ISSUE 687

BULLETIN

INTRODUCTION TO SMART HOMES

November 2023

- There is a rapidly growing number of smart appliances available that can be connected to create a smart home.
- Smart homes offer not just convenience but better energy management, the potential for lower electricity bills and reduced pressure on the electricity grid.
- This bulletin gives an introduction to the topic of smart appliances, smart homes and a smart grid.

1 INTRODUCTION

1.0.1 A growing number of new household appliances are able to be controlled remotely – smart appliances – and in many cases, they can be linked together into a network that is not only convenient but can maximise energy efficiency. This is a smart home.

1.0.2 There are two elements to a definition of a smart appliance or a smart home:

- Smart appliances and devices can be interconnected, automated, managed and monitored remotely, typically through a smartphone via WiFi or Bluetooth. This is sometimes referred to as the internet of things.
- Smart devices can receive, react and respond to external and internal (interoperable) signals so they are operating (and using electricity) at periods of lower demand. This reduces the load on the electricity grid, reduces costs to the consumer and maximises the country's use of renewable electricity, reducing greenhouse gas emissions.

1.0.3 The existing benefits of smart appliances and a smart home for homeowners include:

- convenience, with many devices able to be controlled remotely through a smartphone
- optimising energy consumption and cost savings while still meeting homeowners' needs – for example, appliances such as dishwashers, clothes washers and electric vehicle (EV) chargers can be set to run at periods of lowest-cost electricity
- maximising use of on-site photovoltaic (PV) generation, typically from rooftop solar panels
- energy security.

1.0.4 Another benefit is that smart devices will be able to be controlled remotely by a 'demand flexibility' provider (an electricity distributor) who will pay consumers to permit their appliance to be switched on at a time of lower grid demand. This is already being introduced by some companies and will reduce pressure on the grid over time.

1.0.5 The smart home concept anticipates that there will be a continuing significant increase in the number of EVs and rooftop domestic PV systems. Some models of EV in Aotearoa New Zealand today have bidirectional charging capability – as well as being charged at home, the car battery can provide energy to operate a home for a few hours or to sell back to the grid.

1.0.6 Smart homes offer potentially enormous benefits for the country. Electricity demand is projected to grow at a steep rate in coming years as process heat in industry moves from coal and gas to electricity, EV sales grow rapidly and the size of the economy grows. Making household energy use (about one-third of the country's total use of electricity) more efficient and responsive could have a massive impact because it is the residential peak that drives network investment. For example, some electricity consumption could be moved away from peak hours of 7–9am and 4–8pm (Figure 1). Peak hour generation often requires generation using fossil fuels, so reducing this pressure on the grid will avoid unnecessary overinvestment in generation, transmission and distribution, a potential cost in the billions of dollars that all electricity users would otherwise pay for. It would also help New Zealand achieve its 2050 net-zero carbon commitment.

1.0.7 A current disadvantage of smart appliances is lack of compatibility and standardisation between devices and systems. Interoperability requires communication capability at system and device level. If it doesn't exist at the system level, consumers can have a fully functional smart home that needs reconfiguring each time they change electricity provider. At a device level, a home energy management system (HEMS) can provide a solution by typically communicating with whatever protocol the device uses.

