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DIGITAL ENERGY FUTURES

FUTURE HOME LIFE
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Acknowledgement of Country

We wish to acknowledge the people of the Kulin Nations, on whose land we work. We pay our respects to their Elders, past and present.

A partnership between:

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EXECUTIVE SUMMARY

The Future Home Life report presents changing digital lifestyle trends and their potential impact on household electricity demand in the near (2025-30) and medium-far (2030-50) future.

The report summarises the research findings from the second stage of the Digital Energy Futures project, based on qualitative research with 72 households across Ausgrid and AusNet Services distribution networks located in New South Wales and Victoria.

Research design

The research was mainly conducted using digital ethnographic methods. Participants were recruited through a survey sent to Ausgrid and AusNet Services residential customers. Households from seven different consumer groups were included, based on their survey responses and further information gathered throughout the ethnographic research:

- Early adopters – energy tech

- Early adopters – digital tech

- New estate homes

- Apartment renters

- High demand homes

- Sea- or Tree-changers

- Regional agricultural area

Due to the social distancing requirements and travel restrictions caused by the COVID-19 pandemic, participants were invited to participate in two 'virtual visits' to their home and a range of interim activities (selected based on their available time and interest). A further five households were chosen to take part in additional research activities for a documentary film.

Our recruitment process enabled a diverse sample of participant locations, ages, lifestyles and ensured gender, cultural and linguistic diversity.

Emerging digital energy future trends

The findings were analysed to understand emerging trends in digital energy futures across **seven domains of everyday practice,** where the majority of energy demand and peak electricity demand takes place, and/or where significant changes are emerging.

Each practice domain discussed in the full report provides the following sections:

Relevant technologies: A list of technologies that are either continuing to be used in association with the trends or are emerging, accelerating and speculative.

Key emerging trends: An overview of the concerns, practices, routines and priorities that are unfolding now or likely to unfold in the near future, involving digital and energy technologies.

Explaining the trends: Further explanation as to why the trends are occurring.

Everyday future visions: Participants' hopes, anxieties and aspirations for their futures.

Complications and resistances: Counter-trends or additional circumstances that complicate the key emerging trends or lead to resistance from some people and consumer groups.

Implications for electricity demand: The likely outcomes of the trends for residential electricity demand (including peak demand, average demand and other infrastructure or policy implications).

Comparison to industry visions: How the ethnographic findings compare with digital technology and energy predictions analysed during the first stage of the Digital Energy Futures project.

Case study vignettes: Short illustrative stories, each featuring one participant household to show how the trends are emerging in relation to people's everyday lives.

Digital Energy Futures: Future Home Life

Seven domains of everyday practice

1

Charging and Mobility

Households are increasingly acquiring mobile battery-powered devices and vehicles that require regular charging. This includes mobile devices used at home and when out, power tools and gardening equipment, and vehicles such as electric cars and scooters. During the COVID-19 pandemic, charging at home intensified. Many households envisage continuing to spend more time at home, and charging electric vehicles at home, in the future.

Key trends

- Personal mobile devices are continuing to be charged at home

- New charging routines are emerging

- Control continues to be a priority over automation

- Electric vehicles are increasingly desirable as local mobility options

- Electric vehicles are becoming more desirable for sustainability but limited by feasibility constraints

- There are emerging concerns about navigating costs of EV charging at other people's homes

- Autonomous driving vehicles are increasingly seen as part of everyday futures

- People's transport and mobility practices are diversifying

2

Cooking and Eating

Home cooking and food storage – involving a range of increasingly specialised appliances and additional fridge/freezer capacity – was accelerated by the COVID-19 pandemic and associated lockdowns. Smart features are starting to emerge for kitchen appliances and fridges; however, there is considerable scepticism about their value.

Key trends

- Increasing and diversifying home food preparation and appliances

- Refrigeration and freezer space is expanding

- Increasing reliance on pre-prepared food delivery services

- Smart features becoming more desirable but still not delivering benefits

3

Healthy Indoor Air and Thermal Comfort

Households are becoming more interested in managing the air quality of their homes — especially to reduce exposure to bushfire smoke, allergens, moisture, mould, toxins, and unpleasant odours. They are also adjusting heating practices, particularly in response to flaws in home and heating/cooling system design or alterations to the use of household space as a result of COVID-19 lockdowns.

Key trends

- Increasing interest in technologies for 'healthier' indoor air

- Air-conditioned cooling increasingly considered 'essential'

- Households are increasingly layering and tailoring their heating strategies in response to winter comfort dissatisfaction

- There is continuing reliance on manual strategies to stay warm or cool before using heating or cooling systems

- More rooms and spaces in the home are being heated and cooled to enhance lifestyle and respond to COVID-19

- Growing heating and cooling for pet health and comfort

4

Living and Play

Many households were spending increased time in the home due to the COVID-19 pandemic, which led to increased investment in household comfort, smart home technology, digital entertainment devices, and recreation. Expanding expectations for the home are also leading to increasing diversity, and simultaneous usage of digital devices used to enhance lifestyle, provide entertainment, and recreation or support other everyday activities.

Key trends

- Multiplication of screen-based viewing

- Homes are becoming increasingly luxurious by people's own standards

- Digital voice assistants are not reaching their predicted potential

- Few smart devices are achieving enduring benefit

- Robotic vacuums are acting as harbingers for automated futures

- Increase in home internet demand for everyday activities

- Gaming spaces and accessories are multiplying

- Increasing flexibility of energy use for solar PV households

5

Working and Studying at Home

The COVID-19 pandemic saw many working and studying from home and adapting their routines, household spaces, and purchasing digital technologies to accommodate this. Many hoped that some of this flexibility would continue and envisioned a future where they would continue to work from home two to three days a week.

Key trends

- A hybrid work and study model is on the rise

- Increasing space and internet needs

- Multiplication of devices for online schooling and work

- Increasing variability of working hours

6

Caring for the Home and its Occupants

Caring is a central practice in which emerging digital technologies are playing a significant role and are expected to become increasingly important. Many participants suspect that they will adopt more technology as their caring needs increase and envision that as they require more care themselves as they age, technology will play a greater role in supporting them. The COVID-19 pandemic also led to a greater familiarity with practices of care at a distance through digital technologies, such as remote health care and telecommunication technologies to maintain social connections.

Key trends

- Proliferation of electric devices for care

- Children's technology use is increasingly managed through more technology

- Remote care is on the rise

- Technology is enabling independent living

- Temperature control is becoming a key practice of care

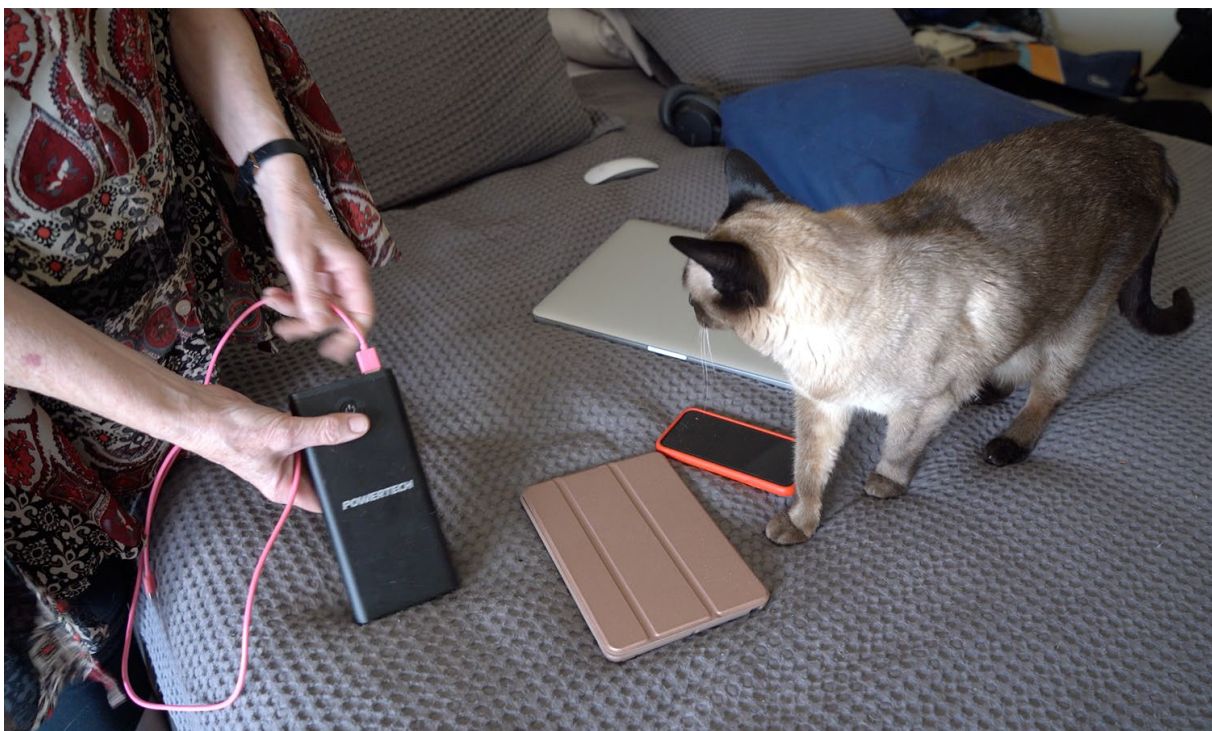- Increasing household monitoring of the home and its occupants

7

Making, Saving, Storing and Shifting Energy

Many household practices are changing in response to new energy technologies and shifting possibilities in the energy market. However, greater energy knowledge does not directly lead to change as many activities remain inflexible, and many people reject the need for smart technologies for energy management, preferring to rely on their own routines and more hands-on control.

Key trends

- Households are continuing to eschew tariff awareness and response

- Energy interest in data and tariffs continues to be mixed and individualised

- There is accelerating self-consumption of solar electricity generated at home

- Households are increasingly aware of and enthusiastic about the opportunities provided by home energy generation and storage

- Storage is an engaging but complexifying concept for households

- Participation in demand management opportunities makes increasing sense when explained

- Increasing interest in transitioning to an 'all-electric' home

- Energy data continues to have limited impact on use

- Smart tech enthusiasm is diverging from an interest in energy management

Digital Energy Futures: Future Home Life

Comparing Industry Visions to Household Research

Stop: Does not correspond   **Proceed with caution**: Somewhat corresponds   **Go:** Corresponds
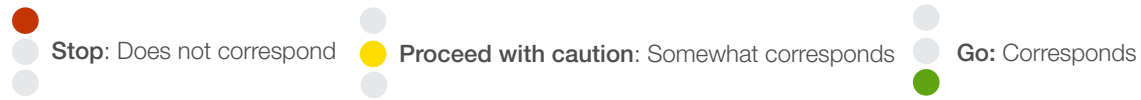
Practice domain	Industry prediction	Finding supported by research	
Charging and Mobility	Technology will enable management of EV charging and match it to the needs of the energy sector.	The industry vision of charging electric vehicles during daylight hours at work was seen as infeasible by most participants, but increased working from home presents an opportunity for daytime charging of EVs during the solar peak.	🟡 (caution)
	Technology will increasingly automate EV charging decision making for consumers.	Some EV owners had charging settings automated into the car, others had developed manual workarounds to override the car's automated charging function to better fit their existing routines.	🟡 (caution)
Cooking and Eating	Smart appliances will proliferate and improve the convenience of everyday routines.	Many smart cooking appliances fail to deliver substantial benefits for consumers.	🟡 (caution)
Healthy Indoor Air and Thermal Comfort	Smart home technologies will manage heating and cooling to deliver savings for both consumers and the energy industry.	Most participants maintain manual control over heating and cooling because they prefer only intermittent use 'when they need it'. The smart functionality in many existing smart technologies, such as air purifiers, are not set to respond to energy pricing but to air quality monitors.	🔴 (stop)
Living and Play	Broad adoption of smart home technologies is 'just around the corner', bringing improved efficiencies, convenience, and immersive household entertainment. Digital voice assistants will become the hub of the smart home and enable greater household automation.	Households had a wide range of digital devices, but many of these technologies do not live up to industry predictions, such as digital voice assistants, which were mostly used for minor entertainment or simple requests, rather than household automation.	🟡 (caution)
	Smart appliances will enable better energy management through automated and remote control.	The main appeal of digital technologies was about increasing pleasure and entertainment in the home, not the opportunities it provided for energy management.	🔴 (stop)
Working and Studying at Home	New technologies, such as improved telecommunications, virtual reality (VR) and augmented reality (AR), will enable studying and working from home in more industries.	The COVID-19 pandemic was accelerating industry predictions of a working from home future, and many desire a hybrid work model. The experience of working from home was less positive for those with smaller spaces and without the financial means to upgrade home spaces or invest in technology. VR was primarily used in gaming, but some suspected VR and AR to be used in future remote work.	🟡 (caution)

Caring for the Home and its Occupants	Smart home technologies will enable older people to be cared for at home through health and safety monitoring technologies and robotic caring.	Participants were willing to explore technology to support ageing at home and were open to incorporating technology that had clear health and safety benefits. However, many found the automated alerts on existing monitoring systems too frequent to handle everyday life circumstances.	⚪🟡⚪
	Emerging technologies are rarely mentioned as playing a role in caring for children but are causing concerns about children's excessive screen time.	There was hesitancy towards children's use of technology, but a number of devices were often balanced with strict usage limitations, such as tablets that were routinely used in children's care.	⚪⚪🟢
Making, Saving, Storing and Shifting Energy	Better data and automation will enable more efficient management of energy, reduced peak demand, and reduced energy costs for consumers.	Consumers have limited interest in technology for energy management, and enthusiasm for digital technologies is likely to increase energy demand. Very few participants showed long term engagement with their energy data and did not change their practices despite awareness of high energy usage. Many participants expressed preferences for manual control over automation.	🔴⚪⚪
	Consumers are primarily motivated by financial incentives and time-of-use tariffs enable price signals and will encourage load shifting.	Energy saving was driven by a much more diverse set of motivations than price, including educational opportunities, desires to share energy with others in the community, and aspirations towards self-sufficiency. Time-of-use tariffs alone are unlikely to encourage significant load shifting.	🔴⚪⚪

Accounting for the pandemic

Most of the ethnographic research for this project was conducted in 2020 during the COVID-19 pandemic when Australians experienced lockdowns and periods of physical distancing restrictions that impacted normal life. While Australia has mainly returned to a 'new normal' in 2021, many changes to household routines are likely to have a lasting impact. These changes include:

- More people working and studying from home for all or part of their working weeks

- More people spending more time at home, with a corresponding interest in making the home a comfortable, attractive and work-friendly environment

- Increased focus on physical health and wellbeing, resulting in increased uptake of associated technologies and appliances such as air purifiers and health monitoring devices

- Ongoing impact on mental health and associated uptake in personal computing devices and apps

- New questioning of apartment living prompted by concerns about airborne transmission of viruses, and lack of space and gardens; and

- Increasing interest in regional relocation, made possible through opportunities to work from home and the desire to have more space and live in a less densely populated area.

Principles for future home life

Our research indicates a series of key principles that speculate on the conditions and circumstances of future home life and how digital energy futures are likely to unfold. Together, they form a set of recommendations to orient energy planning and forecasting for future home life.

1. Increasing insecurity and ongoing transition

People's futures will become (or be increasingly perceived as) more insecure and/or transitional.

2. Tailored digital and energy systems

Diverse forms of Digital Do-It-Yourself (DDIY) will likely be just as common as conventional DIY in the future.

3. Care as a moral imperative to ensure health and wellbeing

Care will continue to be a central and evolving feature of everyday life, resulting in new digital technology trends and energy demand implications.

4. Accelerating work-life flexibility and home-based working

Working from home will continue to be a desirable option for many households, with increasing diversity and flexibility in working hours.

5. Predictable routines with sporadic variation

Household routines will continue to follow patterns but will always be subject to occasional and sporadic variations that have implications for peak demand.

6. New opportunities for sharing and peer trading, including energy and mobility services

The platform economy has introduced new opportunities for sharing and peer trading, and these will continue to grow in the future. However, interest in and uptake of sharing and peer trading systems for energy and mobility services will vary.

7. Expanding expectations of the home and property

Households will continue to retrofit, renovate or transition their homes and properties to cater for more of their needs, practices and desires. The home will become an increasingly important site for energy demand.

8. Strong demand for transition to renewables and opportunities to participate in a sustainable energy future

There will continue to be widespread household demand for the transition to renewables, including for non-financial reasons, and households will pursue innovative and affordable opportunities to participate in sustainable energy futures.

9. Continuing digital and energy divide and equity challenges

Policymaking, regulation and industry standards will need to accommodate a continuing and possibly widening divide between digitally-enabled households and those who cannot access increasingly digitised lifestyles or new energy technologies or prefer to preserve less tech-dependent home lives.

10. Futures will shift as everyday life, technology and energy trends evolve and intersect

Energy planners and forecasters must continue to be attentive to the unpredictability of the future and the need to create flexible and future-proofed propositions in plans and designs.

The energy sector should consider new ways to co-design future digital and energy technologies that people can be productively involved and engaged with.

CONTENTS

LIST OF TABLES AND FIGURES

GLOSSARY OF TERMS

AI	**Artificial intelligence:** Technologies that can perform tasks or solve problems using algorithms and machine learning, ideally without the direct intervention of humans.
AD	**Autonomous driving vehicles:** A vehicle, usually an automobile, that can drive largely without human intervention through technology that allows it to sense its environment and navigate through it.
AR	**Augmented reality:** a technology which projects or superimposes a digitally produced image onto the user's view of the real world.
CALD	**Culturally and linguistically diverse:** Participants were categorised as culturally or linguistically diverse if a language other than English is the primary language spoken at home, they are not fully fluent in English, or they were born and lived the majority of their lives in places other than Australia, New Zealand, the UK and North America.
CBD	Central business district.
DVA	**Digital voice assistant:** A device or operating system which responds to voice commands and can perform tasks, often embedded into smart speakers (e.g. Amazon Alexa and Google Home).
Demand management program	Programs that seek to alter consumers' energy demand and/or usage (e.g. battery storage and discharge) during specific time periods to manage peak electricity demand or to support grid stability, efficiency and/or sustainability of the energy system.
EV	**Electric vehicle:** Any vehicle, usually an automobile, that uses an electric motor for propulsion (including hybrids).
Flat rate (tariff)	Electricity pricing that remains the same throughout the day and night.
Load profile	A graphic display of energy demand (and local generation) over time.
Load shifting	A load management technique involving moving electricity demand from one time period to another, including to reduce peak demand, access lower energy prices or use available renewable electricity.
Microgrid	A small network of electricity users with a local source of supply that can function independently but is usually attached to the wider grid system.
Off-grid	Disconnection from, or lack of, mains electricity services in favour of on-site energy generation and provisioning (may also be used in reference to other utilities).
Peak alert	A notification sent to energy consumers (e.g. households) informing them of a period of peak demand or network constraint, often accompanied by a rebate or incentive offered to consumers who reduce their peak demand for a specified period.

GLOSSARY OF TERMS

Peak electricity demand	The period in which the overall amount of electricity used is at its highest. May refer to daily, seasonal, critical or annual peaks.
Peak event/ demand response event	Periods when electricity demand is projected to be particularly high, usually in response to extreme weather, some energy retailers or distributors offer incentives to customers to reduce their energy demand during these times.
Peer-to-peer trading	Buying or selling of energy (including excess solar energy) between grid-connected parties (peers) via a trading platform.
PV	**Photovoltaic (e.g. solar PV array):** Technology that converts sunlight into electricity.
Smart	Infrastructure or appliances that are automated and/or connected to the internet that generate and communicate data. Also known as the Internet of Things.
ToU tariff	**Time-of-Use tariff:** An electricity tariff that charges different rates for electricity use at different times of the day. For Australian households, ToU refers to a 3-part daily tariff (peak, off-peak and shoulder) as advertised in states or by different retailers. The peak, off-peak and shoulder times usually vary between weekdays and weekends.
VPP	**Virtual power plant:** A network that provides services to the electricity system via its ability to organise and aggregate multiple small distributed energy resources, such as rooftop solar PV and battery storage, that generate and store electricity at a local level.
VR	**Virtual reality:** a technology that simulates an immersive environment, primarily through the use of a headset.

PART 1
BACKGROUND AND REPORT OVERVIEW

This Future Home Life report presents changing digital lifestyle trends and their potential impact on household electricity demand in the near and medium-far future.

The Digital Energy Futures project is a three-year research project led by Monash University's Emerging Technologies Research Lab, involving three industry partners: Ausgrid and AusNet Services (distribution businesses managing networks in the Australian states of New South Wales and Victoria) and Energy Consumers Australia (a national advocacy body for residential and small business consumers).

The COVID-19 pandemic and other significant events, such as the 2019-20 bushfires, have created new uncertainties for energy sector planning around how people will live in the future.

The pandemic has already substantially altered household routines and accelerated the uptake of digital technologies. As Australia begins to emerge from this crisis, and as it continues to chart a course through the changing climate and the advent of artificial intelligence (AI) and other emerging technologies, it is absolutely critical to understand how energy consumers' lives are changing and what this will mean for residential energy demand.

This report presents the findings of qualitative ethnographic research with 72 households across Ausgrid and AusNet Services distribution networks located in the states of New South Wales and Victoria. Through this research, we identified:

- **Emerging digital energy future trends** organised across seven domains of everyday activity in the home that are relevant to households today and are likely to affect energy demand in the near-future (between 2025-2030). This timescale aligns with forecasting cycles of distribution businesses (5-10 years) to reflect trends likely to impact electricity networks.

- **Principles for future home life** to guide residential electricity planning and forecasting in the near and medium-far future (2030-2050). These principles draw on households' everyday hopes, aspirations, and anxieties to understand the adoption and adaptation of digital and energy technologies and guide thinking about emerging electricity demand trends and requirements.

The remainder of this report is structured into three key sections.

Part 2 presents the research process and includes detailed information on our research participants.

Part 3 presents the emerging digital energy futures trends organised into seven domains of everyday practice relevant to household electricity demand:

- Charging and mobility

- Cooking and eating

- Healthy indoor air and thermal comfort

- Living and play

- Working and studying at home

- Caring for the home and its occupants; and

- Making, saving and storing energy.

Part 4 presents principles for future home life to guide energy planning and forecasting.

PART 2
RESEARCH PROCESS

The Digital Energy Futures project is innovative in both its approach and methodology. The project's goal to inform energy forecasting by incorporating in-depth knowledge of Australian households, their digital and energy technology usage and their future visions, is a world-first.

Although the COVID-19 pandemic and associated lockdowns required us to shift our research methods from in-person research with households to online and virtual methods, we continued to develop novel online ethnographic methods, which allowed us to maintain the goals and objectives of the Digital Energy Futures project.

Research Design

The Digital Energy Futures project seeks to contribute to innovative demand forecasting and scenario-planning methodologies that incorporate in-depth sociological understandings of changing everyday practices from the perspectives of householders.

The Digital Energy Futures project is being conducted in six stages:

Stage 1 (complete): Digital and energy futures analysis of industry predictions, trends and scenarios for the home, findings available in Stage 1 report Digital Energy Futures: Review of Industry Trends, Visions, and Scenarios for the Home.

Stage 2 (complete): A research recruitment survey followed by digital ethnography with 72 households across Ausgrid and AusNet Services network areas.

Stage 3 (in progress): Addition of future-focused questions to annual household surveys conducted by Energy Consumers Australia, informed by the Stage 2 ethnographic research.

Stage 4: Twelve future scenario workshops with Ausgrid and AusNet Services customers to further revise and develop scenarios and principles for future home life.

Stage 5: Modelling and forecasting development to cross-analyse the findings and develop an interdisciplinary forecasting methodology for the energy sector.

Stage 6: Demand management innovation to identify opportunities for increasing the affordability and reliability of the electricity supply to residential consumers.

The findings of the first stage of the Digital Energy Futures Project were published in the Digital Energy Futures: Review of Industry Trends, Visions, and Scenarios for the Home report, including a content analysis of 64 energy and technology sector reports that identified industry predictions about the future of digital and energy technologies.

