

The distribution sector in New Zealand is divided up into Electricity Network Businesses (ENBs). Together the ENBs manage approximately 150,000 km of local lines, $7.35 billion in assets and are forecast to spend $7.5 billion on capital and operating expenditure in the next 10 years [13].

C. Electricity Networks Association – Smart Networks

The Electricity Networks Association (ENA), an organisation providing advocacy and support services to ENBs, recently released a report, *"The case for deployment of smart network technologies in New Zealand"* [13], in which a cost benefit analysis of smart technologies was presented. The ENA created a Smart Network Working Group (SNWG) comprising of representatives form 10 different ENBs. The objectives of the SNWG are to:

- Develop the business case for smart networks (in the New Zealand context) in order for Electricity Network Businesses (ENB's) to maximise the value of the technology for their customers and owners; and

- Develop industry positions with regard to the implementation of and opportunities presented by smart networks technology in line with the stated objectives of the Electricity Networks Association and its members.

The ENA suggests in [13] that *"Electricity flows are likely to move from unidirectional to two way flows with the possibility of widespread micro DG (notably photovoltaics) and storage. Variability and intermittency of generation sources will come with increases in renewable generation and greater penetration of DG. The prospect of a significant step-up in demand from electric vehicles and the possibility that they may also provide system storage are more changes that are likely."*

The participants in the SNWG developed a cost benefit analysis of the deployment of smart network technologies presented in Table 1. They analysed several different ways that smart network technologies could be expected to benefit the ENBs and consumers such as deferred capital expenditure, increased reliability and efficiency and compared to the expected costs to implement these systems. Furthermore, the SNWG was able to assemble these into ‘Worst case’, ‘Possible outcome’, and ‘Optimistic case’ scenarios.

The analysis suggests there is likely to be significant gains, from a national perspective, from the adoption of smart network technologies. Although, individual ENBs are likely have differing costs and benefits depending on their current situation regarding asset age, expected growth, spare capacity etc.

TABLE 1: ESTIMATED PRESENT VALUE OF SMART NETWORK COSTS AND BENEFITS [13]

Benefits	PV ($millions) Worst Case	Possible Outcome	Optimistic Case
Deferred generation capital expenditure	$200	$400	$400
Deferred transmission capital expenditure	$182	$363	$436
Reliability, PQ and customer engagement	$132	$264	$396
Deferred distribution capital expenditure	$129	$258	$310
Carbon saving from less fossil fuel base load build	$84	$168	$168
Less petroleum fuel use	$26	$27	$27
Metering	$8	$17	$25
Smart Network Benefits	**$761**	**$1496**	**$1761**

Costs	Worst Case	Possible Outcome	Optimistic Case
Metering	$380	$201	$201
Changes to Network planning	$220	$120	$90
Improved demand forecasting	$219	$119	$89
Demand response	$199	$78	$59
Additional Smart Network Operating Costs	**$1018**	**$518**	**$439**

Benefit Cost Ratio	Worst Case	Possible Outcome	Optimistic Case
All benefits / all costs	0.7	2.9	4.0

D. Advanced Metering Infrastructure

Like many countries in the world, New Zealand is currently in the process of a national roll out of smart meters and AMI. Figure 4 provides a projection the estimated number of AMI installations for New Zealand. However, due to a number of reasons, the roll out in New Zealand differs significantly from those overseas. The use of advanced meters in New Zealand is being driven by market forces, rather than by government or regulatory decisions. This is because New Zealand already has a centralised load management system (the ripple control system) in place since the 1950s. Therefore, load management is not a primary driver of AMI in New Zealand as seen in some other countries.