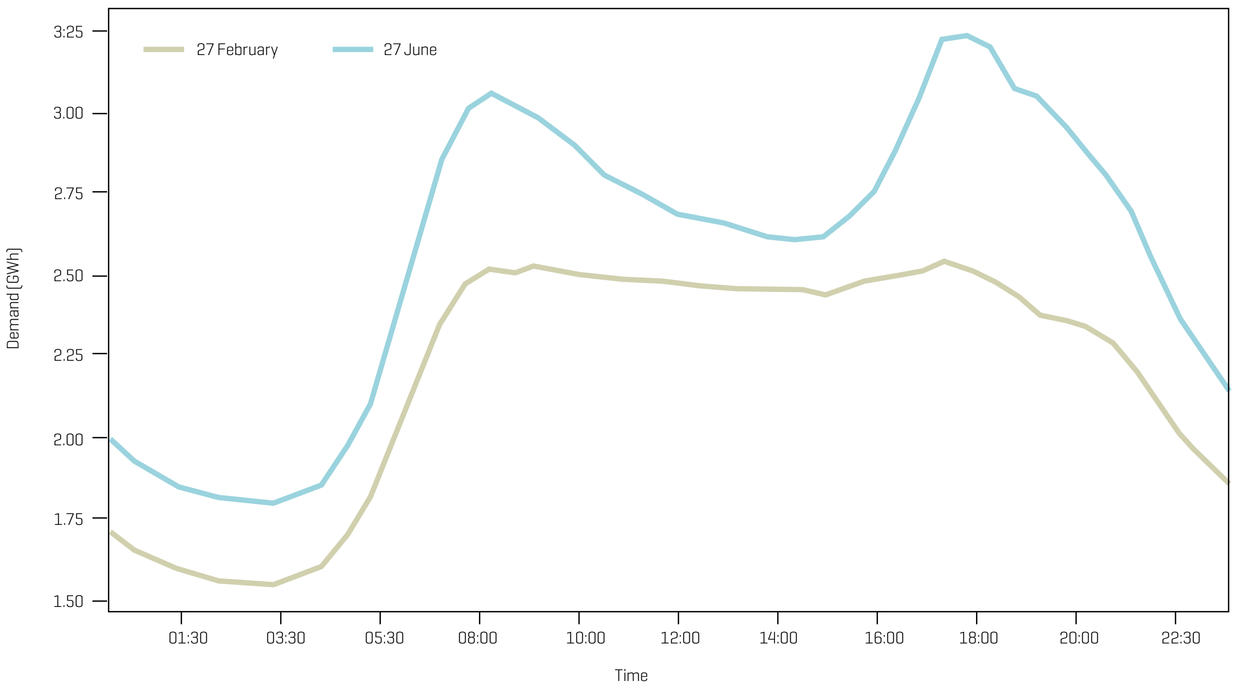

Figure 1. Daily electricity demand on 27 February 2023 and 27 June 2023 showing typical morning and evening peaks. (Source: Electricity Authority)

1.0.8 Smart homes and the smart grid concept are still in their infancy but this is a trend likely to grow rapidly and quickly. Although electrical workers will undertake much of the hands-on electrical work in homes, architects, designers, builders and other practitioners will need to be familiar with the concepts as they make provision for smart appliances and devices in the new homes they are designing, specifying and building. These are some issues to be considered:

- Whether a smart home system will be completely wireless or whether to make provision for cavities or conduits for potential future cables.
- Where an electrical vehicle may be changed overnight, determining the precise location of the charger and assessing electrical load capacity and safety issues. The residential EV charger specifications PAS 6011 (see 7.0.1) can assist with this.
- If a solar PV system is not installed at the time of original construction, how housing should be designed to allow problem-free retrofitting in future. This includes roof orientation and design (north-facing roof surfaces are best for PV systems) and installing the necessary PV electrical cabling from the roof space to a distribution board at the time of house construction.

1.0.9 It is also possible to retrofit connectivity into existing devices and homes. This would see smart thermostats fitted to existing electric hot water cylinders and heat pump connectivity enabled (heat pumps have been required under regulation to have simple capability built in since 2001).

2 SMART APPLIANCES

2.0.1 Simple controls such as timers have been available for many years and been successful in saving energy and reducing household costs, but what smart appliances can do today goes far beyond that. Practically all areas of a home can be automated, from closing window blinds to turning on a heating or ventilation system. The three biggest energy end-use areas will be space and water heating and EV charging, but the full range of smart appliances and devices is enormous. These are some examples:

- A smart thermostat or energy meter on a hot water cylinder can track water use, automatically turning the cylinder off or down when hot water isn't being used or only switching it on during periods of low-cost electricity. (One electricity distributor trialling these meters found they could save households an average $128 per year.) Smart thermostats map consumption patterns to enable safe turning off when consumers are unlikely to use water.
- Hot water diverters allow hot water cylinders to operate as a battery when there is excess solar generation rather than having to export electricity to the grid.
- HEMS can switch on appliances such as clothes washers, dishwashers and water heating cylinders when a PV system is generating sufficient electricity, minimising electricity purchase from the grid. They may also receive a signal from the electricity retailer to operate when the cost is lowest.
- Smart power outlets automatically switch off when they sense that an appliance or device is not being used or is in standby mode.
- Smart light bulbs can automatically change brightness depending on the level of natural light and can also be turned on and off remotely.
- To fool potential burglars when the householders are on holiday, smart lighting systems can turn lights on and off and change lighting in unpredictable and more realistic ways.
- Smart meters display real-time data of power consumption and can show which devices are using the most energy.
- Smart security systems can incorporate lights, motion sensors, cameras, video doorbells, locks (code, fingerprint or remotely operated) and other devices that can be operated from a smartphone. For example, if someone is at the door, you can see who it is on your smartphone and talk to them through a small outdoor speaker.

2.0.2 In some cases, it is possible to modify existing appliances or to use a smart plug that can connect through WiFi with a smartphone app and/or services such as Amazon Alexa or Google Assistant. Smart plugs can also react to a signal from a HEMS, which in turn can react to a signal from an external party.

3 SMART HOMES

3.0.1 Having a few smart appliances in a home doesn't automatically make it a smart home. That requires linking the appliances together into a network with the specific goal of achieving greater efficiency. This is often done through a HEMS installed by an electrician. Some individual components such as inverters already have enough smarts to be their own version of a HEMS (or part HEMS).

3.0.2 A dedicated HEMS for the whole system is a central control point that all the smart appliances are connected to. Its key role is to maximise energy efficiency in the home.

3.1 INTERNET SPEEDS, SYSTEMS AND WIFI

3.1.1 As smart home technology develops and becomes more widely installed, homes will require faster internet speeds than have been used in the past. Fibre (optical cable) provides higher speeds and other advantages over older technologies such as ADSL. The government's Ultra-Fast Broadband roll-out was completed in December 2022, bringing fibre to over 1.8 million homes across 412 cities and towns and 87% of the population. You can check the broadband options at any given location at broadbandmap.nz/home.

3.1.2 When homeowners take a fixed-term contract with an internet service provider, they are usually provided with a router. These are often very basic models. Consumer NZ has tested routers for speed, coverage and security and says that homeowners buying their own device can get an immediate boost in WiFi signal and range.

3.1.3 A single router may work well for small homes, but if larger homes have dead spots where the WiFi doesn't work so well, a mesh WiFi system may be a better option. A mesh system has modes in different locations around the house, with one connecting to a modem and all creating a single network.

3.1.4 All systems within the home don't need to operate wirelessly. Consumer NZ recommends considering options such as ethernet cables: "Wired internet might seem antiquated, but it's faster than WiFi. Try to run ethernet through a wall cavity if you can – the cables are unsightly and prone to damage in the open."

3.1.5 As with most digital tools and services, the WiFi protocol has been upgraded over time, with WiFi 6 the current iteration of the WiFi network protocol. If you are buying a mesh WiFi system, check that it supports WiFi 6. WiFi 7 is on its way, with a promise of faster connections. WiFi 7 will be backwards compatible, and both WiFi 6 and WiFi 7 will co-exist.

3.1.6 Other protocols exist besides WiFi. For example, Li-Fi uses the lighting system to receive and send a control signal. WiFi is quite an energy-hungry protocol compared to some other options.

4 THE ROLE OF ELECTRIC VEHICLES

4.0.1 MBIE has estimated that, by 2050, EVs will make up between 44% and 74% of the light vehicle fleet. Standards NZ points out that, if every household that owned an EV all plugged them in at the same time (after arriving home in the evening), the electricity system would need dramatic investment in infrastructure to meet the additional demand – one consulting group has suggested the figure could be $40 billion. This would result in higher electricity costs for everyone. To help avoid this, EVs are likely to be a significant element in smart homes and the drive for energy efficiency.

4.0.2 EVs can usually be charged from a standard 10 amp domestic power outlet, but this is trickle charging only and can be very slow. Most charging cables using this method are not smart and cannot be remotely managed – they are often not designed for extended daily use but as an emergency back-up option. Consumers trickle charging for consistently long periods are also likely to pay a lot more.