The Stage 1 report synthesised the critical findings from the content analysis into a series of comic-strip scenarios, which illustrated the expected impact of changing digital and energy technologies for the home. This report identified the foundation of what the technology and energy sectors envision future home life will look like. The subsequent stages of the research compare and contrast these industry visions with the findings from research with households.

In addition, all stages are informed by the research team's ongoing review of:

- Relevant international peer-reviewed literature in the energy social sciences,

- Continuing digital technology and energy demand trends sourced through the

Australian Bureau of Statistics (ABS) and other leading data analytics and market research organisations, and

- Extensive past research on residential energy consumption, digital technologies and household social practices conducted by the authors of this report (e.g. Maller & Strengers 2011, 2018; Martin 2020, Nicholls & Strengers 2013, 2015, 2017, 2018, 2019; Strengers 2013; Strengers & Maller 2011, Strengers & Nicholls 2017, 2018; Strengers et al. 2019, 2020, 2021; Leder Mackley & Pink 2013; Mitchell et al 2015; Pink 2011a, b; Pink & Leder Mackley 2012, 2013, 2015, 2016; Pink et al 2013).

The research presented in this report summarises the findings from the second stage of the Digital Energy Futures project, which involved digital ethnography with 72 households. This ethnographic research focuses on the everyday lives of people and their own visions for the future across seven everyday practice domains where the majority of energy consumption and peak demand occurs, and/or where demand is expected to grow or change in the near future (see Figure A).

Digital Energy Futures: Future Home Life

FIGURE A: EVERYDAY PRACTICE DOMAINS

CHARGING & MOBILITY

electric vehicles; car and ridesharing; automated vehicles; public transport; battery charging; device charging stations battery operated gardening equipment

COOKING & EATING

multiplication of cooking devices and small appliances; food storage; refrigerators and freezers; smart kettles, coffeemakers and other appliances; meal delivery services

HEALTHY INDOOR AIR & THERMAL COMFORT

digital and connected heating, ventilation and air conditioning systems; changing expectations of heating and cooling; air purification, dehumidifiers, and diffusers.

LIVING & PLAY

multiplying or converging devices; livestreaming; home cinemas; video games; virtual and augmented reality; voice assistants and smart home technologies.

WORKING & STUDYING AT HOME

home-based work and study, home-based businesses and digital collaboration, flexible employment and schedules

CARING FOR THE HOME & ITS OCCUPANTS

home-based childcare and care of older people; changing trends in assisted living; care for pets; care for home and security systems

SAVING, SHIFTING, & STORING ENERGY

solar photovoltaics, smart meters, smart plugs and smart appliances, battery storage and automation, energy trading and sharing

The practice domains were inspired by past scholarship which focused on the social practices which people use energy for (Shove & Walker 2014). This approach places emphasis on people's everyday activities (which involve energy demand), rather than what they think or know about energy. Everyday practices are distinct from individual behaviours because they are socially shared, and involve common meanings, skills and materials (e.g. technologies) to carry out (Shove et al. 2012; Strengers & Maller 2014).

Recruitment

In consultation with the project partners, the research team designed a household recruitment survey including questions about respondents' home, occupancy, appliances, energy bills and tariffs, energy and digital technologies, lifestyle, occupation, and demographic details.

In early 2020, Ausgrid and AusNet Services sent an invitation to participate in the online survey to 10,800 and 8,500 customers, respectively. A prize draw incentive was offered for completing the survey and the response rates received were approximately 5%, 570 (Ausgrid) and 340 (AusNet Services) of the total number of customers invited. The Monash University research team received the survey data and contact details of 360 (Ausgrid) and 146 (AusNet Services) respondents who agreed to share these with Monash University and to be contacted about further research activities.

Monash University used the survey data to select 72 households (36 from each distributor partner) to participate in the research, based on their potential to be classified into one or more 'consumer groups' (see Table 1) and with the aim of selecting a diverse cohort of participants across a range of socio-economic variables including gender, age and cultural background. The 72 households involved 81 participants as seven households included multiple family members in the research.

Consumer group categories

Based on their recruitment survey responses, households were identified as belonging to one or more consumer groups (see Table 1). The consumer groups were determined in consultation with the project's industry partners to be of interest to demand forecasting because:

- They have geographically significant impacts on household electricity demand (e.g. **Sea- or Tree-changers** and **New estate homes**)

- The style, size and ownership of housing impacts electricity use (e.g. **New estate homes** and **Apartment renters**)

- They have a higher impact on electricity demand and supply (e.g. **High demand homes** and **Early adopters – energy tech**)

- They are at the forefront of the transition towards digital technology and/or distributed energy futures (e.g. **Early adopters – energy** and **Early adopters – digital tech**); and/or

- They are an under-researched type of household, which may face disadvantages or differences that may impact their participation in planned energy futures (e.g. **Apartment renters** and **Regional agricultural area**).

Thirty households belonged to more than one consumer group (up to three per household). Changing life circumstances meant some participants transitioned into or out of particular consumer groups during the course of the project and interviews enabled verification of survey responses. As a result, nine households interviewed did not meet the criteria for any of the seven consumer groups.

Some trends are more relevant to certain consumer groups, and we refer to them throughout the report. We also use the icons and codes shown in Table 1 to signal the consumer group that participants belong to when they are quoted in the report, or when they are referenced in the text.
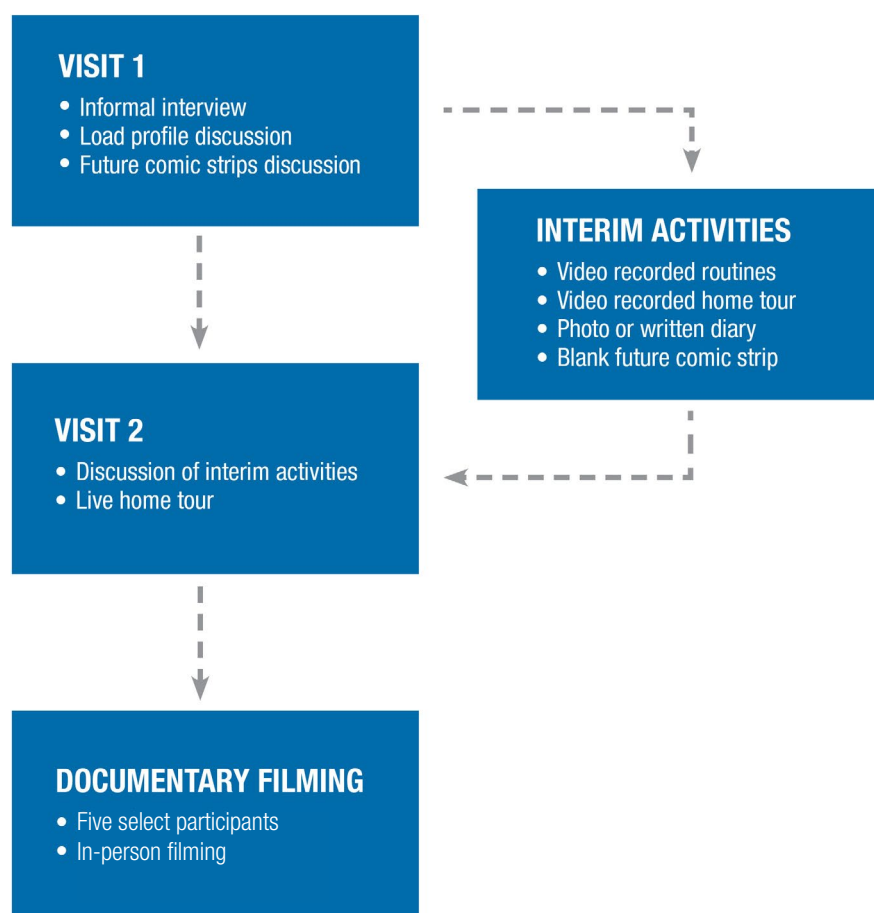
TABLE 1: CONSUMER GROUPS

Category	Total Households	Definition	Icon/Code
Early adopters - energy tech	11	Home has battery storage and/or an electric vehicle	EnTech
Early adopters - digital tech	24	Has four or more smart technologies in the home (excluding music/speakers or smart TVs), or has very novel smart technology (e.g. a robot or virtual reality), or uses a lot of automation/control, including via a digital voice assistant	DigTech
New estate homes	16	Capital city housing development on the urban fringe, home 10 or less years old (apartments and regional housing estates)	NewEst
Apartment renters	14	Living in a rented apartment (at the time of survey completion)	AptRnt
High demand homes	13	Electricity bills >$600 per quarter (survey response) and or load profile data has high demand peaks (typically over 8kW in a 30-minute interval)	HiDem
Sea- or Tree-changers	10	Moved from a capital/major city to a coastal or regional/country area in the past 10 years	SeaTree
Regional agricultural area	15	Includes rural and farm locations and residents of smaller regional towns (e.g. Drouin and Moe in Victoria; Singleton and Tumbi Umbi in NSW)	RegAgr

Ethnographic fieldwork

Due to the social distancing requirements and travel restrictions related to the COVID-19 pandemic, most of the research with the 72 selected households was conducted remotely, primarily through online video conferencing and recorded videos or other activities completed by the research participant and shared with the research team. To achieve this we adapted established visual ethnographic face-to-face methods normally undertaken in people's homes (Pink et al 2017, 2021).

Participants were invited to take part in two 'virtual visits' to their home, and to complete a range of interim activities (selected based on their available time and interest). A small number of households without access to, or confidence with, digital technologies were interviewed by phone and sent hard copies of the interview materials for discussion. After COVID-19 restrictions were lifted, a further five households were selected to take part in a video-recorded and in-person visit to develop a documentary film (see Figure B).

FIGURE B: STAGES OF ETHNOGRAPHIC RESEARCH

VISIT 1
- Informal interview
- Load profile discussion
- Future comic strips discussion

INTERIM ACTIVITIES
- Video recorded routines
- Video recorded home tour
- Photo or written diary
- Blank future comic strip

VISIT 2
- Discussion of interim activities
- Live home tour

DOCUMENTARY FILMING
- Five select participants
- In-person filming

First virtual home visit and interim activities

In the initial visit, with one or two members of the research team, participants shared details of their household routines, their technology use, and their current and future energy concerns.

Interview questions covered the following topics:

- Typical day

- Technology and COVID-19 routines

- Heating, cooling and comfort

- Working and studying from home

- Caring

- Transport

- Entertainment

- Energy management

- Energy use

- Energy futures

- Automation; and

- Trust and privacy.

Where available, researchers also showed participants several graphs visualising their electricity load profiles on three contrasting weather days from the past year (provided by Ausgrid and AusNet Services, see Figure C) and discussed how activities in the home might have contributed to the household's electricity use. Future comic strip scenarios that emerged from Stage 1 of the Digital Energy Futures Project were also discussed. These Aggregated Scenarios are available as part of the Stage 1 report *Digital Energy Futures: Review of industry trends, visions and scenarios for the home.*

After the initial interview of approximately two hours, participants were invited to complete a number of optional activities, including:

- A video recording of household routines

- A recorded video tour of their household

- A photographic or written diary; and/or

- A blank comic strip on which they could illustrate their predictions for their household and future home life in 2050.

FIGURE C: SAMPLE LOAD PROFILE

Cold COVID-19 lockdown weekday: 5 August 2020

Digital Energy Futures: Future Home Life
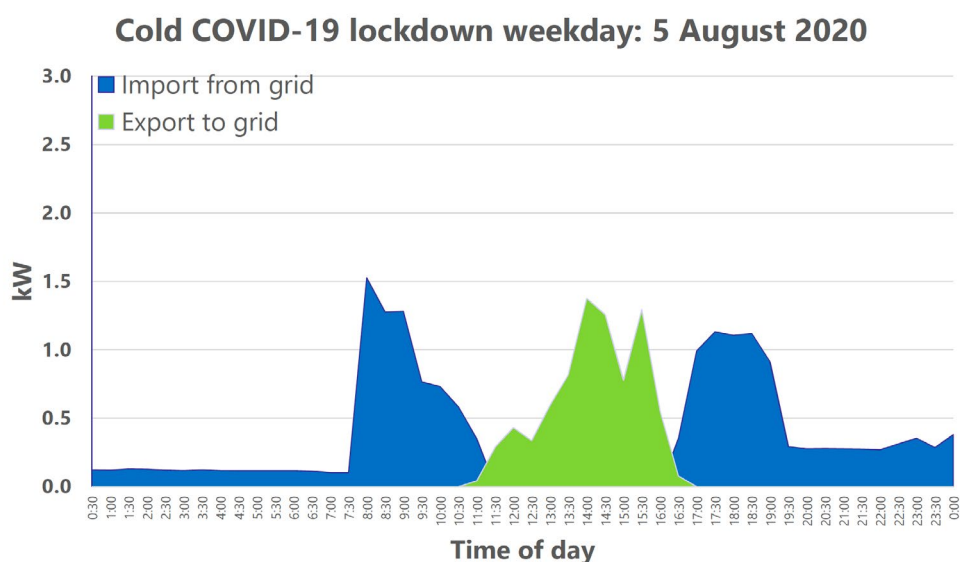
Second virtual home visit

The majority of households (68 of 72) participated in a second visit approximately one month after the first. During this visit, any materials that the research participant produced were reviewed together, and the researcher(s) asked follow-up questions regarding the practices revealed in the interim activities.

For those participants who agreed, a live home tour was conducted, where the research participant walked around their home on a mobile device while videoconferencing with the researcher.

In-person home visits for documentary film

In 2021, five participating households were selected to participate in an ethnographic documentary video and were visited in their homes by between 2-3 research team members who video recorded with them. This process enabled the team to test the relevance of the remote research findings in situ with participants in their homes and to produce new visual materials.

Analysis

Both online visits were audio and video recorded, as agreed to by the participant, and the audio was transcribed. We uploaded these transcriptions into NVivo qualitative analysis software. The research team developed a broad coding structure around key themes and the organisation of the ethnographic visits to enable systematic analysis of the sample.

About the participants

The 72 households involved in the ethnographic research were evenly split between NSW and Victoria (at the time of recruitment, as several moved during the research), with an additional nine household members taking part in the research providing a total of 81 participants (see Figure D). Our recruitment process, described above, enabled the selection of a diverse

sample of participant locations, demographic characteristics, and lifestyles (see Figure E). Twenty-three households were culturally or linguistically diverse (32%).

Use of participant data

The remainder of this report includes direct quotes from research participants that were gathered in the process of our ethnographic research. Depending on the preference of the research participant, either a pseudonym or their first name is used. Their age, the general location of their home, and any consumer groups that they belong to are also attributed to their quotes to provide greater context to the participant's background. Any consumer groups that the participant belongs to will be signalled through the use of icons and code (indicated in Table 1). These icons will also be used throughout the report to signal when a trend or insight is relevant to a particular consumer group.

Quotes from participants are essentially verbatim, but [square brackets] indicate language not spoken by the participant that is needed to provide greater clarity or context to the direct quote. Ellipsis points (…) signal a break in the quote where the participant said other words that were deleted for brevity. This editing is never used to alter the meaning of the quote, only to provide greater clarity for the reader.

All images in this report come from our research and portray the participants, their actual homes, and technologies. Some were taken by the researchers, whereas others were provided to the research team by the participants themselves.

All names, quotes and images are used with participants' consent, in accordance with our human ethics procedures.

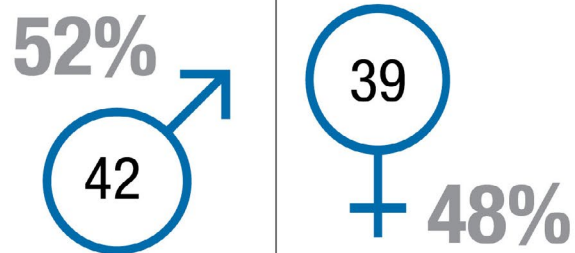## FIGURE D: MAPS SHOWING LOCATIONS OF PARTICIPANT HOUSEHOLDS
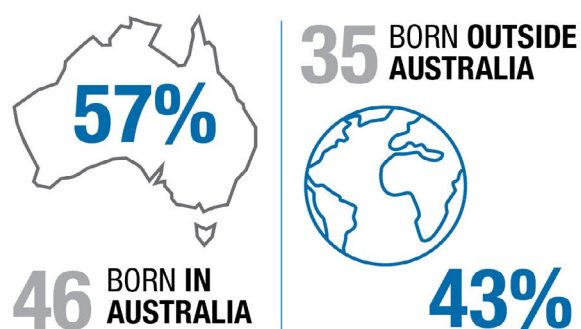

VICTORIA

NSW

Digital Energy Futures: Future Home Life
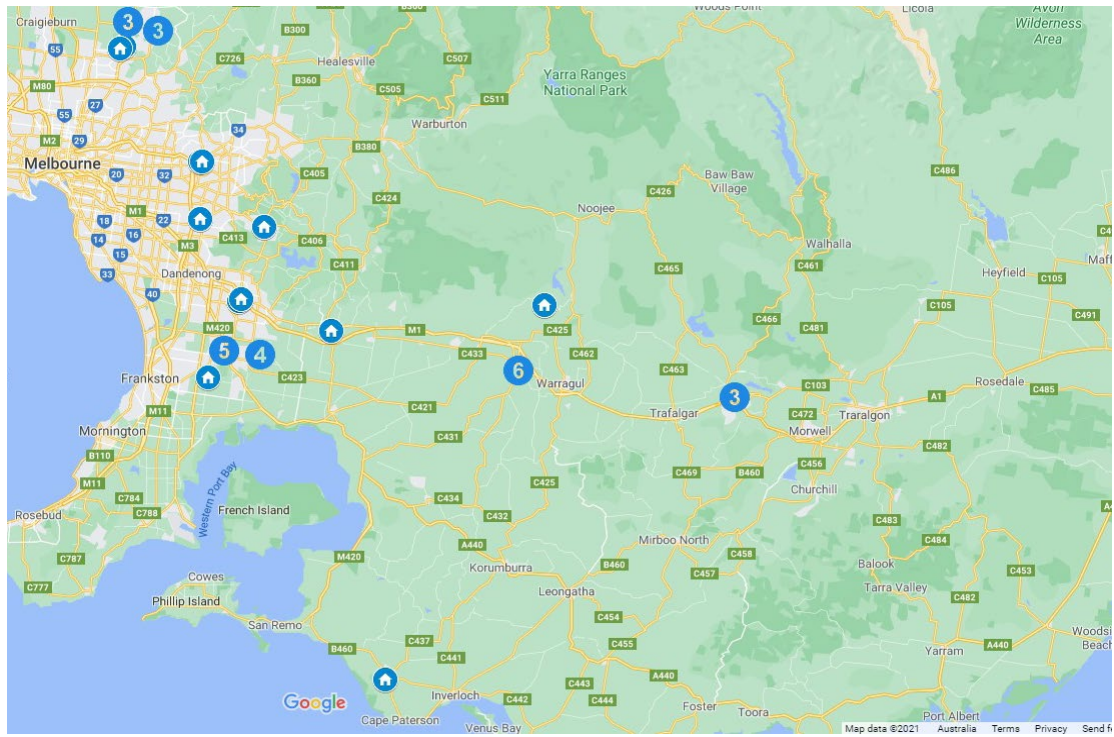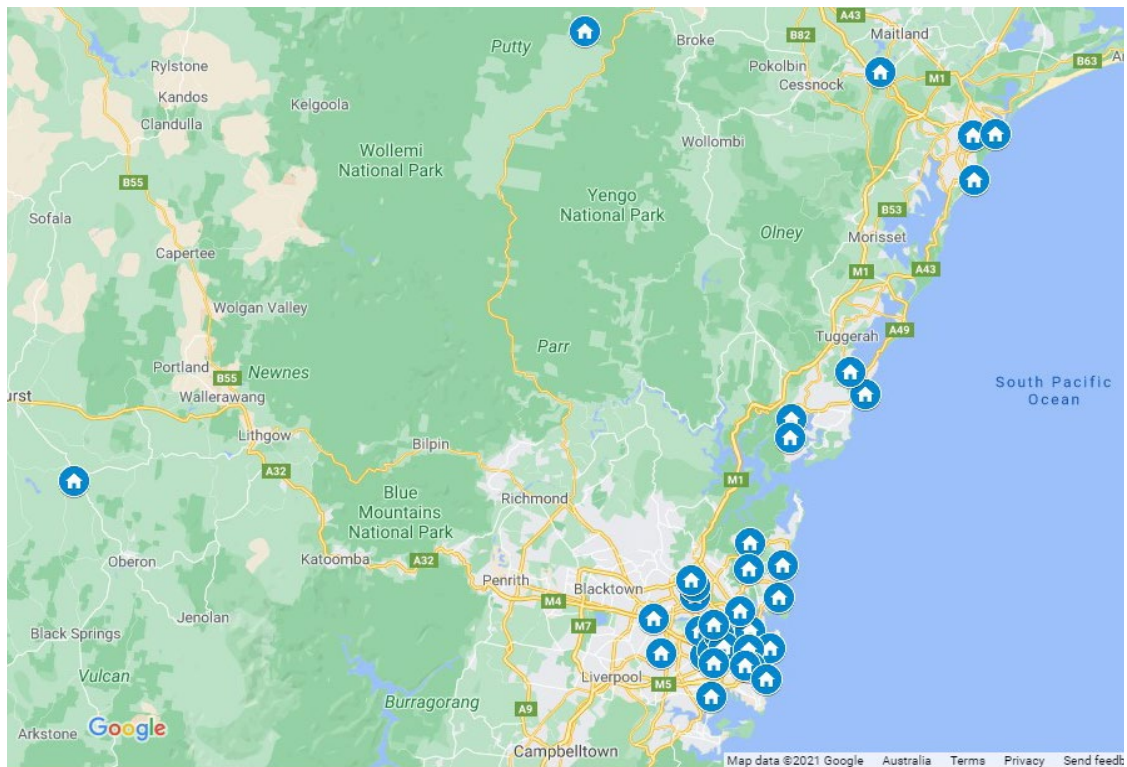
FIGURE E: ABOUT THE PARTICIPANTS

GENDER

52%
42

39
48%

COUNTRY OF BIRTH

57%

35 BORN **OUTSIDE AUSTRALIA**

46 BORN **IN AUSTRALIA**

43%

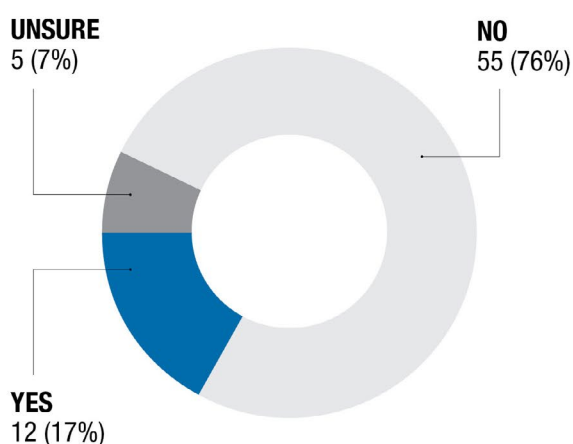**Country of birth**
UK, Japan, India, Hong Kong, Argentina, Vietnam, China, Taiwan, Spain, Germany, Russia, South Africa, Ukraine, Italy, Pakistan, New Zealand, Mauritius, Chile, Netherlands.