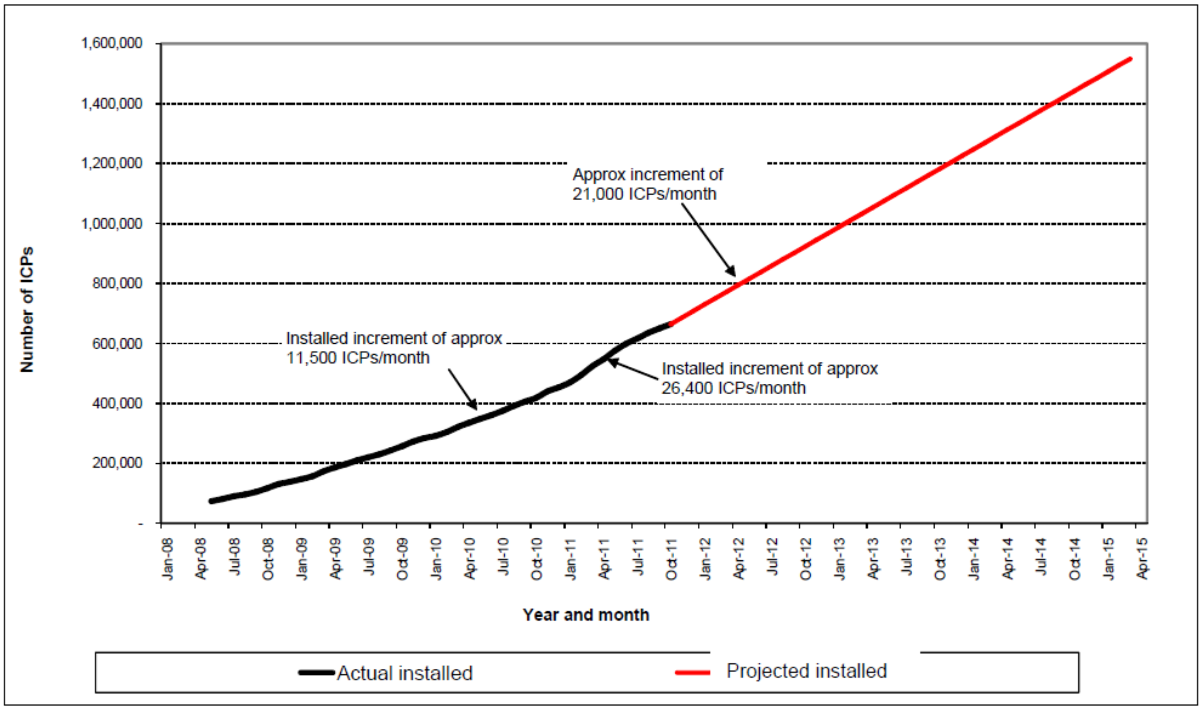


FIGURE 1: ESTIMATE OF ACTUAL AND PROJECTED AMI METER INSTALLATIONS

According to the Electricity Commission's report on the AMI roll-out in New Zealand [58] there also appear to be several other drivers that have not been seen in other countries. These are:

a) Interim compliance deadline of 2015: The Rules provide that retailers must ensure that meters at residential and small commercial premises are fully certified by 1 April 2015. Retailers must either:

- ensure that their existing meters are fully certified, by requiring the meter owner to fully certify their meters. That can involve statistical sampling of meter populations to the individual testing of each meter installation, the removal and testing of meters, and the replacement of meters once certified; or

- install or acquire new, fully certified meters.

Many retailers and meter owners have taken the opportunity to install new advanced meters that deliver additional functionality, rather than certify their old meters.

b) Lease costs for advanced meters have fallen.

c) Operational efficiencies that reduce retailers' costs to serve.

d) Competitive provision of metering assets.

Unlike many other countries where the provision of metering is a monopoly activity, in New Zealand, the provision and operation of meter services is a competitive market. As some of New Zealand's major electricity retailers do not own meters, they face no stranded metering asset costs if they switch from existing basic meters to advanced meters. Those retailers therefore face a lower financial hurdle to using advanced meters than retailers that own meters.

For a similar reason, meters are usually not replaced when a consumer switches retailers. Provided the meter has the attributes required by the retailer gaining the consumer, the gaining retailer will normally lease the use of the meter from the existing meter owner (which could be the outgoing retailer or a third party supplier).