4.0.3 Dedicated charging units that provide faster home charging sometimes (but not always) come with smart functionality incorporated. This can include the ability to connect to the internet and be controlled remotely – a flexibility provider/electricity distributor (see 6.1) would engage with the HEMS or the individual smart device. Charging can be done at times of lowest grid demand (with cost savings to consumers). These systems are able to manage the demand from the charger to fit within the other needs of the household and may be able to provide (and to be paid for) services to network companies and retailers. Such installations must comply with Part 6 of the Electricity Industry Participation Code.

5 PHOTOVOLTAIC GENERATION

5.0.1 There has been rapid uptake of solar PV systems in New Zealand, due in part to a fall in prices. In a July 2019 forecast of future electricity generation and demand, MBIE estimated that, by 2050, there will be over 500,000 installed residential PV systems.

5.0.2 Where a smart home has a dedicated HEMS, the PV system will be part of this. One of the priorities of the HEMS will be ensuring that as much of the electricity produced by the PV installation is used on site. The HEMS might also store unused PV generation in a home battery unit or an EV or donate it to a charity or a family member under a peer-to-peer trading platform. Sending PV generation to the grid is typically the least-favoured option in a fully functional smart home unless the price being offered by the grid is financially a better deal for the consumer. Note that smart inverters (with app controllability) can already provide many of these functions and are not uncommon, although they do not typically control other energy end uses in the home in the same way that a dedicated HEMS does.

5.0.3 A variation on the smart home idea is a trial currently under way by Kāinga Ora. Its homes fitted with solar panels share excess solar power with its customers whose roofs are unsuitable for solar installations.

6 SMART GRID

6.0.1 The electricity grid in New Zealand is under pressure. At peak times for electricity consumption and during extended periods of low rainfall (when hydro dam water levels are low), generation from renewable sources is supplemented by electricity generated from burning gas and coal (Figure 2). There have also been times in recent years when severe weather events have

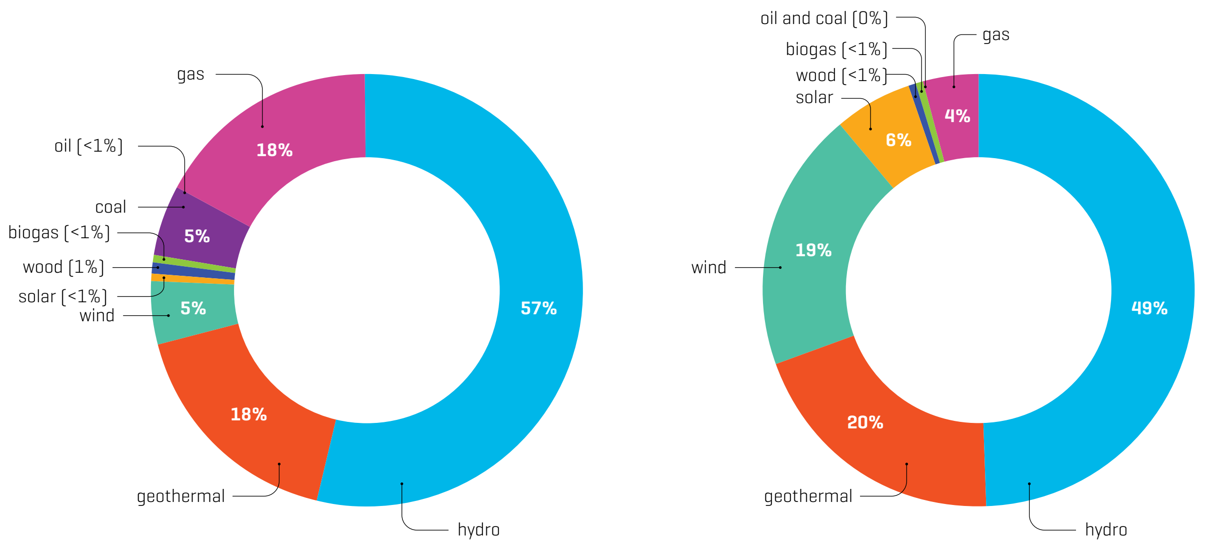

Figure 2. Average electricity generation 2017–21 and projected generation by 2035. (Gen Less, based on data from the Climate Change Commission projections of electricity generation – Electricity market modelling datasets 2021.)