LOW INCOME/ENERGY HARDSHIP

UNSURE
5 (7%)

NO
55 (76%)

YES
12 (17%)

Categorised as low-income/energy vulnerable if:
• Households with children and income less than 80K/year
• Households with concessions on bills (excluding older retired households with income over 40K/year)
• Reported difficulty paying energy bills, or involvement with retailer hardship programs
• In unstable, temporary employment (based on COVID)

AGE BREAKDOWN

1 (1%)   41 (61%)   21 (29%)   10 (14%)

18-24   25-44   45-64   65+
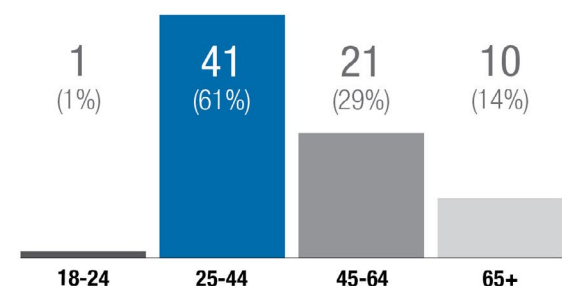
73 of 81 participants provided their age

MAIN LANGUAGE SPOKEN AT HOME:

ENGLISH:
59 **82%**

OTHER:
13 **18%**

Other languages include: Mandarin, Russian, Ukrainian, German, Spanish, Hindi, Japanese, Bahasa Malaysia

HOUSEHOLD TARIFF AWARENESS

38

26

8

53% Confident   36% Uncertain   11% Didn't ask
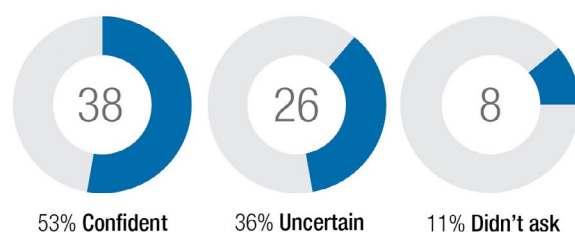
HOUSEHOLDS WITH ENERGY TECHNOLOGIES

28 (39%) SOLAR PV HOUSEHOLDS

6 (8%) BATTERY STORAGE HOUSEHOLDS

HOME OWNERSHIP

75% 54 HOMEOWNERS

25% 18 RENTERS
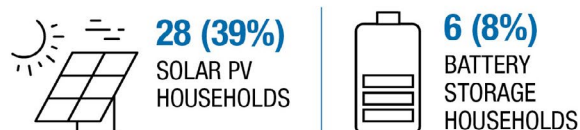
PART 3
EMERGING DIGITAL ENERGY FUTURE TRENDS

This section presents the emerging digital energy future trends across the seven everyday practice domains.

1. Charging and Mobility
2. Cooking and Eating
3. Healthy Indoor Air and Thermal Comfort
4. Living and Play
5. Working and Studying at Home
6. Caring for the Home and its Occupants
7. Making, Saving, Storing and Shifting Energy

Each domain provides the following content:

- **Relevant technologies:** A list of technologies that are either continuing to be used in association with the trends, or are emerging, accelerating and speculative.

- **Key emerging trends:** An overview of the concerns, practices, routines and priorities that are unfolding now or likely to unfold in the near future, involving digital and energy technologies.

- **Explaining the trends:** Further explanation as to why the trends are occurring.

- **Everyday future visions:** Participants' hopes, anxieties and aspirations for their futures.

- **Complications and resistances:** Counter-trends or additional circumstances that complicate the key emerging trends or lead to resistance from some people and consumer groups.

- **Implications for electricity demand:** The likely outcomes of the trends for residential electricity demand (including peak demand, average demand and other infrastructure or policy implications).

- **Comparison to industry visions:** How the ethnographic findings compare with digital technology and energy predictions analysed during the first stage of Digital Energy Futures project.

- **Case study vignettes:** Short illustrative stories featuring one participant household to show how the trends are emerging in relation to people's everyday lives.

1. Charging and Mobility

Households are increasingly acquiring mobile battery-powered devices and vehicles that require regular charging. This includes mobile devices used at home and when out, power tools and gardening equipment, and vehicles such as electric cars and scooters. During the COVID-19 pandemic, charging at home intensified. Many households envisage continuing to spend more time at home, and charging electric vehicles at home, in the future.

RELEVANT TECHNOLOGIES: CHARGING AND MOBILITY

Categories	Continuing Technologies	Emerging, Accelerating, and Speculative Technologies
Transport	Fossil fuel cars and vehicles Bicycles Public transport	Electric cars Electric bikes Electric motorbikes and scooters Converting old fossil fuel cars to electric EV charging stations in apartment buildings Public EV charging stations EV fast chargers Self-driving cars Hydrogen powered cars Extensive and visible EV charging infrastructures Low cost electric cars Automated EV charging Solar charged electric scooters
Personal and Entertainment Devices	Headphones (wireless) Mobile chargers	Electric toys and mobility devices (e.g. skateboards and scooters) Automated and gamified features in EVs Charging banks, hubs or stations Wireless charging pads at home Wireless charging in EVs Smart watches Body monitoring technologies
Gardening and DIY	Power tools Lawn mowers	Battery powered lawnmowers Battery powered tools

Trend 1: Personal mobile devices are continuing to be charged at home

Households are using multiple mobile devices such as smartphones, tablets, wearables and fitness devices (e.g. smart watches), wireless headphones, and mobile battery chargers both at home and when out.

The pandemic has led to a home-based life for many, which means charging takes place predominantly at home. To support this, household charging hubs are common and are typically located in shared family rooms and in adult and children's bedrooms, where they are often found beside the bed. The need for charging has led to a growing interest in and diversity of charging technologies, such as charging stations, wall-mounted USB ports, and wireless charging pads. Households also sometimes use wireless and USB charging devices in cars.

"Yeah, that's the hub. The kids each have a charger in their room for their phones, but that here is the sort of family charger for anything extra: [my husband] and my phone, [and my daughter] charges hers here too. She has a Fitbit she charges and sometimes speakers and all of this sort of crap, so yeah … We put them on at night before we go to bed and unplug them in the morning."

— Kelsey, 59, inner Sydney

HiDem

Trend 2: New charging routines are emerging

The proliferation of mobile devices that require battery power has made charging an everyday necessity.

Charging is now an obligatory everyday task, which has become integrated into daily life routines in ways that suit both individuals and households. Most mobile devices are charged overnight, but some personal devices are charged during personal care routines, such as charging smartwatches while showering. Some people have duplicate devices, such as two pairs of wireless headphones, so a second pair can be used when the charge runs out. Some devices (e.g. smartphones) are charged in cars, but with the loss of regular commuting due to the COVID-19 pandemic, this is not a frequent charging routine.

"For things like my Fitbit watch, I plug it in whenever I go to have a shower. So, I take it off, take off my glasses, go have a shower, come back and put it back on there. For my headphones, it generally depends. Sometimes, I'll just plug them in at night time, and sometimes I'll plug them in during the day. If I get the low battery message after I've been for the run, I'll plug it in then and then grab them before I go to the gym."

— Lucy, 34, inner Sydney

AptRnt

Trend 3: Control continues to be a priority over automation

There are increasing possibilities for wireless and automated charging, but people continue to prefer personal control over charging.

Most people wish to maintain control over the location, times and amounts that their devices and batteries are charged. Participants held strong beliefs (sometimes misconceptions) regarding optimal charging levels for all devices, including mobile devices such as smartphones and power tools, and gardening equipment such as lawnmowers.

Many participants had devised their own ways of timing and controlling how their devices (including EVs) were charged by using traditional timers that would turn on and off the power supply, or charging within their everyday routines to ensure that devices were charged at the optimal times for their use.

Some participants had misconceptions regarding how to save money, for instance, by unplugging devices and charging them later when they believed energy would be cheaper – even though they were not on Time-of-Use (ToU) tariffs. Most people value the flexibility created by the charging regimes they devise themselves and do not believe that automated charging would benefit them.

"I just charge it [electric car] up on [off] peak... I can plug it in, and it's got a [automated] thing whereby I want it to go from 10:00 [PM] until it's charged, and it'll do that like if I come back in the afternoon and I know I'm not going to use my car … It does all those things [automatically]. [But] if I've gone, like when I go to my daughter's, it [takes] more than 10:00[PM] until 7:00[AM] to charge it, so I just charge it up for that amount, and then I might charge it the next day; it just depends what I'm doing."

— *Pamela, 75, outer Sydney*

EnTech NewEst

Digital Energy Futures: Future Home Life
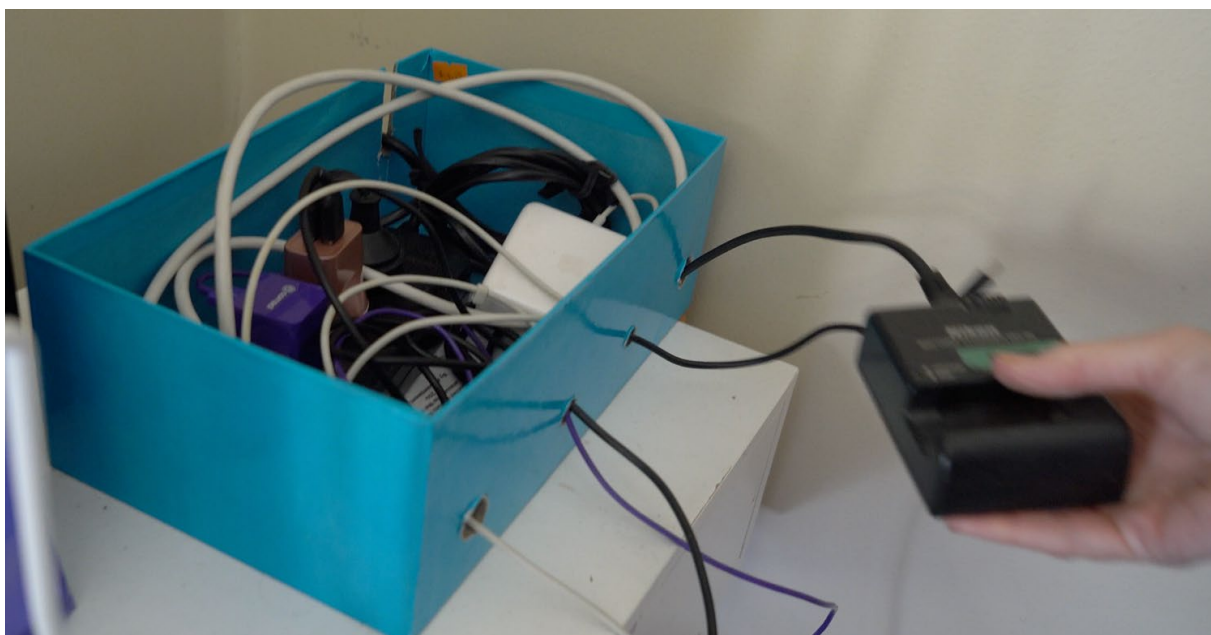
Trend 4: Electric vehicles are increasingly desirable as local mobility options

There is growing interest in electric cars and scooters.

Electric cars are frequently purchased or anticipated as local use vehicles in household mobility systems. They are usually charged at home and used for local travel and short commuting, while a larger fossil fuel or hybrid vehicle is kept for long-distance trips and holidays.

The flexibility offered by car ownership was a requirement for most urban and rural participants. Electric vehicles are a preferred option that maintains individual car ownership above carshare or rideshare schemes. Most participants saw themselves as having electric vehicles in the future and envisaged charging them at home. Electric vehicles were used for or envisaged for short commutes to local workplaces or train stations in longer commutes, taking children to school and shopping.

For many participants, electric cars were not currently feasible. In many cases, the cost was still prohibitive, and **apartment dwellers** noted the absence of charging infrastructures in or near their building for home-based overnight charging.

Often participants who did not have electric cars were not aware of the possibilities offered by national charging infrastructures.

Most of the participants who already owned **electric cars** (9 participants, including 2 with plug-in hybrids) had extensive knowledge of and confidence in national and state charging infrastructures. Participants who used their EVs for longer regional and interstate travel had developed established charging routines that predominantly involved charging their cars at home and planning for charging when travelling longer distances.

Participants did not generally see it as viable to charge their cars at work, given the current shift towards working from home.

"I have a little Mazda 2, which I've purchased in the last 18 months, and I find that that is perfect for the short stretch commutes – economical, easy to park, you know, all those sorts of things. And so an electric vehicle I could imagine would fit that bill quite nicely. I understand they don't necessarily have the range of if we go to Dubbo or the North Coast, you're going to be struggling with range for some of those things. But for the short – the less than 50k's – it sounds like a pretty good idea."

— Dianne, 60, regional NSW
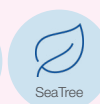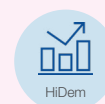
Trend 5: Electric vehicles are becoming more desirable for sustainability but limited by feasibility constraints

While the uptake of electric vehicles as an environmentally sustainable option is growing, for many people, they are not feasible due to cost or infrastructural constraints, and for some, they are not regarded as sustainable.

Most, but not all, participants saw electric vehicles as more environmentally sustainable and their (or their family's) eventual ownership as almost inevitable. Some participants owned electric or hybrid cars on this basis. Some participants questioned the idea that electric cars are sustainable, citing the reliance on fossil fuels to create electricity and the impacts of battery materials. Others were concerned about the affordability of electric cars and were 'waiting' for costs to come down.

Electric car purchases do not make fossil fuel cars immediately redundant or reduce the environmental impact of the existing stock of vehicles since older cars are passed on to children or 'driven into the ground' alongside the use of the electric car. Fossil fuel cars are also used for longer journeys or camping trips, or kept in circulation to provide extra convenience.

"An electric car is not an option as far as we're concerned ... they're so expensive to buy and number two if we're powering it up from home, it's free but ... I don't see any value to the environment at this point in time because most of the power that's going into the grid is being generated from coal-fired power stations."

— Clara, 68, regional NSW

RegAgr   SeaTree   EnTech
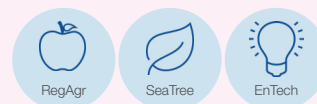
"The only reason we use the petrol car is because both of the child seats are in the car, and it seems crazy to always be taking them out and putting them in [the Tesla], and then back into the other car. Who's got time for that? Maybe if I'm home for a few days over Christmas, I might do it, and then we'll use this car as the family car for the Christmas break, but otherwise, no."

— Malcolm, 36, outer Melbourne

DigTech   EnTech   HiDem

Trend 6: Emerging concerns about navigating costs of EV charging at other people's homes

As the home becomes the preferred place for charging EVs, new questions arise concerning access to home charging.

Participants pointed out that when they travel by car, it is often to visit family or friends. In these scenarios, the home being visited would be the most convenient place to recharge an EV, rather than stopping at a charging station elsewhere. Participants envisaged 'awkward' situations arising in which their hosts might not welcome a request to use their electricity to charge an EV.

"I think there's also an awkward social interaction [when visiting friends] ... 'Hi, I arrived, do you mind if I plug my car in and you pay to fill my car?' ... It's a discussion I could have with my brother, but I can't...at a friend's place … You know, it's not going to cost you a lot, but it's still a bit weird."

— Peter, 43, inner Sydney (no consumer group)

Trend 7: Autonomous driving (AD) vehicles are increasingly seen as part of everyday futures

Most participants believed that AD vehicles (privately owned cars, taxis, shared cars or logistics vehicles) would be part of the future but had mixed views regarding how they would access them.

Participants did not see AD vehicles as part of their immediate futures but assumed that they would become part of everyday futures eventually. They saw legal, insurance and regulatory issues as holding this up. Some did not believe that AD cars were safe, while others felt they would be safer than existing vehicles. Some participants saw themselves as owning cars in the future and continuing to enjoy driving themselves, while others saw being able to call for an AD car as being appealing.

While some envisaged AD cars as part of car-sharing services and were keen to use them in this or a taxi type service, many insisted that they would need flexibility in their lives that these services would not be able to offer and would prefer an ownership model for an AD car.

"Self-driving cars, yeah, I don't really see much of a difference between that and driving and getting in an Uber, right? There's a lot of convenience to it, and it'd probably be cheaper than an Uber because you won't have to pay for a person. And possibly safer. So yeah, I'd be down with that."

— Linsay, 32, inner Sydney

AptRnt

Trend 8: People's transport and mobility practices are diversifying

People are taking advantage of an increasingly diverse range of mobility services and transport technologies to cater for different types of trips and circumstances.

Most urban households had a number of different transport and mobility options. Transport technology and service use depended on many factors including the distance, time available, activities involved, weather conditions, safety, cost, accessibility, parking, fitness, and the people, pets or equipment being transported. The transport option taken was often embedded in a regular routine (like commuting) but also varied considerably based on changing circumstances.

The COVID-19 pandemic further disrupted transport routines. Although in general people were leaving the home far less often, for the remaining trips householders were often reluctant to use public transport, taxi and rideshare services due to the infection risk of occupying an enclosed space with others. Travel by private car, bike, scooter or foot was considered safer and preferred. Reduced road congestion and travel times during lockdowns, and before most workplaces encouraged return to the office, further encouraged car travel by those still working on site. There were signs that pandemic-induced transport shifts would linger as some households now owned additional cars, motorbikes, bicycles and scooters, and new routines and appreciations of other travel modes (including walking) had developed.

Alongside pandemic-induced shifts towards private vehicle travel, urban households and younger people especially, were also participating in a wider shift towards owning less or no cars, or using their car less often. Where available, rideshare services such as Uber were increasingly being used for short trips, such as for social activities and when likely to drink alcohol. Carshare services such as GoGet and Car Next Door were also enabling less or no car ownership. Driving private cars was commonly preferred by people that especially enjoy car ownership, and families or for people with pets who needed to transport children and animals to school, parks or other activities. Driving was also particularly important for people living in **New estate homes** and **Regional agricultural areas** with less or no reliable and convenient public transport, rideshare and carshare services.

NewEst

RegAgr
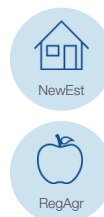
Interest in electric bicycles, scooters and motorbikes was increasing in urban areas as a COVID-safe and convenient commuting mode, or as a leisure activity involving more time outdoors. Electric bikes were seen as a way to ride further and more often, into more scenic locations, and with others — without requiring very high levels of fitness. Children and younger people were also using electric skateboards and scooters for short trips or fun. Other mobility leisure technologies, such as (electric) boats, were being used by a small number of participants or were of interest for future activities and investments.

"The electric [motor]bike's got, like, maybe, up to 200kms before you need to charge it, so if I need to go to say, like, the other side of the city and then to another friend's house, another friend's house, and I don't feel like charging along the way, I'd probably just take the petrol [motor]bike"

– Fred, 33, outer Melbourne

EnTech   DigTech   NewEst
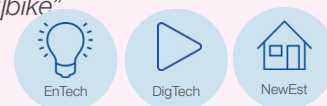
"If I'm taking my dog then we go in the car. ... Do I need to carry things? If I need to carry things, then I'll take my car. If I'm travelling light, I can go on my bike. If I'm going to be drinking then I'm going to get public transport or an Uber. Yeah, they're usually the three first considerations, like where am I going and am I taking my dog, what's the drive like, is it worth me getting my bike out for that and am I going to get drunk?"

– Kylie, 39, inner Sydney

AptRnt

Digital Energy Futures: Future Home Life

Explaining the trends

- Increased time at home during COVID-19, and continued emphasis on working from home, has made the home the focal point for charging mobile devices.

- Australia has an enduring car ownership culture, based on a belief that this enables personal control, freedom and flexibility. This means that carshare and ridesharing schemes are neither appealing nor viable as the main mode of transport for many who participated in our research.

- Everyday mobility is seen as distinct from regional and holiday travel, making electric cars a viable option for everyday local mobility.

- Most concerns about the feasibility of EVs relate to the affordability of these vehicles and their perceived utility, as well as the belief for some that electricity is currently no cleaner than existing fuel options (e.g. petrol, diesel).

- Some households are concerned about environmental sustainability and see electric vehicles as a current and longer-term sustainable option as electricity becomes more 'green'.

- Households have access to an increasingly diverse range of mobility options and vehicles, including cars, bicycles, scooters, public transport and ride-share services.

"The amount of fuel and that consumption has got to cease. And the thing at the moment where businesses want people to return to the office, and one of my things is why would you do it when you're protecting the environment by staying at home. And it seems to work. People seem to now become more and more accustomed to it."

— Brian, 60, regional VIC

Everyday future visions

- Participants envision that they, or society generally, will move towards electric vehicle ownership but that this might not be in the near future.

- Participants envisage charging electric vehicles at home for convenience and practical reasons.

- Increasing dependence on solar is seen as part of a future which will change the landscape of battery charging and the timing of routines around charging.

- Participants imagine that working from home will continue to be part of their own and/or other people's futures; this will have implications for charging and energy demand at home.

- AD cars and AD features might make EVs more popular in the future since it is likely that AD cars will be powered by electricity.

- In the future, people who depend on solar and battery storage for their energy at home might need to schedule and limit its use in such a way that they would not necessarily have the flexibility or availability of electricity supply to be able to offer or trade energy with others for EV charging.

"Electric cars will be, become, just the norm. I think the petrol cars will be, like, seen as a kind of dinosaur. Maybe in 30 years they would have drones that would pick you up and drop you off, maybe. I think we'll be able to fly to the moon."

— Alastair, 40, regional VIC

RegAgr DigTech SeaTree

Digital Energy Futures: Future Home Life
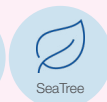
Complications and resistances

- The mobility requirements and priorities of households and individuals vary considerably between urban, suburban and rural locations.

- **Apartment renters** have particular concerns about their ability to charge EVs due to the lack of charging infrastructure in apartment building car parks and less accessible outdoor spaces for charging.

- People have varying degrees of knowledge and (mis)understanding about electric vehicles and charging infrastructures.

- Some households find it unproblematic when devices run out of battery power and do not feel they need to be continually connected or using devices.

- Some people express doubts about the sustainability of electric vehicles and batteries (under current grid and policy conditions).

- People have multiple mobility routines involving different vehicles (electric, hybrid and fossil fuel cars, cycling, public transport, car-sharing, taxis, and mobility platforms such as Uber).

- The car culture of Australia means that some people are particularly attached to the sound, smell and other sensory experiences delivered by fossil fuel cars and are unlikely to desire switching to an electric alternative.

- Some people and households don't have (or want) a car, can't drive, and/or don't hold a valid driver's licence.

- There is no existing evidence to suggest how, if, and to what extent people would use technological solutions for energy sharing and trading using instant peer-to-peer cash transfer tools.

*"I'm a petrol head, and [have a]... deep affinity with petrol driven cars. Electricity has to be made, and in Australia, electricity is made by coal-fired station[s]. If that changes to some extent, I still wouldn't consider it, I think, but I would think about it. I think it's just a scam to say that they're environmentally friendlier than petrol cars, you know?"*

— Kelsey, 59, inner Sydney

Implications for electricity demand

- Greater electricity demand may emerge from the focus on the home as a place for charging an increasing array of mobile and personal computing devices.

- The interest in current and future electric car ownership and in-home charging may increase electricity demand for single homes and apartment complexes that provide charging infrastructure.

- The growing interest in solar should be considered in relation to the growth in home charging because it has implications for how people will schedule their charging and use of different devices and technologies.

- The focus on home charging may have implications for electricity demand elsewhere, such as the workplace or neighbourhood EV charging stations.

- The increasing diversity of mobility and transport options is disrupting predictable commuting and driving routines, which may make it more difficult to establish regular EV charging patterns.

- The desire to control when charging happens and how much devices and vehicle batteries are charged may discourage people from accepting automated systems and generate new evening peaks around charging, particularly through wider adoption of EVs.

- There may be growing demand for electric vehicle charging facilities available through Airbnb and similar schemes.

- Peer-to-peer energy trading platforms or mobile charging platforms might need to be established to accommodate charging of EVs at other people's homes.