A roll-out of AMR meters in Christchurch by Meridian Energy via its subsidiary Arc Innovations, appears to have acted as a catalyst for other retailers to roll out advanced meters. This indicates that competition in the deregulated electricity market is producing benefits. Therefore, the roll-out of advanced meters by one retailer appears to have placed competitive pressure on other retailers to do likewise.

4.5 RETAIL

The New Zealand retail electricity market consists of 17 companies. The five major electricity generators in New Zealand own 9 of these retail companies between them and service approximately 95% of the ICPs as of 2011. These major retailers offer a range of different pricing plans to the consumer these include:

- Anytime / 24 hour / Continuous / All Day / Uncontrolled
- Controlled / Economy
- Composite / Economy 24 / All Inclusive / All Day Economy / Inclusive
- Day / Night
- Night Only
- Night Plus / Night
- Triple Saver - Night / Peak / Off-Peak
- Day / Night (controlled)

The above shows how New Zealand companies have been offering to customers Smart Grid style options such as time of use pricing and load management through hot water ripple control.

It is expected that as the technology matures, load management features could be expanded to include smart appliances such as those that have been trialled overseas or to offer “real-time” pricing options to consumers. However, the current roll-out of AMI from the retailers seems primarily concerned with remote meter reading and little emphasis has been placed on providing these options to consumers.

5 CONCLUSIONS

New Zealand already possesses an electricity system that many other countries are striving to achieve by their move to Smart Grid technology. The majority of our electricity is generated from renewable energy sources such as hydro, wind and geothermal and effective peak load management is achievable through ripple control and contracted interruptible load. These two factors are the most common reasons stated by countries for the need for a Smart Grid.

Does this make New Zealand a world leader in Smart Grids? Unfortunately not, as there are a number of aspects to Smart Grid technology where other countries are further advanced than New Zealand. For example, responding to new consumer demands (such as HVAC and EV), distributed generation, and the use of distributed storage. Also, at the policy level, many countries are seeking to reduce oil and gas dependency and this is a considerable driver for smarter networks that can facilitate low carbon transport and diversification of renewable energy sources including greater use of distributed wind, wave, tidal and solar.

There is enough evidence to suggest that there will be significant economic benefits by companies investing in smart technologies through deferred capital expenditure, increased efficiencies and reliability to customers. A number of conclusions regarding the future of electricity and Smart Grids in New Zealand can be stated, these are:

- The demand for electricity in New Zealand is likely to increase in the future.
- The generation mix is going to change. There will be more emphasis on renewable energy resources with the goal of reaching 90% of electricity generation from renewables. New generation is likely to be made from a combination of wind and geothermal. Energy storage systems may become necessary.
- Also there will likely be an increase of distributed generation on low voltage networks as the price of photovoltaic cells continues to decrease. This will need to be carefully managed to avoid the voltage problems that have been seen elsewhere in the world.
- Utilities will gradually install Smart Grid solutions into their networks such as EMS and IEC 61850 based systems to improve interoperability between systems and reliability to customers.
- The ripple control system and contracted interruptible load will continue to be used to manage the peak loading of the grid.
- AMI installations will continue to be installed. This is one area which would benefit from more leadership. With the current regime of each retailer and ENB wanting to install their own systems there is the real risk that overall metering infrastructure of the country will too fragmented to facilitate future smart technologies. This could result in some serious problems in the future as the Smart Meter and associated Home Area Network could be an excellent method for controlling the charging of electric vehicles and other loads.

The introduction of new technologies (at scale rather than simply as demonstrations) will have considerable impact on network company businesses requiring attention to business processes, IT and control system architectures, planning policies, procurement policies, spares and field support, and company skills. It may require new partnerships and interactions with consumers at a much closer level than in recent years. International experience shows that the above tasks are frequently underestimated and many of the excellent demonstrations that can be seen around the world and are described in this report, remain as one-offs. The transition from innovative demonstration to *"Business as Usual"* is critical because it is only when innovation is deployed at scale are the benefits released to consumers and to wider society in the form of productivity gains, exports, and delivery of government policy goals.

6 ACKNOWLEDGMENT

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