resulted in spikes in demand, insufficient generation and homes losing power. These outcomes reflect our current approach to grid electricity generation where investment in networks is sized to balance the costs to consumers (who ultimately pay for the infrastructure) against ensuring the lights stay on. A bullet-proof distribution network would be extremely costly.

6.0.2 Building a smart grid can help to smooth out peaks in demand, reduce the risk of blackouts and help the country move toward a greater use of renewable generation.

6.0.3 Two key elements required in a smart grid are demand flexibility (an automated system where use of certain electrical appliances and equipment is shifted, reduced or switched off when the grid requires it) and use of distributed energy (such as using the electricity in EVs to contribute to the grid when required).

6.1 DEMAND FLEXIBILITY

6.1.1 One smart grid area where major planning is already under way is demand flexibility, where consumers receive a financial incentive to reduce consumption in periods of high demand. For example, if there is a cold snap and lots of people turn on heaters at breakfast and dinner time, causing a spike in electricity usage, the system could switch off certain appliances or equipment (such as clothes washers or dishwashers) to compensate. This reduces the need for big power generators to burn coal or other fossil fuels.

6.1.2 Demand flexibility will also be important with management of generation from wind and solar where the supply is intermittent. (Around 91% of new electricity generation projects are either wind or solar.)

6.1.3 At the moment, demand flexibility is mostly available to commercial users (the Tiwai aluminium smelter and Glenbrook Steel both have this in their contracts), but it is slowly being rolled out to domestic users. Customers can choose whether to participate and through which plan. In some cases, financial benefits are offered to customers who take up the option.

6.1.4 Supply-side open communication protocols are crucial to ensure switching between electricity providers will still be available with demand flexibility. EECA has worked with the Electricity Engineers' Association to establish common open communication protocols that will be consistent across all flexibility suppliers. (Currently, some electricity distributors are locking consumers into proprietary systems that will only operate under their system and not be switchable without a site visit and reconfiguration of the network.)

6.1.5 EECA is also working with partners on a project called FlexTalk, which is trialling a communications protocol, OpenADR, to enable actively managed EV charging in New Zealand homes. The same protocol could potentially be used to enable demand flexibility with other devices such as hot water cylinders and heat pumps.

6.1.6 Methods that can be used for demand flexibility include:
- demand flexibility control systems embedded in appliances and chargers (including EV chargers) that respond to external signals
- battery storage systems
- behind-the-meter generation (such as residential rooftop PV) with smart inverters.

6.1.7 Demand flexibility doesn't mean that your house is suddenly dark or cold or your EV isn't charged when you need it to be. Rules can be set out that reflect that homeowners want their homes to be a certain desired temperature and they want their EVs sufficiently charged when needed. Demand flexibility in New Zealand will feature a manual override button that a consumer can use to opt out if necessary. It resets after a few hours.

6.1.8 Even without flexible demand electricity, households can still benefit from off-peak discounts. Several websites that can help with online comparisons: Powerswitch (operated by Consumer NZ and part-funded by the Electricity Authority), Glimp and Power Compare.

6.2 DISTRIBUTED ENERGY

6.2.1 The advantages of flexible demand will be compounded if a house has additional electric infrastructure such as connected solar panels or an EV, allowing a smart grid to send generation to where it is needed. Engineering New Zealand, in its report Engineering a better New Zealand: Cleaner energy, puts it this way: "Virtual power plants could help by aggregating small-scale generation … including domestic electric vehicles or solar panels and feeding it back into the grid. For example, to cover a sudden generation need, a virtual power plant could tell your fridge freezer to take a brief break and your electric vehicle battery to join with thousands of others in feeding energy back into the grid." Electricity distributors say this requires consideration of local conditions in a distribution network. Dropping load is generally fine, but bringing load on can be problematic if it is not coordinated correctly.