Digital Energy Futures: Future Home Life
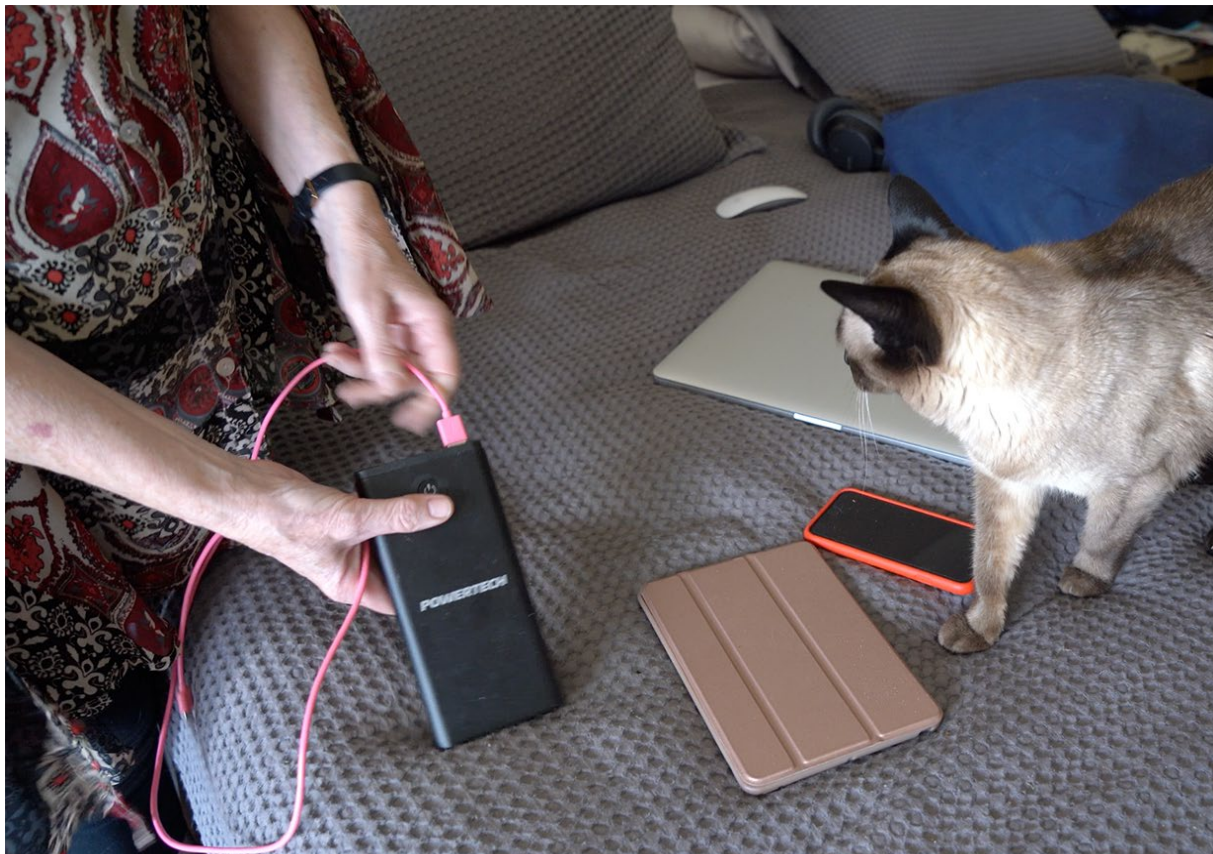
Comparison to industry visions

Key claim from Stage 1 analysis of industry reports

Technology will enable better management of EV charging and match it to the needs of the energy sector. This includes an assumption that people will charge EVs at times that correspond with price incentives.

"A grid that enables variable pricing can also help accelerate the move to electric vehicles and equipment by encouraging charging during the solar peak. Even more important, vehicle batteries and other energy storage devices can provide grid stability – as well as incentives to customers – if system operators can tap these reserves, using stored energy to help meet peak demand and then recharging when solar is abundant."
(Hawaiian Electric 2017, ES-3)

Comparison with ethnographic findings

The majority of current EV owners that participated in this research charged at home and during off-peak times in the evening. The industry vision of charging electric vehicles during daylight hours, when people are parked at their workplace, was generally seen as infeasible by most participants. However, due to increased working from home, there may now be more opportunity for daytime charging of EVs at home during the solar peak.

Key claim from Stage 1 analysis of industry reports

Energy sector visions suggest technology will increasingly automate the EV charging decision making for consumers.

"'Smart' charging of electric vehicles can help to shape electricity load around solar and wind generation, supporting the efficient use of renewable energy."
(Deloitte 2018, 17)

Comparison with ethnographic findings

While some EV owners had charging settings automated into the car, we also found that others had developed manual workarounds to override the car's automated charging function to better fit with their routines. For non-EV owners, we also saw many beliefs and routines around charging digital devices and electric tools that may counter the charging practices ideal for grid stability and may discourage acceptance of industry visions for automated charging.

CHARGING AND MOBILITY
CASE STUDY 1

"You should generally have more than enough charge."

### Murphy's reflections on his new electric car

Murphy is an engineer who lives with his wife and their four-year-old son and 10-month-old baby in a modern house in a quiet area of a regional CBD. Murphy sees his job as a "paycheck" and invests his interest in technology in developing smart home systems in his house, which balance automation and control in such a way that suits him and his family. He also has solar panels and a Tesla battery for storage in the yard.

Murphy's family became more "car-centric" in the last year due to changes in the weather, bushfire smoke and having a small baby. After the lockdown, he bought a new electric car — a Hyundai Ioniq — "in anticipation of not being in lockdown". Previously they had just had a hybrid Toyota Prius, which he had chosen for environmental reasons, and used to commute to work while his wife rode her bike. He sees the Ioniq as a good family-sized car that can replace the Pruis when it "dies". It is now the primary car with the kid's car seats in it, which his wife will use for work, while he will use the Prius. He will still use the Prius for the eight-hour drive to visit his parents until a fast-charging infrastructure is available at an optimal point in the journey, enabling them to follow their established journey routine.

Murphy charges the Ioniq at home, overnight for 12 hours using the standard wall socket, in a weekly routine. He doesn't believe that it's necessary to have a fast charger at home because there is one five minutes from his house that would charge the car in 28 minutes. He believed future car charging would be at home, saying it would not make sense for either employers or people commuting to work to charge their cars at work: "I mean, you know, it's not like you recharge or refuel your physical gasoline car every time you arrive at work. You should generally have more than enough charge to get to work and back."

For him, stationary energy storage at home was more viable than using his car as a home battery since, "I just don't see a house having to suddenly deal with a battery that starts to just disappear, you know, drives away and then comes back home and drives away and comes back home." He had made an active decision not to invest in the Nissan Leaf, which could power a home from its battery because he felt his money would be better invested in a new power wall at home.

Murphy, 41, regional NSW

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Digital Energy Futures: Future Home Life
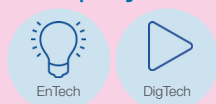
CHARGING AND MOBILITY
CASE STUDY 2

"It's saving our time."
Deepa and her charging routines for smart devices

Deepa and her family moved to Sydney from India about five years ago. They live with a significant amount of tech — including their smartphones — and two children who have their own iPads and use laptops. In the bathroom, the toothbrushes, timed to be on for two minutes, are plugged in next to Deepa's husband's shaver. The family has several kitchen gadgets, a washing machine with wifi settings, and a VR headset and Xbox under the TV. They also have a Google Nest Hub and many gadgets, some of which they use Google Nest Hub to control — such as the smart lights and smart TV. For Deepa, this way of being able to control her home environment is often more efficient than doing so via a smartphone app: "We just thought, let's try how it works, and it's really good, it's saving our time". She would like to automate as many technologies as is viable in her future home. At the moment, they continually invest in and try new technologies because their priority is to make their lives easier. Yet, at the same time, they balance this to be careful about energy use.

Many of these technologies need to be charged, such as Deepa's smart projector — at the time, she told us, the smallest in the world, it could easily sit on the palm of your hand. She explained how they use it both for her and her husband to watch movies in bed and sometimes for the children when they go to bed, so they can lay down to watch films on the ceiling rather than on TV in the living area:

> "When we are in bed, and when we want to watch some movies or something, then we project it on the wall or the roof, and then we just lie down and watch it. It's very handy as well, and it connects to the app... from a smartphone, you just connect it, and whatever we want to play, we just select the Bluetooth."

The device has a USB charger, and they plug it into the power bank when the battery is low. One of the charging devices lays on the small table she uses to work from in her bedroom, with four

USB cables coming from it. She also has a dedicated charging station, with a camera, smartphones, iPad, smart watch, Bluetooth speaker and power bank either kept next to it or being charged at the time.

Like many participants, Deepa likes to control how her technologies charge and uses a "wifi plug" to achieve this. She sometimes unplugs the device when she wants to switch it off but often uses it with a mobile app on her smartphone to turn it on and off remotely and monitors it when she is out. The benefit is that if she has connected an appliance to it to charge, she can then turn it off at a distance, meaning that the family can "reduce the charge" if they wish. Thus giving them greater control over energy demand and the amount of time appliances are left charging.

Deepa, 41, regional NSW

DigTech

2. Cooking and Eating

Home cooking and food storage – involving a range of increasingly specialised appliances and additional fridge/freezer capacity – was accelerated by the COVID-19 pandemic and associated lockdowns. Smart features are starting to be incorporated in new kitchen appliances and fridges; however, there is considerable scepticism about their value.

RELEVANT TECHNOLOGIES: COOKING AND EATING

Categories	Continuing Technologies	Emerging, Accelerating, and Speculative Technologies
Cooking and Heating	Steam oven Pizza oven Multi-cooker (e.g. Thermomix) Coffee machine Breadmaker Deep fryer Microwave Snack and sandwich toaster/press/grill pan Pie maker Slow cooker Pressure cooker Rice cooker Egg cooker Dishwasher Toaster Kettle Electric frypan Popcorn maker Waffle/crepe maker Electric BBQ Food dehydrator Electric and gas cooktop/stovetop	Air fryer Meat smoker Induction cooktop Smart kettle Smart coffee machines Other smart cooking appliances Self-cooking and cleaning appliances (e.g. smart Thermomix)
Refrigeration	Fridge-freezer combination (including ice-maker) Upright and chest freezer Water cooler	Smart fridge Bar/wine fridge
Food making and Preparation	Food processor Blender Juicer Grinder Sausage maker Pasta maker Electric knife	Alcohol distiller Beer brewer Cheesemaker (and fridge conversions for cheesemaking)
Other		All-electric kitchens Self-ordering cooking devices/fridges/pantries

Trend 1: Increasing and diversifying home food preparation and appliances

Households are acquiring and using more specialised electric cooking and food preparation appliances.

Most households are acquiring and using more electric appliances used for specific applications that provide specialised cooking functionality or enable greater convenience (e.g. bread makers, pizza ovens, slow cookers, deep fryers, air fryers). This has been accelerated by the COVID-19 pandemic, which encouraged home-cooked meals and prompted households to purchase or acquire additional cooking appliances. New homes or home renovations are also contributing to these trends through increased kitchen space. Many homeowners had undergone or were considering renovations to include a second or third full-size oven (e.g. steam oven) installed in the main kitchen, a 'butler's pantry' or an outdoor, shed, or garage kitchen or kitchenette.

"Tonight, I'm making fresh Fettuccine for my family for dinner. I've already made my dough, and now I'm going to roll it out [machine sound]. Now we're up to the part where we actually cut the Fettucine [machine sound]. There's our Fettucine on the drying rack and ready to go."

– Dianne, 60, regional NSW

"We renovated our laundry and put a little kitchenette in here. So there's a second dishwasher, a second oven and a two-burner but that's all not connected yet, and we won't use it. It's just for the future [when] we might rent out the back of the house."

– Kelsey, 59, inner Sydney

Trend 2: Refrigeration and freezer space is expanding

Bulk buying and cooking, preserving local produce, storage for pet food, and the desire for convenient cold beverages is encouraging households to maintain or install a second or third fridge/freezer.

Older fridge/freezers are unlikely to be decommissioned when an upgraded appliance is purchased; instead, they stay on to provide extra capacity, are sold second-hand, or passed on to friends/family members. Refrigeration and freezer capacity are a high priority for many households as they seek to provide convenient meal options for themselves and their home, store food in bulk, or provide on-demand entertainment options. Second fridge/freezers are typically always on (for bulk storage) or used occasionally for entertainment or to offer cold beverages in the warmer (summer) months.

""The outdoor bar fridge has been converted into a cheese cave."

– Peter, 50, regional NSW

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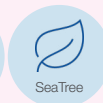
"We bought a new fridge when we moved here, and the old fridge is in the laundry. So we've already got two big fridges, and my partner's got a smaller fridge/freezer up in his little 'man cave'. Which, in the winter, it's turned off. We don't use it because what's the point of running something for cold drinks when you're not even going to be up there? So, we just run that in the summer. And the other two fridges are adequate for what we need."

– Marj, 71, regional VIC

SeaTree   RegAgr
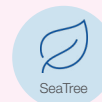
Trend 3: Increasing reliance on pre-prepared food delivery services

Households are relying more on services that deliver cooked, ready-to-eat restaurant meals (e.g. Uber Eats) or meal kits (e.g. MarleySpoon)

Concerns about leaving home, and additional household pressures resulting from COVID-19 lockdowns (e.g. schooling and working from home), increased demand for food delivery services such as Uber Eats, Menulog and Deliveroo. Other households sought to improve their 'home cooking' through 'meal kit' services which require less shopping and chopping but still need to be 'cooked' (e.g. Marley Spoon, Light n' Easy, HelloFresh). Some households find this very convenient, whereas others find that it can take longer than cooking meals themselves.

"When I cook, I normally just put the veggies on the steamer and the steak on the stove, and it takes me five or six minutes, and I'm done. But yeah, with Marley Spoon it was really nice meals, but it's just the time and the fiddly stuff, and I just don't enjoy it, so I stopped doing those. [My partner's] still doing the HelloFresh, but half the time, it's a battle just to get cooking it on time before the meals go bad… so by the time she cooks them, it's Hello not so Fresh."

– Bob, 35-44, regional NSW

HiDem

"I joined a Facebook group which is created by a Chinese [girl] and that Chinese girl has organised different kind[s] of stuff that we like, so it can be a Vietnamese Pho, it can be a Japanese ramen, it can be a Peking duck, it can be other stuff that we like and then let's say she said, okay, we will have a Peking duck delivery next Friday, and then we will need to order it beforehand, and then it will get delivered cold, and you can just heat it up, and that's a meal."

– Yuet, 34, outer Melbourne

NewEst

Trend 4: Smart features becoming more desirable but still not delivering benefits

As households upgrade their kitchen appliances, they are turning to 'smart' options that provide added features. However, most still question the benefits.

Smart features, such as Bluetooth or wifi connectivity, are becoming increasingly common but are often seen as gimmicky or lacking value. Many households have some experience with smart kitchen appliances (e.g. smart kettle, smart coffee machine). However, they don't see significant benefits from these features, and the cost of smart features is commonly not viewed as delivering sufficient value to justify their small benefits.

"...which is stupid, big time – the smart part. I mean, it's an amazing coffee machine, makes amazing coffee, was my Christmas present from last year, but to be honest, thinking that [my wife] spent like two and a half grand on this coffee machine ... just because it has Bluetooth and you can make your coffee from a distance [laughing]... and I don't know how because the milk jug is in the fridge. I mean, it's stupid, honestly. It's really stupid. I think that for some kinds of appliances, their smart feature is just a marketing feature."

– Miles, 41, inner Sydney

AptRnt   DigTech

"Oh, [I've got] the smart kettle. It's just a normal kettle, though. It's literally a normal kettle. It's like $1 extra for the smart feature. I've never really actually used it."

– Morgan, 26, outer Sydney

AptRnt   EnTech

Explaining the trends

- The COVID-19 pandemic encouraged home cooking and prompted households to purchase or acquire additional cooking appliances in response to concerns about the food supply, contact with others, and desires for more self-sufficiency.

- There is increased availability, affordability and marketing of specialised cooking appliances and equipment (e.g. pasta maker), which is leading to increased uptake of these technologies.

- Growing interest in more nutritious and healthy food and eating (normalised and promoted through cooking shows) is leading some households to purchase or acquire additional specialised cooking appliances and/or services.

- Some households prefer home delivery and specialised appliances because they find them convenient and help save time preparing meals.

- Many consider food preparation at home to be a part of the provision of care and a way to provide comfort, pleasure, entertainment and education.

- The proliferation of cooking appliances is partly due to gifting and hand-me-downs from family members (e.g. making life easier when a new baby is born).

- Increasing appliances are part of home renovations to create more space and capacity at home for various activities, including cooking or hosting guests (e.g. Airbnb kitchenette).

- Many prefer to prepare and store bulk food to reduce food costs (especially low-income households).

Everyday future visions

- Many participants have longer-term anxieties about their health and the quality of food prepared by others, making home-cooking and healthy delivery options desirable for the future.

- Participants envisage smarter kitchen appliances in the future, but find it difficult to imagine robots or appliances that could cook and clean themselves.

- While some households want to downsize their homes and kitchens in the future, many desire to expand their cooking capacity through renovations, additional appliance purchases or increased refrigeration.

"I have heard of the Thermomix, the Thermomix cult. Yeah, my old neighbour's got one, and she loved it, but she's an amazing cook, but I was still unimpressed, because when I heard about it... I thought that you could just throw your onions in, it would peel them. No, you still have to prepare your things. It has all these functions, but you still have to be in control of it… [I would want something] magic. Set and forget, yeah. Maybe it's even stuck to the side of your fridge, and it selects them and makes it happen. You just don't even have to open your fridge."

– Kylie, 39, inner Sydney

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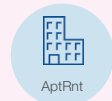
Complications and resistances

- Most participants expressed resistance to replacing a fridge before the old one 'dies', despite understanding that it is less energy-efficient than more recent models.

- **Apartments** and other small homes lack space for a second fridge/freezer and expansion of kitchen capacity.

- Low-income households are less likely to pursue more costly food trends involving specialised kitchen appliances, smart appliances, or food delivery services.

- Some participants born in countries outside Australia find the number of kitchen appliances that Australian households typically have overwhelming and undesirable.

- People with poor digital skills, ethical concerns about on-demand or 'gig economy' deliveries, and people who prefer only to eat their own food, resist the home delivery food trend.

- Households in the city fringe and **Regional agricultural areas** may not have access to pre-cooked food delivery services or may have their access limited by patchy mobile coverage.

- Some participants are entirely disinterested in having more smart appliances or devices in their lives or kitchens due to privacy, security, usability and/or functionality concerns.

- Despite the trend towards electric appliances and cooking, some households still prefer gas for cooking (oven/stovetop) and maintain a gas BBQ.

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Implications for electricity demand

- Energy outcomes are complex and varied; detailed research is needed to test the convention that cooking accounts for about 5% of the total energy bill. This research suggests this may be changing.

- Smaller cooking appliances that replace oven use (e.g. slow/pressure cookers and microwaves) can reduce energy use.

- Families with babies and young children pursuing care, comfort and convenience imperatives often have additional food-related energy demand.

- Concurrent use of multiple full-size ovens or kitchens may increase evening peak demand or entertaining demand (weekends, public holidays), particularly in high-income areas, **New estate homes** featuring additional kitchens, and **Sea- or Tree-changer** areas where properties are likely to attract guests.

- All-electric home conversions will add cooking-related electricity demand, especially from induction cooktops used in the evenings when households with solar PV are no longer generating electricity (unless they install battery storage).

- Older fridges and freezers are often kept to provide extra capacity, passed on to friends or family members, or sold when a new, more energy-efficient appliance is purchased.

- Even though new fridges are likely to be more efficient than older models, the increasing reliance on second or third fridges or freezers undermines energy efficiency gains. This may increase electricity demand, particularly in larger homes with space for extra appliances.

- Sporadic and occasional use of takeaway and restaurant food delivery services may complicate the predictability of electricity demand from cooking.

- More households seeking to save time and improve health by replacing grocery shopping and cooking with reheating (typically via microwave) of pre-made, delivered meal services (e.g. Light n' Easy) will limit cooking-related energy use in these homes.

NewEst

SeaTree

"We bought a bread maker that was on quite a good sale [laughs]. [An] automatic bread maker … so, rather than using [the] conventional sized oven, with this new machine ... I think it will use, it has, less wattage use and the whole program runs for probably only less than two hours, I think, non-stop. So I think that's pretty efficient in terms of time, but also power usage."

– Haruki, 49, outer Melbourne (no consumer group)

Comparison to industry visions

Key claim from Stage 1 analysis of industry reports

Smart appliances will proliferate and improve the convenience of everyday routines, as well as produce data that is useful for the sale of other products and marketing.

"In 2018, Amazon quietly debuted a smart microwave that can be controlled using Alexa—and will someday automatically track what you're heating up. If you're a Prime member and subscribe to certain groceries, the microwave and Alexa will work together to make sure that you never run out of staples, like microwave popcorn, again." (Future Today Institute 2019, 289).

Comparison with ethnographic findings

There is considerable appeal for increasing the convenience of cooking enabled through a proliferation of small cooking appliances. However, many smart cooking appliances such as smart kettles or smart coffee machines fail to deliver substantial benefits for households. The data generated from these devices may be of interest for industry commercialisation and marketing, but this has limited appeal for consumers who adopt these appliances to increase the convenience of meal preparation. For example, technologies such as the Thermomix (multi-function cooking appliance) are being enthusiastically adopted by some and seen as the possible early stages of more automated cooking futures. The affordability of smart appliances is still a key concern for many households.

COOKING AND EATING
CASE STUDY 1

"One of those fridges that talks"

Beatrix's hopes for a smart fridge

Beatrix is in her early-60s, living alone in Sydney's eastern suburbs. She described herself as a "hopeless cook". Since being diagnosed with osteoporosis, high cholesterol and being a "borderline diabetic", she was making changes to her diet and lifestyle. She had recently stopped buying ready-made foods from the supermarket and was focusing on "getting better with my cooking" and preparing meals that "could last me two days".

Her fridge was a big component of making sure these meals stayed fresh for leftovers. Refrigeration became even more important during quarantine, and the isolation brought about by the COVID-19 pandemic when Beatrix was cooking more from home. During the research (as part of her technology diary, see Figure F), she reflected on how her fridge was the technology that she could most not live without. She explained that while she had lived without television and a phone in the past and could do so again, the fridge was indispensable "because it preserves my food and it saves me money as well."

Beatrix had a self-described "basic" fridge but was interested in updating to a plumbed model with "the water outlet thing and the ice cube maker thing." She also expressed interest in a smart fridge, which she understood as "one of those fridges that talks and tells me what I can cook for dinner, or what I'm lacking."

Reflecting on what a smart fridge might say to her, Beatrix noted that "I could imagine one of those modern fridges saying to me, 'What do you want now?', or if you went to get an ice cream, 'No, you can't have that. It's too fattening.'" She further explained, "I do have a weight problem, and I like my food." She was seeking advice from a dietitian about this issue but could imagine a smart fridge also helping her with appropriate nutrition. However, Beatrix also reflected on how a smart fridge that talked back to her could be annoying, "especially if I [were] craving something, like an ice cream."
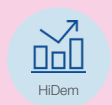
Beatrix, 62, inner Sydney

HiDem

FIGURE F: BEATRIX'S WRITTEN DIARY

Diary Template
1. The technology that gets used the most? FRIDGE
2. The technology that you could not live without? FRIDGE
3. The technology that you think uses the most electricity? FRIDGE

Technology	Day 1: Date TUES 15/10/2020	Day 2: Date: WED 16/10/2020	Day 3: Date: THURS 17/10/2020
1. FRIDGE	USED FOR STORAGE OF FOOD & FREEZER COMPARTMENT FOR LONG TERM PRESERVATION OF FOOD. NO ISSUES, WORKS WELL.	AS PER DAY ONE. THIS IS THE PRODUCT I COULD NOT LIVE WITH- OUT AS IT KEEPS FOOD FRESH FOR DAYS & HENCE SAVES MONEY.	AS PER DAY ONE & TWO BASIC MODEL. WOULD PREFER MORE MODERN ONE WITH DRINKS MACHINE AUTOMATIC DE FROSTER ETC. IT IS PROBABLY THE ITEM THAT USES THE MOST ELECTRICITY.
2. MOBILE PHONE TABLET / SMART WATCH	MOBILE PHONE. SYNCED TO TABLET & SMART PHONE. USED TO COMM- UNICATE WITH FAMILY & FRIENDS & TO KEEP UP TO DATE ON NEWS	THIS PRODUCT IS USEFUL FOR SOCIAL CONTACT & OFFERS A SENSE OF SECURITY IN TERMS OF FEELING SAFE. HOWEVER ALTHOUGH CONVEN IENT I CAN GO SEVERAL HOURS WITHOUT IT @ WORK.	AS PER DAY ONE & TWO CONVENIENT. COMPACT CAN FIT IN HANDBAG. CAN BE DISTRACTING AT TIMES. WORKS MOST OF THE TIME CHANGE BATTERY OVERNIGHT
3. T-V TABLET / SMART PHONE	T-V. USED TO KEEP UP TO DATE WITH NEWS. MAINLY USED TO WATCH NEWS DOCUMENTARIES & POPULAR T-V. PROGRAMS	T-V. OFFER ME COMPANY AS I SPEND A LOT OF TIME AT HOME ALONE. IT CAN ALSO BE A FORM OF RELAXATION OFFERING A VARITY OF ENTERTAINMENT.	AS PER DAY ONE & TWO TOPS UP BETWEEN T.V. AND FRIDGE AS TO BEING ABLE TO LIVE WITHOUT. FRIDG A NECESSITY, CAN GO WITHOUT T.V. FOR SHORT TERM PERIODS (FEW DAYS) & NOT A NECESSITY. CAN LIVE WITH- OUT IT BUT WOULD MISS IT.

COOKING AND EATING
CASE STUDY 2

"Super-duper all singing, all dancing coffee machine"

Alastair and his (smart) appliances

Alastair, 40, lives in West Gippsland with his wife and two young children. He and his family had several modern kitchen appliances, including a "pretty big fridge, freezer with an ice and water function" that they'd received some money back on through the VEET [Victorian Energy Efficiency Target] scheme, and a "super-duper all singing, all dancing coffee machine." His family mostly had their groceries delivered and ordered them online. Alastair had solar panels and tried to time the dishwasher's start time around the availability of power during the middle of the day. If there wasn't enough power being generated during the day, he would set a timer to run it late at night.

A Thermomix was central to the family's meal preparation and storage routines. Used "every day, every single day", Alastair explained how this "amazing" appliance produced a range of convenient meals such as "perfect consistency porridge", "enormous chilli", chicken curry and stir-fries. It was also "connected to the wifi at all times so I can actually go on and take a menu from here and send it to the Thermomix, which is quite clever."

Alastair explained how his wife would make multiple dinners for their daughter, which she packaged up and froze. The family had an "overflow" chest freezer in their garage that they'd had for about five years to cater for their meal preparation and storage, as well as to store bulk purchases such as meat. Ideally, Alastair would have liked to get a bigger fridge/freezer inside the house, but he was limited by the existing capacity of the cabinetry in their kitchen. He explained that they'd probably get a larger fridge/freezer when the family moves into a new house, which they were in the process of designing and planning for, as Alastair worked in architectural design. Alastair was interested in a smart fridge but thought they looked "pretty expensive". Explaining the appeal, he said he liked the idea of being able to "keep tabs of what's in there, and I don't like wastage… if it was able to link it to like Coles, Woolworths and say 'okay order this, order this, order this' or 'we've run out of this', click, click, click.'"

Alastair, 40, regional VIC
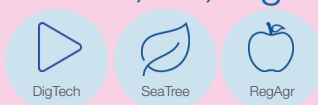
DigTech   SeaTree   RegAgr

3. Healthy Indoor Air and Thermal Comfort

Households are becoming more interested in managing the air quality in their homes — especially to reduce exposure to bushfire smoke, allergens, moisture, mould, toxins, and unpleasant odours. They are using an increasingly diverse range of heating and cooling appliances and technologies, and are starting to introduce new indoor air appliances, such as air purifiers. Heating and cooling trends are changing in response to flaws in home heating/cooling system design, alterations to the use of household space as a result of COVID-19 lockdowns, other lifestyle changes, and/or concerns for family health and comfort, including pets.

RELEVANT TECHNOLOGIES: HEALTHY INDOOR AIR AND THERMAL COMFORT

Categories	Continuing Technologies	Emerging, Accelerating, and Speculative Technologies
Space Heating and Cooling	Individual room heaters (gas or electric) Ducted heating (gas or electric) Split system heating and cooling (reverse-cycle) Refrigerative air conditioning Evaporative cooling Portable air conditioners and coolers (refrigerative and evaporative) Ceiling and pedestal fans	Shed or garage heating/cooling Hydronic heating Smart thermostats Remote controlled heating and cooling Smart blinds and pergolas
Personal Heating and Cooling	Heat packs Hot water bottles Electric blankets	Heated floor mats Heated pet mats
Household Air Quality		Air purification units and functions Dehumidifiers and humidifiers Diffusers (oil) (including smart versions)

Trend 1: Increasing interest in technologies for 'healthier' indoor air

Households are becoming more interested in managing air quality in their homes via air purification, dehumidification, humidification and diffusing.

Interest in air purification and other air quality management has accelerated. The 2019-20 bushfires exposed many households, including Melbourne and Sydney residents, to extended periods of bushfire smoke, and health authorities raised awareness of the risks from breathing smoky air. Many households attempted to keep smoke out of the home and/or avoided going outside as much as possible. Some used their air conditioning more than usual to remove smoke from their indoor air, while others switched off evaporative cooling to avoid drawing smoke into the home. Some used clothes dryers instead of the washing line or worked from home instead of travelling to workplaces.

Around one in ten households in our research had specialised air purification units. Many more had considered buying these emerging technologies during the bushfires but had held off due to lack of availability, doubts about effectiveness, or uncertainty that they would need them after the 2019-20 bushfire season.

Some air purifier purchases or interest pre-dated the bushfire crisis. In addition to smoke, air purification and modulation technologies were also desirable to reduce exposure to allergens, moisture, mould, toxins, dust and unpleasant odours, or enhance mood or enjoyment of the home. Some households adopted air purifiers in response to a doctor's recommendation for a respiratory health issue. The use of air purifiers may be more common in some culturally diverse households (e.g. for the health of children or to manage cooking odours) and households with a general enthusiasm for adopting new technologies.

Air purifier purchases prompted by an event (e.g. bushfires), could result in long-term, ongoing use as some households found them reassuring. Both regular and intermittent use of air purifiers could occur alongside household doubts about what air contaminants were being extracted. The potential to reduce exposure to COVID-19 is also likely to increase the adoption of air purification.

"[I bought] two air purifiers, a smaller one for here and a bigger one for the lounge room. Obviously, for the bushfires. It was pretty bad… getting one that's closer to medical-grade was an option… they both have auto mode, so we just leave them on … when it first comes on in the morning out of night mode, it'll fire up and do a heavy job at cleaning ... [it] glows red and then comes back down to a nice soothing mood, and everyone feels safer … There's definitely still stuff in the air [since the bushfires finished]... there's definitely particulates for sure … Just put your faith in it and let it do its thing."

– Peter, 50, regional NSW

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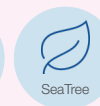
"[We're] Vietnamese, we cook the fish, and you know how stink-ety with the house? So, we use the [air purifier] to reduce the odour during the cooking… one of the kid's got a severe problem with pollen, and I have hay fever... [so we] buy an air purifier. Actually, it works."

*– Nigel, 38, outer Melbourne*

DigTech   NewEst

Trend 2: Air-conditioned cooling increasingly considered 'essential'

Access to home cooling is increasingly seen as necessary, at least for use in very hot periods and for the health of one or more household members.

The need to turn off evaporative cooling to prevent drawing bushfire smoke into the home caused some households to pursue or consider installing air-conditioned cooling (usually split systems). Others felt that their evaporative cooling was no longer sufficient to meet the household need for cooling, especially in extremely hot or humid weather, so households with evaporative coolers are increasingly installing or considering split systems for cooling.

Few households are confident that their home is sufficiently well designed and insulated or capable of being sufficiently upgraded to eliminate or minimise the need for cooling — especially if they end up working from home or under COVID-19 lockdowns during summer, or have more 'heat sensitive' or vulnerable household members.

Bushfire smoke provided the extra impetus to get air conditioning installed, especially tenants wanting landlords to install air conditioning, as households could no longer rely on ventilation to help manage uncomfortable heat. Homes became 'stuffy' without access to fresh air from open windows and doors. Portable cooling appliances were being used by tenants in **apartments** and other rental properties without in-built cooling and to counteract the high cooling energy use caused by lack of zoning in ducted cooling systems (especially in **New estate homes**).
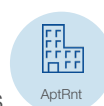
"We found with our … evaporative cooler … even on the lowest setting it seemed to be too cold, and you had to cool the entire house. … [With the four inverter units installed last year] you're heating or cooling a much smaller space, which is ultra-efficient. I haven't removed [the evaporative cooling]. I suppose I probably should seal up the vents or something to help keep the house more air-tight, but I guess we've got it as a backup if we ever need it."

– Malcolm, 36, outer Melbourne
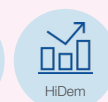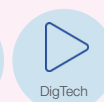
"We got our landlords to install the air-conditioning after the bushfires. Just because if we locked everything and closed all the windows, there was barely anything to breathe inside. It was quite an [unpleasant] environment [in our apartment] …. because it was so hot as well… we communicate through agents, but the way we positioned it is to save ourselves the hassle, and you hassle looking for new [tenants]... I guess that worked because they installed it for free."

– Ruslan, 27, inner Sydney
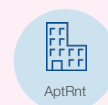
Trend 3: Households are increasingly layering and tailoring their heating strategies in response to winter comfort dissatisfaction

Many participants implemented additional heating strategies to quickly overcome newly-recognised heating challenges and winter discomfort associated with COVID-related lockdowns.

With more time and people at home over the 2020 winter due to COVID-related lockdowns and working from home arrangements, unsatisfactory home and heating system designs became more apparent. Participants reported feeling cold during long sedentary periods working, studying or otherwise spending time at home; many anticipated or received high energy bills due to increased heater use. Poorly maintained rental properties, low quality newer homes, large open plan living spaces (common in volume built **New estate homes**), and inadequate zoning capacity in ducted (gas) heating systems were among the cool weather comfort challenges.

In response, participants acquired new and/or used existing standalone heaters or small under-desk heaters, purchased electric throw blankets, or used microwaveable heat packs and hot water bottles. In some instances, these strategies involved moving their work or study to a smaller room that could be more effectively or efficiently heated than the much larger open plan area of the home. Personal heating strategies were used in addition to, or instead of, ducted systems (e.g. depending on whether other family members were still utilising the larger spaces). Split systems, initially installed for cooling, also provided another layer of heating options. Hydronic heating systems were often seen as an ideal heating solution.

Another aspect of comfort impacting heating choice or use is perceptions of the quality of heat produced. Preferences vary but include avoiding sleeping in 'dry' or 'stale' air (e.g. from ducted systems and closed windows), ensuring fresh air is available (including to minimise the risk of CO_2 poisoning from gas appliances) and avoiding drafts (e.g. from split systems).

"This is my monstrosity of a living area. You can see how cold it would have gotten in winter… see the tiled floor as well. … At the beginning of the lockdown, I also had myself [and my work computer] located out on my lounge... because I've got gas ducted heating, it led to my gas bills going astronomically high because I've got a very big open space... so I've actually then moved... cleared out a spare room ... I've been able to heat it with a small electric heater rather than heating the whole house… it allows me to concentrate on work a lot better." [Participant lives alone in a large open plan home]

– Tiana, 42, outer Melbourne

"In winter, this room gets cold, so instead of turning on the main heater... I bought one space heater… we have central heating… sometimes it's a waste of energy because we're not in all [of] the house, all the time. So, it would be better to have it split into sections or something, but that's not how it is."

– George, 44, outer Melbourne

Trend 4: Importance of manual strategies to efficiently stay warm or cool is conflicting with ideas of automated or programmed thermal comfort

Many households prioritise manual and low-energy adjustments to their home, activities and clothing over primary reliance on heating and cooling, and as such, have doubts that automated or programmed heating and cooling will deliver energy-efficient thermal comfort.

Many households view manual strategies to manage home temperature as essential to comfort and energy efficiency (e.g. closing blinds to keep the sun out, opening windows to provide cross breezes and fresh air, adjusting clothing, being outside when possible, using a pool if available, switching off the heating while sleeping). Manual strategies access 'natural' thermal comfort and provide a sense of control and 'free' heat or cool for the home. Instead of believing the efficiency promises of technology, households often highlight the range of activities, moods and temperature preferences that they consider too complex for automation or algorithms to understand.

Tech enthusiasts (usually men) showed more interest in advanced programming and automation of thermal comfort. However, high energy use was seen in some households that embraced heating and cooling automation.

"There's a timer on the air conditioning and on one of the gas heaters, so I could [automate] that, but we don't really use it enough for me to even bother ... [I'm] not so interested in making all that sort of stuff happen [like smart thermostats]."

– Jade, 49, inner Sydney

EnTech

"At home, yeah, I've got a heated little throw blanket, so I just put that over my legs... I'm always cold, so [a smart thermostat] wouldn't help … an algorithm would have to take into consideration so many metrics like 'What's my comfortable temperature? What's my husband's comfortable temperature? What are the children's comfortable temperatures? What heat is actually coming in from windows? ... I reckon it would cause more dramas than if we just say, well, this is what it's going to be."

– Lauren, 39, outer Melbourne

HiDem

Trend 5: More rooms and spaces in the home are being heated and cooled to enhance lifestyle and respond to COVID-19 and other events

More people at home pursuing a range of activities, including work and schooling, contributed to the utilisation of spaces such as garages and sheds for one or more household members to work, study, pursue hobbies and DIY projects, exercise (home gym), relax, and/ or find solitude or peace. This is creating new heating and cooling needs.

The use of garages and sheds more frequently and for a broader range of activities is accelerating in response to the COVID-19 pandemic and its impact on the increasing occupation of homes. These spaces often lack insulation and sealing, so they heat up quickly in summer and are particularly cold in winter. Improving the 'man cave' and expanding its use to other family members to make these into additional 'living' spaces can involve introducing a heater and/or portable or installed cooling devices (including when spaces are repurposed for activities such as exercise).

Other lifestyle enhancements that expand or extend heating and/or cooling into new spaces included: outdoor heating (e.g. alfresco living areas); increased interest in having a pool (heated and cooled); and pool 'cabanas' in the backyard.

> *"We have three air conditioners, two are in bedrooms, and one is in the study, which is half of a garage – half of our garage. It was converted into a study, and we have air conditioning in it. So, on a hot day, we either retreat to the study in the garage, we retreat to the bedrooms, we get in the pool, or we go to the beach, which is only 10 minutes away."*
>
> *– Richard, 73, regional NSW*
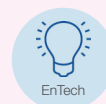
> *"We've just had that deck built, actually… We sit out there a lot. I've got a heater… I've got another fan out there, there's a strip heater... It doesn't push out a lot of heat but it takes maybe a little bit of the chill off. And that's all electric."*
>
> *– Lauren, 39, outer Melbourne*

## Trend 6: Growing heating and cooling for pet health and comfort

Some households use heating and cooling specifically for the health and comfort of their pets — including dogs, cats and birds.

Pet-related energy use can involve additional heating or cooling over and above that needed for human occupants of the home, or use of heating or cooling when pets are alone at home. Veterinary or online advice, poorly designed housing (especially **apartments** that get very hot in summer), and consideration of pets as a family member contribute to heating/cooling use for pet health. Pet energy use can involve products marketed explicitly for pet thermal comfort, such as 'cat mats' (low energy) or heating and cooling devices designed for human use (e.g. standalone or ducted heating and cooling systems).

"That's my geriatric Siamese [cat]. We would [use the cooling for the cat], yes, if the cat was uncomfortable… in extreme heat, yes we have."

– Dianne, 60, regional NSW
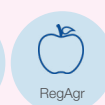
"I was sitting under [the air conditioner] when I did have it on that reasonably hot day and in the living room and I sort of found that it was a little bit too cold. But I was trying to keep the birds [located in a connected room] cool, and I didn't want to bring them into the living room."

– Cheryl, 63, regional VIC

Explaining the trends

- Increased time at home during COVID-19, as well as household members occupying different and therefore more spaces of the home simultaneously, has increased heating and cooling needs.

- There are growing concerns about the quality of indoor air, particularly due to bushfires.

- Poor home design, including large open plan designs, deficiencies in insulation, shading, and draught-sealing, leaves many unhappy with thermal comfort and the energy usage to achieve it.

- Some manual strategies to achieve thermal comfort are more prevalent and possible in detached homes with gardens, homes better situated for natural ventilation, homes less affected by noise, pollution or security concerns, and in **regional households**.

- New housing (especially in **New estate homes**) is increasingly using ducted heating and cooling to attract sales, regardless of whether these systems will be efficient and effective for occupants.

- During home design and construction, there can be a lack of attention to genuine, effective zoning of ducted systems.

- Migrants and other culturally-diverse households may be insufficiently experienced with Australia's housing and energy systems to ensure housing and system selections are affordable and suitable for their needs.

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Digital Energy Futures: Future Home Life

Everyday future visions

- Energy and comfort inefficiencies highlighted during COVID-19 lockdowns are contributing to some households considering or installing more permanent or high-tech heating or cooling options like reverse cycle air conditioners and smart thermostats, and energy efficiency measures including improving insulation, double glazing or tinting windows.

- Anticipation of increased hot weather and bushfires as the impacts of climate change progress is also increasing interest in cooling for comfort and health.

- Some households anticipate a need for more cooling if COVID-19 lockdowns occur during summer or mask mandates are in place during hot weather, which encourages them to stay home more often.

- Many households have concerns about growing costs associated with an increased need for heating, cooling and/or air purification (both running costs and acquiring/retrofitting necessary technologies).

- There is enthusiasm, and many have aspirations, for solar energy enabling free (financially or environmentally low-cost) air conditioning.

"I guess the bushfire season that's just been is one of the worst that's happened in a few years. So I don't know, [air purification] could be something that I'd probably consider next time there's a big bushfire season."

– Dylan, 20, inner Sydney

AptRnt

"Imagine on the 40 degree days [if we are in COVID-19 lockdown]. Well, you probably just wouldn't go out, would you? You'd put the air on and stay home. I would."

– Marj, 71, regional VIC

SeaTree   RegAgr

Complications and resistances

- Some households are ambivalent or deem it unnecessary to use air purifiers in response to bushfire smoke — especially if located in areas less affected by bushfire smoke, if they have access to less smoke-affected ocean breezes, or if they had previously lived in cities which often experienced poor air quality.

- Some households are interested in air purification but have not yet adopted this technology due to uncertainty about the capacity of currently available devices to improve air quality or which product to trust or choose.

- Some households missed out on buying an air purifier when bushfire-related demand caused suppliers to sell out, therefore there is likely latent demand that may result in another wave of air purification purchases in response to future bushfire smoke or other air-related concerns.

- The inclusion of air purification functions in air conditioning units may negate the need for purchasing stand-alone air purifiers but encourage more air conditioning installation and use.

- As a result of bushfire smoke, some households abstained from cooling their homes as much as required or cooled their home in different ways (e.g. fans for internal air movement rather than AC sucking polluted air in), with potential consequences for people's health, comfort and productivity.

- 'Spreading out' of household members using different rooms (including to study, view different entertainments, find solitude during COVID-19 lockdowns) can ensure ducted systems are used without zoning.

- The high costs of many desirable home energy efficiency upgrades impede implementation.

Implications for electricity demand

- Increasing access to and use of sporadic and occasional cooling is likely to increase average and peak electricity demand.

- Increased access to reverse cycle units for cooling (e.g. in response to bushfire smoke and extreme heat) will also shift some heating demand from gas to electricity.

- Heating and cooling demand is likely to rise as activities like working, studying, and exercising are increasingly performed at home, which encourages householders to spend more time in separate areas of the home rather than in communal areas.

- Heating and cooling in sheds and garages will use more energy than in better-insulated parts of the home.

- Energy outcomes of personalised heating strategies will vary, depending on the spaces heated and the comparative energy use of the technologies used in preference to larger systems.

- Impacts of air quality technologies on energy use will depend on devices and usage patterns (e.g. fitting of air filters to AC units might change the use-case for the device from one of cooling to one of improving air quality).

- In households that embrace air purifier automation capabilities, these devices contribute additional energy use throughout the year as they allow the device and incorporated sensors to determine the timing and amount of air purification needed in the home.

- Smart or automated air purifiers may respond to immediate air 'threats' detected instead of energy pricing and demand signals, potentially undermining demand management objectives.

- Some dehumidifiers may use more energy than air purifiers.

- The desire to manage air quality with technology does not necessarily replace the desire to bring 'fresh' outdoor air into the home. As with heating and cooling practices, keeping windows or doors open to introduce fresh air or utilise cross breezes is likely to increase the energy use of some air quality devices.

Comparison to industry visions

Key claim from Stage 1 analysis of industry reports

Smart home technologies will manage increased energy demand from heating and cooling to deliver savings for both consumers and the energy industry, particularly through automation and remote control.

"Specific loads such as electric hot water, pool pumps and air conditioners can be set and controlled remotely to consume electricity at the cheapest times and export it (in the case of solar PV and batteries) at the most expensive times without impacting consumers." (AEMC 2019, 5).

Comparison with ethnographic findings

Most participants maintain manual control over heating and cooling because they prefer only intermittent use 'when they need it'. Most households insisted that technology would not deliver better thermal comfort and energy savings compared to their current practices of manual control and occasional use. Also, the smart functionality in many existing smart technologies, such as air purifiers, are not set to respond to energy pricing and demand signals but to air quality monitors built into them, which are likely to be triggered at existing peak times.

HEALTHY INDOOR AIR AND THERMAL COMFORT
CASE STUDY 1

"You can't sit in the house all the time."

Marj, her husband's shed, and air purification

Three years ago, Marj and her husband made a tree-change from outer Melbourne to regional Victoria. As retirees, they chose a four-bedroom house with an acre of land and a large shed to accommodate several cars, their camper trailer, and tools.

The couple normally lead an active lifestyle, walking several kilometres before breakfast each morning. In regards to energy use, Marj is more "careful" than her husband but tries not to be "miserly" as sometimes her energy saving focus "annoys him".

"[My husband] always says, 'It's only money'. That's his theory... I don't think I'm miserly with [power], but I'm careful... We've got TVs in just about every room and we've got, I've got a desktop computer and we've got the laptops, a laptop each and the phones, so there's always something on charge."

Marj mostly attributed the home's electricity use to her cooking and cleaning activities. They had fans installed in three rooms and a reverse cycle split system to cool the home "on the really hot days". The home's ducted gas heating normally runs throughout cold winter days but spikes in electricity usage in August were explained by oil heater use in the shed:

> "Cars is his big love. He's building a car… [normally] he would be up in the shed during the morning and the afternoon; just come down for snacks and lunch and whatever… got the oil heaters up there and he's been painting… that's probably when the power bill went up that month… But hey-ho, you've got to do something. You can't sit in the house all the time."

The couple considered installing a "potbelly stove" to heat the shed but have concerns about the risk of combining fire with flammable fuels. Instead, although "it was just a dream in the beginning", they will likely install a reverse cycle unit to heat more energy efficiently and enable cooling of the shed.

> "In the summer, on the hot days, it's too hot to go up [to the shed]… I think a reverse cycle's probably… the best way of controlling the temperature for the lowest amount [of energy]. We've had [reverse cycle units] for years and we've always found them very economical... [the idea] keeps popping its little head up more and more often."

After a period of illness and medical advice, the couple bought an air purifier, "[my husband] had a bout of, well we think it was pneumonia… ended up with the respiratory physician… he suggested that we get an air purifier". Marj switches the air purifier on sporadically in response to her husband "coughing more and sneezing" from "an allergic response". She also uses it if she notices other air quality issues including smoke and odours, "I might [turn the air purifier on] if I felt that the house was a bit stuffy or there was some sort of lingering odour or smoke… I don't have a set routine. I just put it on when I feel I might need to clean the air".

Marj has doubts about whether she is using the air purifier enough, but also whether it is effective:

> "Maybe I should be putting it on every day. I haven't been… It's not a power thing. It's just we didn't use it there for a few weeks… whether it works or not, I don't know… It's got different settings and you can set it for ions or, I just leave mine on the normal setting… After a certain time, it does switch itself off. So that could be the automatic function. But it seems to be on for quite a few hours before it turns itself off."

Marj may upgrade the air purifier, "it wasn't an expensive one, because I said to [my husband], 'Really, I just want to try it'. If we feel that it is working, then we'll buy a better one".

Marj, 71, regional VIC

SeaTree   RegAgr

HEALTHY INDOOR AIR AND THERMAL COMFORT
CASE STUDY 2

"I do like things cool, my wife not so much."