6.2.2 These distributed energy resources (DER) could bring considerable benefits to New Zealand, building energy resilience and reducing carbon emissions. There are also large economic benefits possible. A 2021 cost-benefit analysis for the Electricity Authority estimated that the uptake of DER could be worth around $6.9 billion for New Zealand.

7 STANDARDS

7.0.1 New Zealand standards that apply to smart appliances and EV chargers are currently voluntary. The PAS (Publicly Available Specifications) are sponsored by EECA and freely downloadable. These are some of the most relevant documents to consider:
- SNZ PAS 6010:2023 *Commercial electric vehicle (EV) charging* (for residential complexes with shared facilities and a common connection to the network)
- SNZ PAS 6011:2023 *Residential electric vehicle (EV) charging*
- SNZ PAS 6012:2022 *Smart home guidelines*
- AS/NZS 4777.2:2020 *Grid connection of energy systems via inverters – Part 2: Inverter requirements*

7.1 SNZ PAS 6012:2022 SMART HOME GUIDELINES

7.1.1 Standards NZ says the guidelines aim to "help set the path for NZ households to connect to a smart network, reducing electricity consumption and bills". It also supports a reliable electricity grid: "To make sure that our grid remains stable and can continue to deliver the level of service NZ consumers expect, we need to change the way that we use energy in our homes, especially at peak times. We can do this by creating a network of smart home appliances that work together to reduce electricity consumption."

7.1.2 AS/NZS 4777.2:2020 applies to EVs that can supply energy back into the house or grid. It is considered as generation operating in parallel with the distribution network. The current version at the date this bulletin is published is 2020, but the standard is under review.

7.2 EV CHARGING SPECIFICATIONS

7.2.1 The two sets of guidelines for EV chargers were issued in 2021 and then revised in 2023.

7.2.2 Standards NZ says the updated documents introduce the use of smart charging, addressing the smart chargers that have built-in two-way communication capability and are able to vary charging based on external signals. "This will enable the user or a demand flexibility provider to increase or decrease charging levels when flexibility services become available in the NZ market in the near future. Demand flexibility and the cost savings available are often tied to the availability of lower-cost off-peak electricity – for example at night or in periods of lower grid demand."

7.2.3 Bi-directional EV chargers, V2G, V2H and so on will need to comply with Part 6 of the Electricity Industry Participation Code as these are classified as distributed generation.

7.3 MATTER

7.3.1 A different type of standard is maintained by the international body Connectivity Standards Alliance (CSA) and supported by many of the biggest tech companies, including Amazon, Apple, Google and Samsung – all heavily involved in smart home systems. The open-source Matter standard aims to ensure connectivity between smart home devices between different manufacturers. Users can control devices under the Matter standard with a smartphone app or through a dedicated WiFi/Bluetooth audio interface.

matter

8 PRIVACY AND SECURITY ISSUES

8.0.1 It is extremely important to ensure any systems are set up to be as secure as possible. Users should select a username and password for a device or system that someone else cannot guess. When some devices (such as routers) are purchased, they often come with a default username (the name of the wireless network – the service set identifier or SSID). This should be changed immediately. There is a separate password needed when connecting devices to the network that also needs to be extremely difficult to guess. Householders should use a different password from online banking and other online accounts.

8.0.2 Householders should carefully think about who has access to smart home systems and passwords. When someone with access to the system moves out of the home, the remaining occupants should consider whether they should change usernames and password details. Some non-molestation orders following violent relationship break-ups now specifically address smart home controls.

8.0.3 Cybersecurity, including around the installation and use of HEMS, is a major issue that needs very careful consideration beyond the scope of this bulletin. The need is true in all cases, including where systems and services make use of artificial intelligence (AI) technologies. The challenge will be how far AI is allowed to modify safety barriers, with the risk of AI decisions that are undesirable.

9 MORE INFORMATION

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Guidance for smart homes

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The future of energy in New Zealand

ELECTRICITY AUTHORITY

Cost-benefit analysis of distributed energy resources in New Zealand

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