Greg's reflections on heating, cooling and air purification technologies

Greg and his wife recently moved from regional NSW to Canberra. Greg teaches computer studies and enjoys experimenting with new digital technologies. When he introduces new technologies into the home, his wife says, "What's that? When did we get that?" Greg considers his wife's experience:

> "I try to be a little bit circumspect... [I] try not to get the latest gadget, I try and make sure it's got a reason to exist rather than just buying it because I've got it or because it's a possibility. She tends to not. She's not technophobic, and she's quite computer literate, but she doesn't have the same interest in gadgets and technology that I do."

Greg installed a weather station that sent a notification to his wife's phone "saying the CO_2 levels are too high" at night when they are sleeping. He says, "the obvious thing to do is to provide ventilation but [that's] not such a good idea in Canberra in the middle of winter... to improve the air quality from the level of CO_2 level would be something interesting."

Greg's household may adopt air purification in the future if he finds a technology he is confident in. During the 2019-20 bushfire crisis, Greg looked into air purification:

> "I wasn't confident that there was going to be sufficient benefit... the house was very, very big... even just purifying the bedroom, we did look at that. Honestly, there were so many options and so many possibilities I sort of gave up on it."

Both Greg's previous and current homes have had very high electricity and gas use. Still, he doesn't fully understand why: "I'm almost 100 per cent convinced that our high power bills in [regional NSW] were because of the number of devices... vampire [power]... I think I'm 100 per cent guilty of that." He would like to use less energy but making the home more energy efficient has not been a priority, but he hopes it can be in retirement. They recently installed a large solar PV system and considered installing a battery.

Greg runs home servers (for security reasons), and the couple uses ducted gas heating and cooling extensively:

> "We were very, very happy with the air-conditioning unit in [regional NSW]. It was ducted, probably the biggest issue. I do like things cool, my wife not so much. So in my study... I actually ended up putting in a separate split system so that I could have it nice and cool in the area that I was working and that we could have it at a temperature that my wife preferred in the rest of the house."

Greg uses settings to cool before they get home and would like a greater degree of automation and remote access to his heating and cooling systems in the future.

Greg, 60, formerly regional NSW

EnTech   DigTech   HiDem

4. Living and Play

Many households were spending increased time in the home due to the COVID-19 pandemic, which led to increased investment in household comfort, smart home technology, digital entertainment devices, and recreation. Expanding expectations for the home were also leading to increasing diversity and simultaneous usage of digital devices to enhance lifestyle, provide entertainment and recreation, or support other everyday activities.

RELEVANT TECHNOLOGIES: LIVING AND PLAY

Categories	Continuing Technologies	Emerging, Accelerating, and Speculative Technologies
Digital Entertainment	Projectors Streaming services (music and video content) Video games and gaming consoles Smartphones and apps Televisions (digital and smart) DVD and Blu-ray players Laptops/PCs/Tablets Headphones Keyboards	Digital voice assistants (e.g. Google Home) Virtual reality (VR) headsets Smart speakers (e.g. Sonos) Augmented reality (AR) Home cinemas Streaming devices (e.g. Chromecast and Apple TV)
Physical Recreation	Treadmills Ellipticals Rowing machines Pools (pool pumps)	
Household Devices		Smart lights Smart security systems Smart doorbells Pet monitors Smart blinds Mature smart home technology Robotic vacuum cleaners Mini-refrigerators (in entertainment or gaming spaces)

Trend 1: Multiplication of screen-based viewing

On-demand video streaming is replacing live television viewing, and many households, particularly families with multiple generations, watch television and movies individually with each family member on their own device.

Due to the proliferation of multiple streaming devices being used concurrently, many households report problems with their internet speeds during media viewing. As well as digital or smart TVs, several have alternative arrangements such as projectors that they plug their computers into for watching streamed material, or laptop monitors that are used in place of televisions. Some householders, particularly children and teenagers, also watch streamed and other online content on their smartphones and tablets.

"Well, nowadays, yeah, because of the kids' age, [my husband] and I would watch something, my mother would independently watch something because it's in German and the kids each as well."

– Kelsey, 59, inner Sydney

HiDem

## Trend 2: Homes are becoming increasingly luxurious by people's own standards

There is an increase in 'luxury' additions to the home, and many are altering the use of spare rooms and household spaces.

The increase in time spent at home during the COVID-19 pandemic led to increased investment in household technologies and home improvements that participants commonly considered luxuries. More time and money was spent on improvements such as gardening, decorating, and new furniture, but also new digital technology, including smart lights and internet-connected speakers. Many were also interested in or in the process of upgrading outdoor recreation areas, including increased use and **interest in pools, pool cabanas** and other outdoor living spaces featuring many of the electrical appliances of an indoor equivalent.

HiDem

Many altered how they used household spaces, converting spare bedrooms into home offices, home cinemas and home gyms. This often required purchasing electrical equipment and digital technologies, and altering heating or cooling practices for these spaces.

"And then just 'cause I get bored when I'm sometimes doing, on the rowing machine or the spin bike [in my home gym in the garage], we've got a little Apple TV set up there with a mini speaker and a monitor. So that pretty much can be another screen for all the streaming services or fitness services that we've got."

– Pedro, 45, inner Sydney

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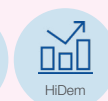
Trend 3: Digital voice assistants are not reaching their predicted potential

Digital voice assistants are increasingly ubiquitous but rarely connected to other devices or smart appliances.

Many people had digital voice assistants (DVAs) in their homes, including many who had received them as gifts from family members or as free give-aways from telecommunications or digital technology providers. However, most still used their DVA in a limited number of ways: for checking the weather, occasionally asking a simple question, or as a smart speaker for playing streamed music or radio. Few used their DVAs to control or automate other smart devices in the home. However, DVAs were very popular with children, although largely serving as a toy rather than a hub for automation.

"[I use the Google Home voice assistant] just to stream music usually. I mean, the one with the screen you can get it to tell you recipes and things like that, but I don't know... It's funny when you actually ask it to play something; it tells you that that's what it's going to play, but then it plays something totally different. So, [laughing] I think there are still some issues that need addressing with those devices."

– Helen, 36, outer Melbourne

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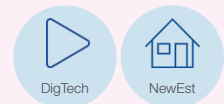
"And it [Google Home] is really good actually for my daughter. My daughter loves it. She comes in and will ask weird and wonderful questions."

– Alastair, 40, regional VIC

DigTech   SeaTree   RegAgr

Digital Energy Futures: Future Home Life
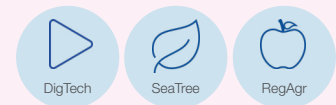
Trend 4: Few smart devices are achieving enduring benefit

Smart devices are of interest, but many are rejected as gimmicks or seen to be inconvenient.

Many **digital technology early adopters** were interested in smart devices and always purchased the 'smart' option when replacing an appliance. However, often these did not live up to their expectations or desires for the technology. Small devices such as smart toothbrushes, smart coffee makers, and colour-changing smart lights, were viewed more as gimmicks or toys rather than providing convenience or other benefits. Several households had also rejected and uninstalled smart home technology, finding that its setup and upkeep required more time and effort than the technology saved.

"I used to have a smart toothbrush, but I threw away the monitor because it's bullshit, honestly… It told you if you were brushing too hard to give you alerts when to change quadrant. Like seriously, you get the same with a $300 toothbrush as you get with a $50. I liked the idea of it, but [sigh]."

– Miles, 41, inner Sydney

## Trend 5: Robotic vacuums are acting as harbingers for automated futures

The robotic vacuum cleaner was a familiar emerging technology that framed and influenced people's future desires and scepticism about automation.

People who had negative experiences with robotic vacuum cleaners were more sceptical of home automation, whereas those with positive experiences were more likely to want more automation. Problems with robotic vacuums included an inability to adapt to the physical structures of homes (principally stairs or narrow hallways), the presence of pets and children (including anxieties about spreading their messes), and distrust in the cleaning capabilities of the technology. Many who had robotic vacuums, particularly earlier models, had stopped using them and became sceptical about other automated technologies. Even those satisfied with their robotic vacuum cleaners tended to see them as a baseline cleaning device that they would supplement with other manual vacuuming to reach areas or dirt that the robotic vacuum had missed. They were largely viewed as imperfect devices that made people sceptical about promises of future smart home automation.

**Digital Energy Futures:** Future Home Life

"[I would not have a robotic vacuum], not with the cats because we have one cat that has stomach issues, and I would end up with cat sick all over the house, no doubt. It wouldn't be a good idea. I prefer to vacuum and know that I've done the job myself, and I get the satisfaction of how good it looks afterwards."

– Jodie, 42, regional VIC

RegAgr
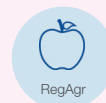
"I would have it [robotic vacuum] running every day, [but]... by the end of the week, we'll clean ourselves, vacuum [with]… a proper vac, because it [robotic vacuum] doesn't do the corners, it doesn't do skirting boards, it doesn't do around chair legs properly."

– Bo-Ann, 40, outer Melbourne

DigTech   NewEst
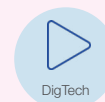
Trend 6: Increase in home internet demand for everyday activities

More time spent at home (during the COVID-19 lockdowns) and increased video streaming for entertainment is increasing some households' internet needs.

COVID-19 lockdowns uncovered home internet deficiencies and the limitations of services on offer, both in major cities and regional areas. Some migrants were surprised that internet services in Australia are more expensive and slower than in their countries of origin. Some participants, particularly in **new apartments**, were surprised that the National Broadband Network (NBN) was not connected and were unhappy with their available internet connection. A number of smart home devices required increased internet speeds. For instance, smart security systems need to be able to stream and upload videos to function as intended. Slow and unreliable internet may hinder the adoption of connected digital technologies.

AptRnt

"[Internet drops out during interview] I think my husband used the microwave… It never used to [drop out], but it does now. We've noticed it, obviously, since this lockdown period. Our microwave completely cuts it out."

– Naomi, 41, outer Melbourne

NewEst   HiDem
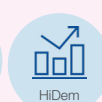
"I was on a lower [internet] plan when I was in an apartment, but the reason I had to upgrade my plan is my ring doorbell. And it's not the download speed; it's the upload speed. Because the upload speed could not cope, so you could not access the video… and you can imagine it took me weeks to figure that one out. The things you don't think about. I didn't need a better plan, but it turns out I did."

– Tiana, 42, outer Melbourne

DigTech   NewEst
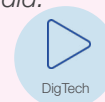
Trend 7: Gaming spaces and accessories are multiplying

Online gaming is increasingly social and linked to special equipment and dedicated spaces.

Video games are increasingly being played online and with friends or family. Therefore gaming is viewed by many as a social activity, particularly connecting people during the COVID-19 pandemic, which involves live chatting and conversation. Dedicated gaming rooms or areas are common, particularly amongst teenagers and young adults. Besides video game consoles and gaming computers, many gamers also have multiple monitors and other auxiliary accessories such as coloured lights, light up keyboards and headphones, and mini-refrigerators. VR gaming is an emerging interest.

"We've got my eldest son's bedroom. He's got the gaming chair, messy bed and that's his setup. So, he's got a PlayStation and a TV.… and he's got a mini fridge in his bedroom [where he keeps] drinks, just drinks so he doesn't have to get up and go to the kitchen, even though it's a very small house… and he's got these…they're LED lights because apparently every year 7 boy needs LED lights in their bedroom 'cause it's cool,' oh I don't know."

– Rachel, 33, regional NSW

DigTech   SeaTree   RegAgr
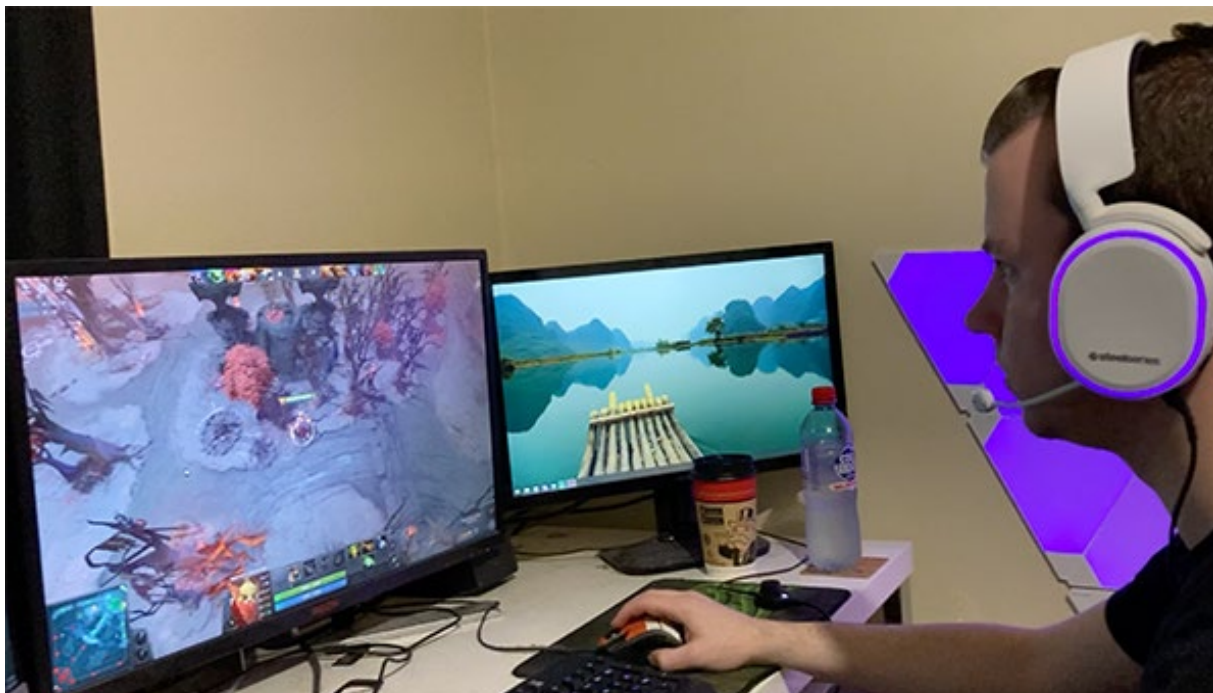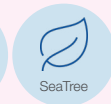
Explaining the trends

- Increased time at home during COVID-19 encouraged increased investment in household comfort, entertainment and recreation.

- Lockdowns associated with COVID-19 encouraged diversified use of household space as the house began to serve more purposes.

- Streaming enables more tailored entertainment options, and the prevalence of multiple video streaming devices (including laptops and tablets) encourages simultaneous, individual viewing.

- Multi-generational families (especially CALD households) prefer to stream content based on their individual preferences and language abilities.

- Video gaming is embedded in a larger gaming culture and community with a particular aesthetic and accessory technologies, hence the interest in dedicated gaming spaces.

- DVAs are increasingly common but used for simple functions due to perceived complexity in managing automated smart home technologies.
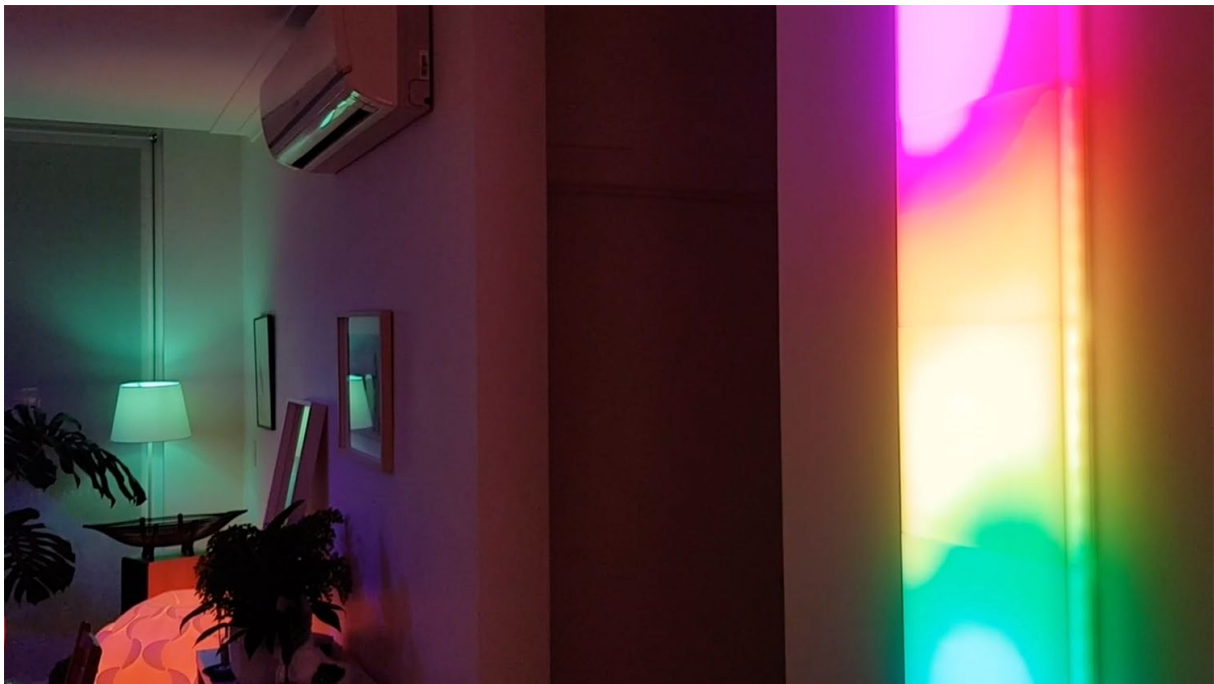
Everyday future visions

- Increased individual viewing is causing concern about isolation between household members, particularly in families.

- More time spent in the home during COVID-19 and possibly into the future is increasing concerns about social isolation from friends and community.

- Social online gaming both discourages the potential isolating effects of video games but also presents new challenges for monitoring children's social interactions and possible bullying.

- Many have concerns about the privacy implications of their DVAs, which they perceive as constantly listening.

- Many desire future smart home technologies that are more intelligent than currently available devices, particularly for **Early adopters – digital tech**

- Many parents have considerable concerns about children's technology use, particularly the need to balance educational and social activities undertaken on digital devices with limits on screen time to encourage active and imaginative recreation and face-to-face social interaction.

- Many participants pointed to VR as the most likely change to entertainment in the future, but some worry that increased individualisation with virtual reality might further increase the trend towards isolation in entertainment.

"I think the more technology you have, the more isolated you get. So, if I didn't have the TVs in the kids' room, we'd be watching it in the lounge room together, which we still do sometimes, but more often, they wouldn't have the option to go and do it by themselves; yeah."

– Rachel, 33, regional NSW
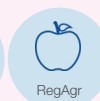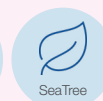
"I think if you were always using a VR headset, you might be even further disconnected from the people that you live with. And now if you're watching TV with someone, you're kind of still there together, and you're in each other's company even though you're just watching something. But I think if you had VR headsets, you're just completely disconnected, and it's like you're never actually with them. So I think that might make you feel a bit isolated."

– Angus, 25-34, inner Sydney, DTech. and Apt.)
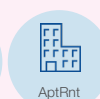
Complications and resistances

- For some people, increased time spent on computers for work and schooling from home leads to decreased interest in digital entertainment and 'screen fatigue' resulting in a preference for physical activities and low-tech entertainment such as crafting or playing board games.

- Many, particularly CALD people, have issues with digital voice assistants understanding their accents and have frustrations with voice control.

- Some people, particularly middle-aged and older women, feel unsure about what digital technologies might offer them, believing these technologies are not marketed to them. This is particularly true for women without children.

- **Renters** are less able to significantly alter their use of the home or make significant investments in modifying or improving their home. Renters instead often purchase smaller technologies such as smart speakers or make other small decorating changes to make their domestic spaces more pleasant.

- The frequency of glitches, unanticipated outcomes and data/security breaches limit the usefulness of smart technologies and increase the digital skills and labour required to keep them running.

"I tried Google, you know, voice recogniser. You can say something, but the trouble is because English is not my second language, it's actually my third language… That's why sometimes we try... actually, we borrow some from my friend. We tried using the Google voice, but because of accent, sometimes it could be very funny."

– Victor, 47, inner Sydney (no consumer group)

"I have an automatic garage door… my neighbour rang me, 'Nigel, your garage has been opened, I'm sure you're not at home'... I'm in Queensland.... then I realise I go through the audit of Alexa. It turns out one of my kids will accidentally say a phrase [that opens the garage door]... [Now] we have a monitoring system in place to make sure things not go awry when we're not there… yesterday when the whole network is going down… the whole house doesn't work. Obviously, you can't turn on and off the light anymore… It took me half an hour to realign it… a little panic. I hate spending a lot of time on it."

– Nigel, 38, outer Melbourne

Implications for electricity demand

- While direct energy demand from entertainment devices and smart technologies may be relatively low compared to other household appliances, the spaces and practices associated with their use may have more significant impacts.

- Increased electricity demand may come from the heating and cooling needs associated with individual viewing, streaming and gaming, as household members use **digital entertainment devices** in different areas of the home.

- Gaming and other entertainment spaces can have other hidden energy needs, such as the use of a minifridge, separate heating and cooling needs, specialised lights and upgrades to other equipment such as larger and higher definition televisions to enjoy the newest generation of gaming consoles.

- Greater electricity demand may come from retrofitting spaces to become home gyms, such as installing an air conditioner in an exercise space, which is often also in a non-insulated shed or garage, as well as other auxiliary digital devices, such as televisions and speakers, used while exercising.

- High energy use practices such as swimming in a personal pool may become more common as more time and money is spent on household entertainment and recreation rather than using public facilities.

- The proliferation of digital devices will likely lead to a small increase in electricity demand at peak times (e.g. afternoons and evenings) from the cumulative effects of multiple devices running concurrently.

- Previous negative experiences with household automation and smart appliances which fail to deliver on their promises of convenience increase consumer scepticism about other automated technologies, potentially increasing resistance to automated energy management systems such as direct load control.

DigTech

Comparison to industry visions

Key claim from Stage 1 analysis of industry reports

Widespread adoption of smart home technologies is 'just around the corner', bringing improved efficiencies, convenience, and immersive household entertainment. Digital voice assistants will become the hub of the smart home and enable greater household automation.

"With technological advances in voice control and artificial intelligence, the intelligent assistant is now a viable control centre for the connected home." (McKinsey 2019, np).

Comparison with ethnographic findings

We identified a proliferation of digital devices, although many purchases and acquisitions were directly linked to the increased time spent at home due to the COVID-19 pandemic. Many of these technologies do not live up to industry predictions, such as digital voice assistants, which were mostly used for minor entertainment or simple requests. Voice assistants were rarely connected to other devices or appliances, used to make purchases, or envisioned as central to more household automation.

Key claim from Stage 1 analysis of industry reports

Smart appliances will enable better energy management through automated and remote control.

"By harnessing BTM [Behind the Meter] assets like smart appliances at granular levels, new value-added predictive maintenance and monitoring services will dovetail with DR [distributed resource] functionality that benefits both the customer and the energy provider." (Navigant 2018, 25).

Comparison with ethnographic findings

The main appeal of digital technologies was about increasing convenience, pleasure and entertainment in the home, not the opportunities it provided for energy management.

LIVING AND PLAY
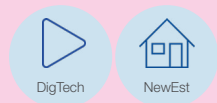## CASE STUDY 1

"It's a super-duper OLED."
Helen's television and gaming upgrades

Helen, 36, and her partner are avid gamers. They have their main console set up in the central living room, with the most recent PlayStation and the Nintendo Switch. They play online as a couple, with their sister and brother-in-law, as a family game night, which allowed them to play together during the 2020 COVID-19 lockdown. They also have a separate gaming room, where they keep their older consoles set up.

For Christmas, Helen's partner was getting the newest generation of Playstation. This encouraged them to purchase a new larger 77-inch television that they hoped would optimise the graphic abilities of the new gaming console: "And we've also just got a new TV that we're waiting to put up. It's massive. We've got the Playstation 5 now. It's a super-duper OLED. So it's got the graphics to support it." Helen admitted that there wasn't "anything wrong with our current TV" and they didn't know what they would do with the current TV once they installed the new one.

Helen, 36, outer Melbourne

DigTech   NewEst

LIVING AND PLAY
CASE STUDY 2

"We use it as much as possible."
Don's outdoor entertaining area.

Don, 51, lives with his wife and two sons in a suburb of a regional city in NSW. He enjoys renovating and upgrading his home and often has various projects on the go. He also likes to entertain at his home and has invested in household recreation spaces, particularly outdoors.

He has a pool that has both a heater, as well as a pool cooler that "takes the edge off [the pool] and cools it down a bit" when the water is too warm. He has these on timers, alongside his pool pump to run during the afternoon when his solar PV is producing and overnight when tariffs are lower. However, he does not alter these timers in response to overcast weather. He runs the pool pump and heater or cooler every day.

In addition to the pool, Don is in the process of installing an outdoor kitchen, it already has a sink, countertop, and barbecue, but he is planning on soon installing a wood-burning pizza oven. The outdoor kitchen also has an awning with a ceiling fan. Beside the outdoor kitchen is also a pool room with its own bathroom. The pool room has a variety of gym equipment, speakers, and a television. The television is used when exercising, as well as when the family has a barbecue. He realises that the pool, in particular, is partly the reason he has higher electricity usage than he would like. Still, he enjoys having friends over to the house as well as the pleasure it brings his own family: "We use it as much as possible."

Don, 51, regional NSW

EnTech

5. Working and Studying at Home

The COVID-19 pandemic saw many people working and studying from home, and adapting their routines, household spaces, and purchasing digital technologies to accommodate this. Many hoped that some of this flexibility would continue and envisioned a future where they would continue to work from home two to three days a week.

RELEVANT TECHNOLOGIES: WORKING AND STUDYING AT HOME

Categories	Continuing Technologies	Emerging, Accelerating, and Speculative Technologies
Digital Devices	Computers/Laptops Tablets Smartphones Printers/Scanners Monitors Webcams Video-conferencing software Keyboards/Mice	AR and VR training courses AR workstations Paperthin monitors Microphones/Headphones External hard drives
Other	Personalised heating and cooling Lighting/Lamps	Computer keeping the room warm Electronic (sit/stand) desks

Trend 1: Hybrid work and study model on the rise

As people look to the future, most desire and expect their workplaces to adopt a hybrid model in which they work from the office two or three days per week.

Although working from home was experienced differently among participants (where this was possible), most agreed that the loss of social interaction with colleagues was a negative experience. Still, they celebrated the time saved on commuting and the increased productivity of fewer distractions from colleagues, particularly in open-plan offices. A hybrid model of two to three days in the office was considered to be the perfect balance to achieve the social interactions necessary for group work and creativity, with time at home for achieving more independent tasks. Some, particularly in NSW, had begun this model and were in discussions with management that suggested this would be a long-term arrangement.

Studying at home for young children was not considered positive, and children's presence at home during workdays was often distracting, especially for mothers in our sample. Few felt that a hybrid model would continue for younger children, but they did believe it would continue for university study, with a mix of online lectures and in-person tutorials.

"My husband... [initially] found working from home difficult, but now he loves it... because he obviously has more contact with the family plus he has an extra three hours up his sleeve because he's not travelling to the city and back again each day."

– Naomi, 41, outer Melbourne

NewEst   HiDem

"She watches her lectures... they can go into Uni, but the lecturers just lodge the lectures online. They have a choice about when they watch them, and then they go in a couple of days a week for workshops and tutorials, or whatever the current name is. And so she really likes it. Because of the convenience of being able to fit it in around other things in her life, including, 'I don't feel like watching a lecture this morning'."

– Dianne, 60, regional NSW

HiDem   RegAgr
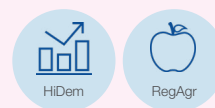
Trend 2: Increasing space and internet needs

Space and internet speeds are the major difficulties of working from home, and many adapt their homes in response.

The experience of working from home depended significantly on the space available in the house. Spare rooms were frequently transformed into home offices, often with additional technologies including multiple monitors, printers, and personal heating or cooling appliances. For those without separate home offices, video conferencing calls were a particular aspect of working from home that stressed the space and internet capacities of the household. This activity required both strong upload and download speeds and privacy from others working or studying in the house.

Multiple household members working and studying from home led many to create makeshift workspaces and shift household activities. The most common change was the transformation of the dining table into a workspace. This was generally viewed negatively as it allowed work to intrude into domestic space, but people developed routines to divide work and home time. Many recognised that at the beginning of the pandemic, they expected it to be only temporary, and were unable to purchase much home office equipment as it was frequently sold out. Now that working from home was expected to continue, many considered more significant technology purchases.

"Yeah, the biggest challenge was [the] internet, of course, and space. So we'd have people on Zoom and kids going, 'I've got to be on Zoom. You're in the quiet room. I want the quiet room, and the big room and the quiet room' and all of that. Card tables set up in different locations to give people desks and stuff. Space was the biggest issue and privacy."

– Jade, 49, inner Sydney

"So in the future, if it's become permanent or if we are able to work more often from home, just two days or become three or four days, then yes, I would consider setting up a proper home office. [It just] depends on the situation. [I] might get a better work desk, workstation, or maybe a bigger monitor maybe. That's a possibility as well. Maybe another keyboard or mouse and the one from work, leave it in the office."

– Kenny, 38, outer Melbourne

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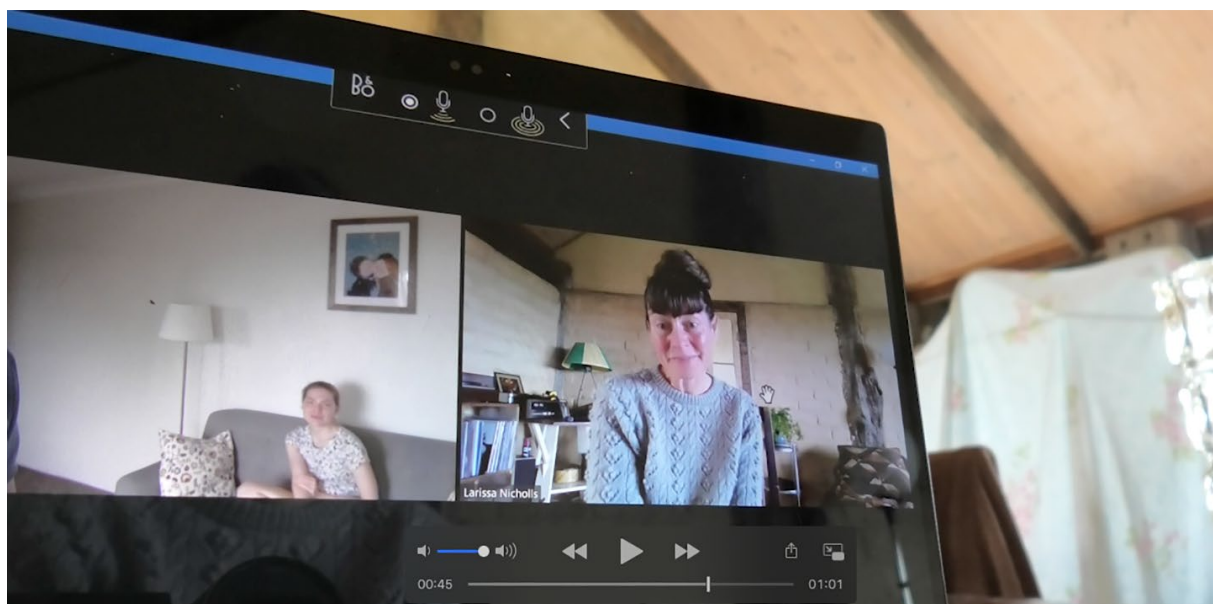
Trend 3: Multiplication of devices for online schooling and work

More computing devices were purchased, repurposed, or lent from school or workplaces to enable the whole household to work and study concurrently at home during the COVID-19 pandemic.

Remote schooling and working led many to purchase computers and tablets or to repurpose old devices, as often every household member was required to be using a device for work or study at the same time. Some received devices from school or work, whereas others had to purchase their own devices. This multiplication of devices is linked to increased individual use of devices for entertainment and social contact, in addition to study and work tasks.

"I bought a laptop because my other laptop is 10 years old, so I replaced that one… For the kids, I didn't buy anything for kids because the school gave them two laptops for them."

– Varghese, 37, outer Melbourne

DigTech   NewEst

"I bought a new laptop just for the sake of having a bigger screen. I study as well, so the small screen was a pain when I had to be trying to study, so that was my one thing. Everything else for work was all provided to us."

– Jodie, 42, regional VIC

RegAgr

Trend 4: Increasing variability of working hours

The internationalisation and casualisation of employment, as well as the increase in shift work and flexible work arrangements, is leading many people to work atypical hours.

In addition to those working in more traditional shift work industries, such as health and aged care, a significant number of participants were in casual work arrangements that meant they did not work typical schedules but responded to client or employer requirements. Some of these clients, employers and work relationships were also overseas with timezone differences that meant work could occur at any time of the day or night. Working from home and flexible work arrangements also enabled those with caring responsibilities to partially shift the hours they worked to evenings when young children were asleep. Increased remote work is likely to follow a less traditional working schedule.

"I start early, but it depends because I have clients that are overseas, so I will have to do calls sometimes late at night."

– Merlin, 55-64, inner Sydney

HiDem

"Most of the time, we [partner and I] work together, but if we need to take care of him [baby], we might just take a break. My team and his team are also very considerate, so yeah, we found this way very good. If we don't work enough time in the daytime, then we will work after he sleeps."

– Yuet, 34, outer Melbourne

NewEst

Trend 5: Increasing flexibility of energy use for solar PV households

The ability to do household chores during the day during short breaks from work is considered a major benefit of working from home, particularly for solar PV households.

Many solar PV households emphasised that their working from home enabled them to self-consume more of their solar power during the day. Even for those without solar PV, the ability to do chores, particularly doing the laundry in the morning and being able to dry in the afternoon sun, was often mentioned as a positive benefit of working from home both for its energy and time savings.

"I loved working from home… I can hang out the washing in the day, and it made my solar ambitions work. I could get chores done during the day."

– Jade, 49, inner Sydney

EnTech

Explaining the trends

- The COVID-19 pandemic required many to work from home during enforced lockdowns and physical distancing restrictions.

- The experience of working from home caused many to question the usual five-day commute and ask their employers for a more productive and healthy balance in the future. Many employers have since changed their workplace policies to allow for additional remote and flexible work options.

- The experience of living through the COVID-19 pandemic has revealed the technical possibilities and limitations of working and studying from home, as people adapted and learned new technologies and interfaces to achieve their work remotely.

- Many households have adapted their homes to make them more effective and comfortable hybrid work and home spaces, encouraging their continued use in this way.

- Other changing employment circumstances, such as increased casualisation of the workforce, the rise of the 'gig economy', and increasing international collaboration or remote international work, are also contributing to more flexible and sporadic working hours.

Everyday future visions

- Most households are optimistic about a future with more flexibility and increased working from home. They feel it would lead to a better and healthier work-life balance, through time saved on commuting, the ability to do chores during the workday, and more time spent with children, family and friends.

- The increase in working from home and its continuation into the future lead many to imagine futures where they could live anywhere, such as regional areas, or be more mobile.

- Most parents did not want children to continue remote learning, except for a hybrid model for university.

- There was some concern that remote work might diminish the workplace culture, but most believe a hybrid model would be sufficient for building camaraderie with colleagues.

Complications and resistances

- Some industries are not amenable to remote work. Technology may make this more possible, but not for all professions.

- Some people, particularly women with young children, find that working from home is very distracting and less productive because of their caring responsibilities and inability to avoid demands on their time by others in the household.

- High-income families in larger homes are more easily able to adapt to working from home as they can purchase new equipment and often have spare space.

- Some people, particularly those living in **New estate homes** in the outer suburbs, already had experience with a hybrid work arrangement, usually negotiated in relation to childcare responsibilities and long commutes. They felt this would become a more common pattern for the entire workforce.

NewEst

"Yeah, I can't focus. So, I can't be in the house because you've got Netflix, you've got cleaning, the kids, so I used to go down to the library and do it, but it just isn't the same. I can't learn from a distance, I need face-to-face. So, yeah, [remote] working wouldn't work either, nope."

– Rachel, 33, regional NSW

DigTech   SeaTree   RegAgr
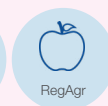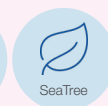
Implications for electricity demand

- Working and studying from home increases daytime electricity demand from working/studying itself, doing chores and cooking during the day, and heating/cooling requirements.

- A hybrid model with two working adults may see at least one person home at all times, leading to overall energy demand increasing or to alternating days of high and low energy usage if working days are coordinated.

- Heating and cooling needs may increase as people shift spare rooms into home offices that previously were not heated or cooled. Using them for stationary activity during long periods of the day had already led some householders to purchase portable electric heaters or coolers to make the new workspace comfortable.

- There is a longer-term possibility that people will prefer to buy and live in larger homes to accommodate home offices, leading to increased heating and cooling energy demand.

- An increase in irregular work patterns and hours may lead to greater irregularity and less predictable evening peaks.

Comparison to industry visions

Key claim from Stage 1 analysis of industry reports

New technologies, such as improved telecommunications (including VR and AR) will enable studying and working from home in more industries.

"In 20 years, you might take your first meeting from home by slipping on a HoloLens or other device where you'll meet and interact with your colleagues and clients around a virtual boardroom powered by mixed reality. Your presentation and remarks will be translated automatically into each participant's native language, which they will hear through an earpiece or phone." (Microsoft 2018, 5).

Comparison with ethnographic findings

The COVID-19 pandemic has accelerated industry predictions of working from home. However, rather than being brought about by technological advancement, working from home was a response to the health crisis. The technologically-driven vision of the sector is complicated by this different motivation; working from home was a necessity rather than a choice for most. Further, our ethnographic findings revealed that although many enjoyed working from home, this also came with significant losses that technology could not replicate, such as casual, social and creative interaction with colleagues. Resultantly, many participants reported their desire and willingness to pursue a hybrid model that sees them in the office approximately half time. Our research also revealed that the ability and experience of working from home was less positive for those with smaller spaces and without the financial means to upgrade home spaces or invest in technology, such as **Apartment renters.** VR was primarily used in gaming, but some suspected VR and AR would be used in future remote work.

AptRnt

WORKING AND STUDYING AT HOME
## CASE STUDY 1

"A virtual screen in the air space"
Haruki's 2050 working life

Haruki lives with his wife and three school-aged children. He works in IT and had been working from home for most of 2020. His children did remote schooling for a few months, and his wife was teaching music lessons online. With everyone working and studying at home, they upgraded their internet connection and purchased wifi extenders to improve internet connectivity in the house. They have a home office that Haruki works in, and another room that his wife teaches online in, and the children work upstairs. He enjoyed working from home but would get frustrated by bad technology and audio breaking up on Zoom calls. He was beginning to feel pains from the poor ergonomics of his working from home set up and was considering upgrading his working equipment.

Haruki drew a comic strip of what he thought 2050 would look like for him, including this depiction of working from home. He envisioned improved technology that would address his current frustrations. As he explained, he will be "working remotely still, option is to travel to the office, but I think that'll become the main format of working style." His image depicts "a big-screen stuck somewhere in my room or my home office space" that is a "paper-thin LED, so that's like a little poster that you can even curl up and put it away." He also depicted himself wearing a VR headset:
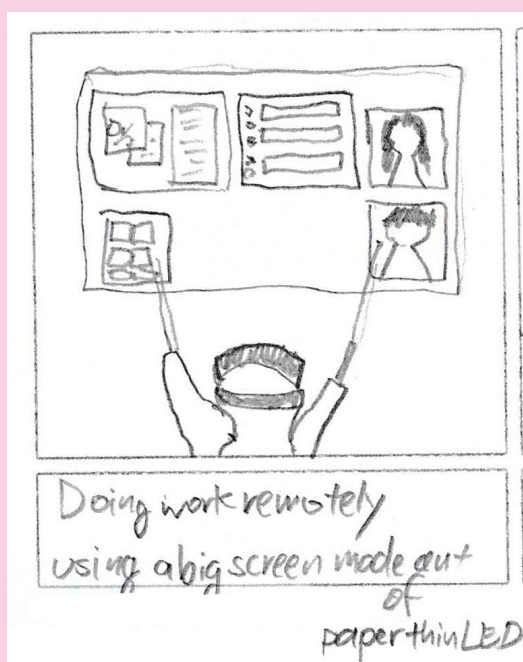
> "That screen could be either VR or physical, on your wall. I didn't really make up my mind there. Then it's got a little focusing device or pointer thing to maybe manipulate windows or maybe switch it on or off or start or mute your voice calls or things like that."

Inspired by the film *Minority Report*, Haruki envisions, "a virtual screen in the air space where you can actually manipulate things and swipe or press things."

HARUKI'S SKETCH

Doing work remotely using a big screen made out of paper thin LED

Haruki, 49, outer Melbourne (no consumer group)

Digital Energy Futures: Future Home Life

WORKING AND STUDYING AT HOME
CASE STUDY 2

"Honestly, I don't think it's in anyone's best interests for me to work from home."

Linsay's complications with returning to the office

Linsay is a 32-year-old mother of two, living with her partner in inner Sydney. She began working from home in the early days of the COVID-19 pandemic. After a few months at home, she was told that she could return to the office. She was happy to return, as she described: "I took my computer back and sold my desk, got rid of a work chair, and I was like that's it, we have our space back." However, Linsay didn't realise how difficult it would be to work from the office while others were still working from home: "Right now, we're in a hybrid mode where people go to the office, but you're still doing a Zoom meeting. And I work in a shared office, so every time I have a Zoom meeting, I have to go book another office." As a result of this experience, Linsay had primarily returned to working from home, but because she got rid of her home office equipment, she now works from the dining room table. Her partner was also working from home during the COVID-19 pandemic; however, he had a separate office upstairs equipped with three widescreen monitors, a Bluetooth mouse, keyboard, wireless printer, and split system air conditioner.

During our online interview, Linsay was regularly interrupted by her children, but she said that this was less of an issue during the workweek while the children were at school. She recognised that there were some aspects of working from home that she enjoyed, particularly the flexibility that enabled her to spend more time with her children. However, she admitted: "Honestly, I don't think it's in anyone's best interests for me to work from

home. Firstly, I'm much more productive when I'm at work, and I know that. And if I want to advance my career, I need to be productive." She recognised that the future would likely see her working from home some days of the week and from the office for others. She imagined "that there will be this altered workweek... three phases of [the] workweek: We have the weekend, we have the work from the home phase of [the] workweek, and we have the work from work phase."

LINDSAY'S WORK AREA AND HER PARTNER'S WORK AREA.

Linsay, 32, inner Sydney

AptRnt

6. Caring for the Home and its Occupants

Caring is a central practice where emerging digital technologies are playing a significant role and are expected to become increasingly important. Many participants suspect that they will adopt more technology as their caring needs increase and envision that technology will play a greater role in supporting them as they age. The COVID-19 pandemic also led to a greater familiarity with practices of care at a distance through digital technologies, such as remote health care and telecommunication technologies to maintain social connections.

RELEVANT TECHNOLOGIES: CARING FOR THE HOME AND ITS OCCUPANTS

Categories	Continuing Technologies	Emerging, Accelerating, and Speculative Technologies
Care of Children	Baby monitors Bottle warmers Sterilisers/sanitisers Breast milk pumps Tablets Heaters/coolers Showers/Baths	Temperature sensors Infant movement sensors Parental control software DVAs and smart speakers Infant sleep monitoring pads
Care of Pets	Water filtration and water pump heaters for aquatic pets Heat lamps for young birds and reptiles Radios and televisions for dogs/cats Heaters/coolers	Water filter pet bowls Automatic dog feeders Heating pads for dogs/cats Pet monitors and cameras DVAs/smart speakers for dogs/cats
Care of Adults and Older People	Alert pendants CPAP (sleep apnea) machines Showers/Baths Heaters/coolers	Smartwatches with fall detection Telehealth appointments Videoconferencing software and hardware Companion robots Caring AI robots VR telehealth Electronic pain management
Care of Home	Washing machines and dryers Housecleaning appliances	Smart speakers Smart heating/cooling Smart security cameras Smart doorbells and locks Smart garage door control Robotic appliances

Trend 1: Proliferation of electric devices for care

There is a growing number of digital and electronic devices utilised in the care of adults, babies, young children and pets.

Video monitors in children's rooms are increasingly popular, as are DVAs and smart speakers. There are also a number of electronic purchases linked to new babies in the house including baby monitors, infant sleep monitoring pads, bottle warmers, bottle sanitisers, and breast milk pumps.

Electronic equipment is also used in the care of adults with health conditions, such as electronic pain management machines or CPAP machines for sleep apnea. Digital technologies are also being used by older adults in need of monitoring through emergency alert buttons/pendants or video monitoring systems.

Pet care is also involving an increasing range of devices. Older technologies such as heat lamps for young birds, and water filtration and heating for pet fish continue. However, there is also a proliferation of emerging technology being used to care for cats and dogs, including water filters installed in electronic water bowls, automatic feeders and treat dispensers, smart speakers, radios and televisions left on for pets, pet monitoring cameras, pet heating and cooling, and electronic pet games and apps.

"Yeah, we've got two cameras that are set up, and we have two Sonos, one in each room, that plays like, in fact, our favourite song at the moment is Barry Manilow's Coco Cabana, that's my four-year-old's favourite song … It's not a voice assistant, but my four-year-old knows if you press play on the top, it will start playing the last song, and she knows how to turn it up and turn it down."

– Alastair, 40, regional VIC

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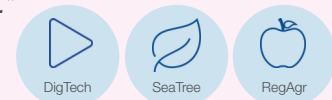
"We do have; I think it's a Google Home Mini. My dad got one free somewhere – and he didn't want to use it even though I set it up for him, and he made me take it. So it kind of sits in the kitchen, and it's only used when we tuck Taco [the dog] in at night. She's got used to having music to go to bed. So if we say 'bedtime', she'll go to her bed and then we have to play the music. So I'll just say, 'Hey Google, play some music,' and she'll have music playing through the night."

– Fred, 33, outer Melbourne

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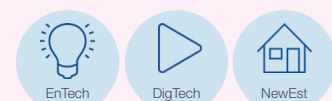
Trend 2: Children's technology use is increasingly managed through more technology

Screen time and online content are being managed through a number of parental control hardware and software installed on children's devices.

The COVID-19 pandemic and move to online schooling increased screen time overall for many children. Many parents considered this an inevitable outcome of lockdowns, but it also heightened existing concerns about excessive time with technology for children. Many digital technologies for children were also finding their way into the home without full endorsement by parents, often as gifts from others, especially grandparents. Most families sought to regulate their children's use of technology, and many looked to technology to help with this through installing parental control and family technology management software to set limits and monitor children's technology use.

"We had to purchase, basically, a hardware and software solution that would allow us to do more strict parenting … That allows us to monitor, block, restrict or limit in terms of what sites they can, what sort of sites or category of websites they can go to or not go to, how many hours on certain apps they can spend time on, or how many hours they can actually run the device."

*– Haruki, 49, outer Melbourne (no consumer group)*

Trend 3: Remote care is on the rise

Digital technology, especially video conferencing, enabled staying in touch and forms of remote care during the pandemic as many more people became comfortable with these technologies across generations.

Staying in touch with grandchildren on videoconferencing, playing games together via online platforms, and even telehealth and videoconference medical appointments became common practices during the pandemic. Older people in particular expressed their surprise at the ease of, and social connections enabled through, these remote communications. While many also missed and emphasised that these digital platforms could not fully replace in-person interactions, they recognised that for certain interactions, these technologies were sufficient and convenient.

"I wouldn't want technology to overtake that when you need to see people, doctors in person. But there is a place for it. I think some sort of Skype technology or something like that for some sort of medical or mental applications."

– Mark, 60, regional VIC

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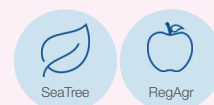
Trend 4: Technology is enabling independent living

Technology that is perceived as providing safety and health, and which is seen to enable independent living, is largely celebrated and appreciated by households.

Whereas too much technology for healthy children was feared to make them lazy, for those who needed it for health and safety, it was viewed very positively. Many prefer to stay at home as they age. They expressed that previous positive experiences with caring devices, such as alert pendants, fall detection on smartwatches, and setting reminders on smartphones, made them optimistic that improved technology would enable more independence for older family members and themselves as they continue to age.

"I've just recently set an alarm on Mum's phone to remind [her that] Dad has to take pills [at] morning, 12:00 pm, 4:00 pm in the afternoon and 8:00 pm and she said, … 'We'd always forget the middle of the afternoon and 8:00 pm at night'. Sometimes she'd fallen asleep on the couch... So I set alarms for them, and she said, 'we haven't forgotten since now', and they both know, and it's just an alarm that says ding, ding, ding, take your pill. [An alarm] that actually reminded them what to do would actually be even better because that way, when the regime gets more complex, it can be something that says, 'Hey, do this.'"

– Bree, 50, inner Melbourne (no consumer group)

Trend 5: Temperature control is becoming a key practice of care

Household temperature is considered a central element of caring for others in the household, especially babies, young children, older adults and pets.

Many use or are interested in technologies that allow for greater control of the temperature, particularly in relation to improving sleep quality. Some participants had remote controlled split system units in children's rooms or temperature sensors that allow adults to remotely monitor the temperature in young children's rooms. A safe and healthy room temperature is considered essential for an infant's sleep, people with health concerns require specific temperature ranges to be comfortable, and older people's comfort is prioritised by many households. For multi-generational households, heating and cooling needs are particularly important, and it is common to utilise individual devices to deal with different sensitivities to household temperatures.

"It seems there might be some mild correlation between temperature and sleep… We're trying at the moment just to cool it a bit more than normal … Yeah, we've got like a little baby monitor with video functionality, and I've got temperature sensors in there that tells us the temperature in there. It helps us a lot."

– Murphy, 41, regional NSW

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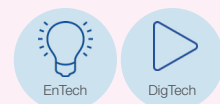
"I got out my heater, which is a radiator; it's got three bars, but with a fan as well. I think I used that maybe once or twice over winter, whereas when I lived with Mum, or when she lived with me, it was on nearly all day, every day, because she has terrible circulation and has done for years, so her hands and feet are nearly always cold, so she needs a lot of heat, whereas I don't."

– Sue, 52, outer suburb NSW

AptRnt

Trend 6: Changing health and hygiene routines are impacting hot water use

New routines developed to ensure household hygiene, particularly in response to COVID-19, have increased hot water use in some homes, particularly through increased bathing and laundry.

The COVID-19 pandemic increased laundry and showering substantially in some households concerned about bringing coronavirus home and exposing other household members. This applied to essential workers who showered and washed clothes immediately when returning home, but also to other householders that considered it safer to shower and wash clothes after shopping for groceries or otherwise leaving the home. These impacts on routines are likely to endure to some extent in hygiene-focused households.

More generally, households spending more time at home due to the pandemic used additional hot water to wash the extra dishes associated with more cooking and eating at home. Some showering that usually occured at the gym or workplace shifted to the home. However, increases in bathing and laundry hot water use found in some households could be offset by decreases in other households that reduced their frequency of bathing, clothing changes (and therefore laundry), or other washing and cleaning practices in response to spending more time at home.

The pandemic highlighted the ongoing role of hot water in care and health. Baths remain an important part of routines to calm and prepare children for bed. Some householders use long hot showers to relax or manage health conditions. Similarly, washing in hot water was sometimes linked to allergies or other health conditions.

"[After work] I'm not allowed to touch or talk to the kids [until I shower] … my wife, she's very good with the way she set up the rules… because of COVID… when the kids are coming [home]… have a shower, all the thing has to go in the washing [machine]... more washing up [dishes too]. We usually don't wash clothes like once a week… now it's about seven or eight."

– Farooq, 54, outer Melbourne

NewEst

"With me having an infection this year, that meant I had to sterilise everything...I have to change my sheets every couple of days at the moment."

– Jodie, 42, regional VIC

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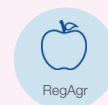
## Trend 7: Increasing household monitoring of the home and its occupant

A desire to care for the home and its inhabitants is leading to an increase in home security system installations, but their use often shifts over time.

Smart security systems were often originally purchased for household security to monitor the presence of unwanted visitors and against burglary. However, live notifications were often too sensitive and annoyed many, leading smart security to be more likely used to occasionally monitor pets or accept postal deliveries.

Because most people with monitoring systems turned off the notifications from their cameras, they became less about immediate security and more about the possibility of providing proof after an incident. Still, most admitted that they had never needed this or were unsure if their cameras were still recording. Indoor cameras were primarily used to monitor children in their bedrooms overnight or to monitor pets left alone inside during the day. A small number of householders had live footage from their cameras streamed to their personal computers, which they checked several times during the day and evening for peace of mind or out of curiosity.

"Yeah, I've turned off the notifications, because every time, like if I went outside five times in 5 minutes, it would go off on my phone. So, I just turned it off, the notifications, and hope that [nothing happens]… [laughter] …there was just constantly notifications coming through, buzzing off the phone. So yep, [I] turned off notifications."

– Rachel, 33, regional NSW

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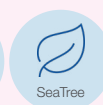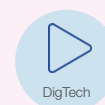
"I have security cameras that activate the pet cam….I check in just to see. They're not everywhere. Because she [dog] has free roam of the house, I don't have cameras in every single room, but I've got enough to see what she's doing or if she's okay."

– Tiana, 42, outer Melbourne

DigTech   NewEst

Digital Energy Futures: Future Home Life

Explaining the trends

- High housing and childcare costs are encouraging multi-generational households, with older grandparents helping in the care of children, more adult children moving back in with their parents, and older parents moving in with their children as their care needs increase.

- Pets are increasingly seen as family members that require care delivered by electrified or electronic forms of comfort and entertainment.

- The COVID-19 pandemic encouraged care at a distance and familiarised many with emerging technologies for remote socialisation and care.

- The significant impact of the COVID-19 pandemic on residential aged care facilities further added to people's desires to age in their own homes.

- The COVID-19 pandemic increased children's technology use and led to a greater concern with monitoring children's time on digital devices.

- Increasing anxieties around the COVID-19 pandemic, global security concerns and extreme weather conditions are making the safety and protection of the home increasingly important to many households, leading to a sense of insecurity and desire to invest in home security and monitoring systems.

"I don't care what dog it is. I believe they should be inside... you should make your home safe for them to be inside and... not leave them outside in the heat … She has a home just like I do, and I believe that's part of what I signed up for, making the home safe enough for her to be in, so I have baby gates through the house in areas that I don't want her to be."

– Tiana, 42, outer Melbourne

DigTech　NewEst

Everyday future visions

- Increased screen time is causing concern for parents about the loss of physical recreation for children, likely leading to ongoing parental limits to or restrictions of digital technology use.

- Despite the general excitement about advances in technology enabling more independent living for older people and those with disabilities, many still have anxieties and concerns, including that:

  - technology for caring will not be able to replace the social needs, human relations, and physical touch that are fundamental to care;

  - with the high responsibility placed on caring technologies, it may malfunction. Therefore there is still the need to continually monitor the technology; and

  - the potential for technologies for elderly care to be misused and contribute to neglect of older people due to the money-making potential of the technology.

- Many people have concerns about the privacy of smart security cameras and monitoring, particularly those inside the house, which is likely to slow technology growth in this area.

"Some stuff, you know, the virtual pet and all that, no way. Robotic carers? Not sure, but generally, yes, it's just a matter of who controls it, who is on the other side. Is it a private supplier that makes money out of the old people? Is it the relatives that will steer the technology and supervise the voice assistance and all of that? There's a lot of scope for misuse and abuse in that sort of thing, I reckon because it would be a money-making machine."

– Kelsey, 59, inner Sydney

Complications and resistances

- Some people have concerns about the idea of monitoring children with cameras. Even those participants with young children who have cameras recognise that they will eventually need to remove them from children's bedrooms and private spaces to provide their child privacy as they age.

- Some parents reject digital technologies as much as possible for their children, preferring non-digital toys made of natural materials. Some worry about the safety of electronics, either batteries as a choking hazard, or have concerns about radio waves.

- Some worry that, particularly for people with dementia, increased technology will be difficult to accept and point towards failed attempts to use video conferencing with older relatives in aged care centres during the COVID-19 pandemic.

"My son can already pretty much use a telephone, which is a little bit scary; he's only three years old, so they're definitely getting on it very quickly, and we do everything we can to put the phones away and not have them visible. He is obsessed with TV as well, so while it can be handy to get some chores done and keep him occupied, it's not the greatest thing. It's definitely a concern moving forward."

– Malcolm, 36, outer Melbourne
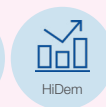
EnTech   DigTech   HiDem

Implications for electricity demand

- Greater electricity demand may come from the heating and cooling or laundry practices associated with caring, particularly in multigenerational households with different needs in different spaces of the home.

- Average energy demand may increase from the cumulative use of digital devices used to provide care, many of which run 24/7, like smart security cameras.

- A future with technologically-enabled independent living for older people may lead to increased energy demand through the cumulative effect of multiple monitoring and digital devices.

- Increased caring in the home, including medical care at home, may potentially increase higher-energy demand medical device use in the home or have cumulative impacts when multiple devices are needed (eg. dialysis machines, oxygen concentrators, ventilators, CPAP machines)

- The increase in digital devices with remote storage and access of data, such as internet-connected security cameras, may have significant offsite electricity implications from data centres storing an increasingly large amount of data in the cloud.

Comparison to industry visions

Key claim from Stage 1 analysis of industry reports

Smart home technologies will enable older people to be cared for within their homes through health and safety monitoring technologies and robotic caring.

"Sensory systems using computer vision installed in homes can monitor movement and behaviours to detect if something is wrong (e.g. a fall or sustained lack of movement) and automatically call for assistance." (CSIRO 2019, 10).

Comparison with ethnographic findings

Participants were willing to explore technology to aid ageing at home and were open to incorporating technology that had clear health and safety benefits. We also found that monitoring the home, in general, was an appealing use of smart technologies; many installed smart security cameras inside and outside the home. However, often people found the automated alerts on these systems were too sensitive to handle everyday life circumstances, such as when animals or neighbours triggered the devices.

Key claim from Stage 1 analysis of industry reports

Emerging technologies are rarely mentioned as playing an increased role in caring for children but are raising increasing concerns about children's addiction and excessive screen time.

"In fact, more than half of the respondents who live with children fear that technology has addictive qualities, and nearly half of families with children are concerned that they rely too heavily on technology." (Accenture 2019, 15)

Comparison with ethnographic findings

There was general hesitancy towards children's use of technology, but we found that a number of devices, such as tablets that were routinely used in children's care, were often balanced with strict usage limitations. We also uncovered a proliferation of non-screen based technologies, such as those used in baby care. Further, we found that the use of heating and cooling was heavily motivated by caring for others and took into account the various needs and preferences of many household members across generations, including pets.

CARING FOR THE HOME AND ITS OCCUPANTS
CASE STUDY 1

"The grandchild we'll probably never have."

Paul and his daughter's robotic friend, Vector

Paul, 70, recently retired to Sydney's Northern beaches. He is an avid technology enthusiast with a particular passion for Tesla. He lives with his wife and his adult daughter, who has an intellectual disability.

His daughter has a robotic friend named Vector, a small robot connected to Amazon's Alexa voice assistant technology. Vector recognises faces and makes expressions with his large eyes. He also purrs and beeps to express himself. Vector is primarily a form of companionship for Paul's daughter. He described that his daughter doesn't have many friends her own age, so "Vector is a bit of company for her and she always asks, when she comes home from work, what's he done during the day and all this stuff." Although Vector is mainly his daughter's companion, Paul also described Vector as somewhere between a pet and a family member: "He's definitely the grandchild we'll probably never have".

Paul, 70, outer Sydney

EnTech DigTech SeaTree

# CARING FOR THE HOME AND ITS OCCUPANTS
CASE STUDY 2

"The washing machine was just going 24/7."
High energy demand from Beatrix's daughter and baby granddaughter

Beatrix, 62, recruited through the high demand and occupancy consumer group, cared for her ex-husband, who moved back in with her after being diagnosed with a brain tumour. Her daughter, her daughter's partner, and her grandchild had also been living with her until recently. Her daughter's family was able to move out and find their own place to rent because of the drop in rental prices due to COVID-19. Beatrix had gas hot water and gas heating, and so was first very surprised and confused by her load profile for May 15th 2020.

She eventually realised: "Oh, my daughter was still here, oh my God." As we looked at the load profile together, she was shocked that "there's more electricity being used in the middle of the night than during the day, is that right?". She was still confused until we asked her if she had any plugged-in electric heaters. "Oh yes, yes, that's what it would've been when my daughter was here with the baby. They had the electric heaters on all through the night in winter, yep." We followed up

BEATRIX'S LOAD PROFILE ON A COLD WEATHER DAY DURING THE PANDEMIC
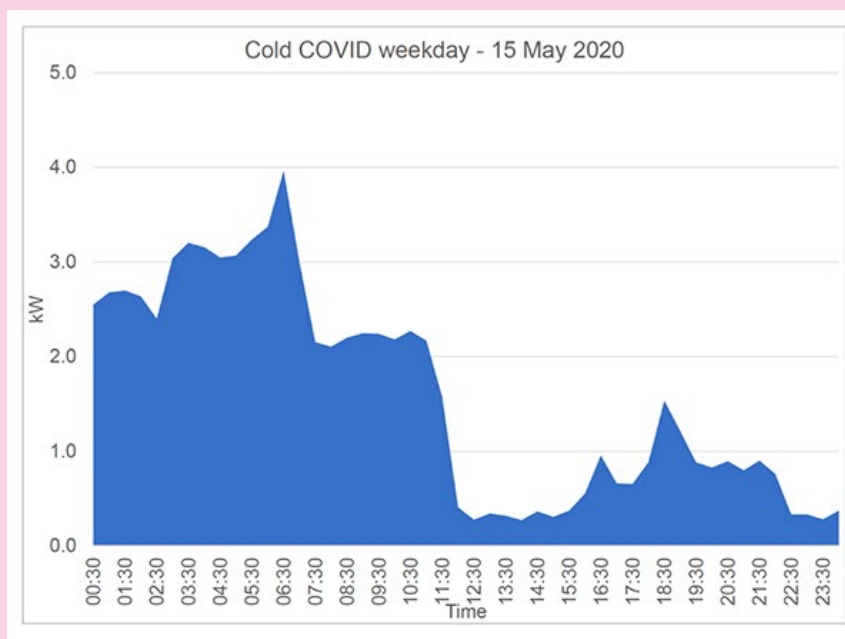
and asked about the 4:30 pm and 6:30 pm peaks: "Probably something similar. Oh, I know what it is, yeah. We're getting them ready for bed, bath time, and then the heaters would be on as well."

She had already mentioned that her energy bills were significantly higher when her daughter's family was living with her, primarily blaming her daughter's laundry usage: "I just try and economise myself on electricity. When there's other people living in the house, it's a bit hard, and especially when my daughter [with a baby] was here and the washing machine was just going 24/7 type thing, the dryer now and again." When we looked at the load profiles together, the use of the overnight heater seemed to be a major contributing factor to Beatrix's high overnight load, which she was largely unaware of.

Beatrix, 62, inner Sydney

HiDem

7. Making, Saving, Shifting and Storing Energy

Many household practices are changing in response to new energy technologies and possibilities in the energy market. However, greater energy knowledge does not directly lead to change as many activities remain inflexible to energy incentives or tariff changes, and many people reject the need for smart technologies for energy management, preferring to rely on their own routines and more hands-on control.

RELEVANT TECHNOLOGIES: MAKING, SAVING, SHIFTING AND STORING ENERGY

Categories	Continuing Technologies	Emerging, Accelerating, and Speculative Technologies
Energy Management	Weather reports and apps Smart metering	Home energy management systems Energy monitoring apps and portals (e.g. PowerPal) DVAs Smart plugs Smart thermostats Smart appliances (washing machines, dishwashers) Direct load control
Generation and Storage	Home solar PV Inverters	Home battery storage Community batteries
Buying, Selling, and Sharing	Feed-in-tariffs ToU tariffs	Virtual power plants (VPP) Peer-to-peer trading platforms Microgrids
Other		Electric vehicles Wireless and automated charging

Trend 1: Households are continuing to eschew tariff awareness and response

Low electricity tariff engagement and response is ongoing amid other household health, life and energy concerns; many challenge the logic, practicality and equity of ToU tariffs

Most householders remain unaware, uncertain or are misinformed about the structure of their electricity tariff. They may speak of using 'off-peak' electricity or try to run some appliances in off-peak times (e.g. run dishwashers at night), but often don't know if they definitely have a tariff with off-peak times or what times of the day or week have lower electricity prices.

Low tariff awareness and response continues despite considerable household concern about increases in energy use and bills due to COVID-19 physical distancing restrictions and lockdowns. Households were generally more focused on managing the health and daily stresses of this period (particularly in Victoria), and COVID-19 health imperatives could override energy management concerns. For example, some households implemented new cleaning regimes, including showering and washing clothes immediately after returning to the home and sanitising surfaces. Some households also noted the need for extra vacuuming and dishwashing.

Of the households that knew they had a ToU tariff, some made minor shifts, such as running the dishwasher at night. However, most households rejected ToU tariffs as something around which to organise their daily activities because they see only the minimal cost savings, are concerned about other issues such as the noise from running appliances at night, or distrust the energy sector's motivations.

"I think there is a peak and an off-peak [in our tariff]. I don't know if there's a shoulder time, but there's definitely a peak and an off-peak… sort of Monday to Friday, generally between 6:00 pm and 9:00 pm is definitely a peak. But I don't know about any of the other times … When I was working, I had to do the washing either at night or on the weekend, which I know is a higher tariff, is one of the peak times... It had to get done."

– Lucy, 34, inner Sydney

AptRnt
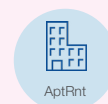
"Another problem is really connected with the noise problem, is that some people who use multi-tariff plan, like daytime tariff and night-time tariff, they attempt to run all their machines [at night]: dryers… vacuum cleaners, dishwashers, and washing machines [etc.]... It's a challenge for Australian governments to find some good balance between the [energy market issues] and the noise pollution."

– Artem, 37, inner Sydney

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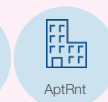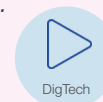
Trend 2: Energy interest in data and tariffs continues to be mixed and individualised

One person in the household generally leads energy-saving or -shifting efforts and often faces resistance from other household members.

There is often only one household member who shows an interest in home energy use (if any). This person may generally try to reduce energy use, engage with energy data, understand the energy tariff, and enter into and try to respond to demand management programs. However, lack of interest or pushback from other household members often limits their energy impact.

The approaches of energy-interested household members to conserve energy tend to vary by gender. For example, men tend to be interested in more **technical and automated system approaches**, whereas women typically implement energy conservation and non-automated load shifting. Most householders consider it difficult or impossible to have much influence over the energy use of other people in the home or are reluctant to restrict or control the activities of other household members.

"I just try and economise [electricity] myself. When there's other people living in the house, it's a bit hard, and especially when my daughter was here and the washing machine was just going 24/7 type thing… she's got a three-year-old now… I wash once a week, probably a 20-minute wash… If I lived by myself, I think I could live very cheaply."

– Beatrix, 62, inner Sydney

"That's a losing game for me because my whole family sort of really believes that a house should always be lit up like the Christmas tree so that even rooms not occupied should have the lights on. So, not sure I'm going to win that one."

– Richard, 73, regional NSW

Trend 3: There is accelerating self-consumption of solar electricity generated at home

Dissatisfaction with feed-in-tariffs is encouraging households to load-shift towards self-consumption.

Most solar PV households are currently unable to store their excess electricity, and some have limited solar export opportunities (including voltage issues). Load shifting to self-consume electricity 'makes sense' and responds to 'unfair' low feed-in-tariffs as energy market arguments about the low value of daytime-generated electricity are not widely recognised and accepted by solar PV households.

The self-consumption trend is growing as more households install solar PV, feed-in-tariffs are further lowered, and fewer households remain on the historical high feed-in-tariffs that could instead reduce self-consumption to maximise solar exports and electricity bill credits.

As a load shifting practice, solar self-consumption has advantages over other energy sector demand concepts such as ToU tariffs, because:

- it is consistently tangible — the sun makes it clear when the home's solar system is generating electricity (and apps can be used to quantify the electricity available); and

- it is practical — doing chores and using noisy appliances during the day fits better with household routines than leaving these activities until late when most people want to reduce noise and relax.

In addition, solar self-consumption does not invoke the same concerns that contribute to householders eschewing ToU tariffs.

Self-consumption shifts are common for clothes washing and dishwashing. Less commonly, some cooking, water boiling (for hot drinks), clothes drying, charging (e.g. vacuum cleaners), and pool equipment, and home cooling may also be aligned with solar generation periods.

Manual (non-automated) load shifting is the most common approach; it works well for people who are often home during the day (especially women and retirees) and was further enabled by the accelerated transition towards working from home, induced by the COVID-19 pandemic. Automation or timers to load shift was predominantly used for pool equipment and some device charging.

A related form of load shifting was taken up by households with **battery storage** that minimised electricity consumption until their battery was fully charged.

"There's an app where we can see the production, and sometimes, we make decisions on do we turn it up now, put the washing on or the dishwasher based on the solar output… personally, I'm not too strict about that, but my wife is more focused on that."

– George, 44, outer Melbourne

"We try to use our energy. If we have high energy needs, we try to use that during the daytime in the sunshine, so the solar's providing it."

– Anton, 69, regional VIC

Trend 4: Households are increasingly aware of and enthusiastic about the opportunities provided by home energy generation and storage

Household visions of an affordable, clean electricity future are accelerating household interest in battery storage, electricity sharing and trading, and demand response opportunities to better utilise the electricity they generate.

Households are now largely aware that renewable energy generation and storage technologies are available and capable of reducing the environmental impact of energy consumption in Australia. In the face of higher energy costs and perceptions that centralised generation has been slow to transition to renewable electricity, households want to generate their own clean energy (including those unable to afford or access solar PV, such as renters or **apartment dwellers**).

COVID-19 lockdowns prompted some households to investigate and/or install home energy technologies, with more time and focus on the home contributing to this pursuit.

Solar PV households see the electricity they generate as a clean, high value resource insufficiently recognised by low solar feed-in-tariffs. They are attracted to alternatives to selling their electricity cheaply to energy companies that they consider undeserving of profiting off the household's considerable investment in solar panels to reduce energy costs and emissions. In seeking to put their solar electricity to better use, many have looked into installing battery storage (e.g. got a quote, researched online and/or talked to others). Most are waiting for anticipated price reductions, policy incentives, or technology advances before installing battery storage. Although householders often express desires to go off-grid, further questioning usually uncovers an intention to have a grid-connected battery in order to:

- Enable self-consumption of their own solar electricity outside of generation periods;

- Reduce rearrangements of household activities to align with solar generation periods;

- Secure access to energy during outages (including **regional households** at risk of bushfire-related outages) and insufficient solar generation and storage; and

- Export excess electricity —- including to share electricity with neighbours or family, to give electricity away to people who struggle to afford electricity, to participate in peer-to-peer trading schemes and microgrids, and to respond to demand management initiatives such as VPP.

Some households considered community batteries to be a more efficient means of storing solar electricity and a way to provide clean energy to the local community, including to renters and **apartment dwellers** without their own solar or storage technologies.

Few participants lived in remote or fringe of grid locations, but the prospect of being transitioned off the grid with renewable battery systems was of interest, especially where improved reliability and resilience benefits were anticipated.

> *"Most days, especially if there's not substantial cloud cover, our usage is vastly covered by our production using the solar. However, because we're late to the party when it comes to the feed-in-tariff, we get a very, very, very low feed-in-tariff... we're paying whatever the premium price for energy use in those dark times…. the idea behind the battery would have been, to say, push that usage to those shoulder [tariff periods]. From what I can see, I'd need a very, very big battery to cover our entire night time usage… community batteries… would be very, very interesting."*
>
> *– Greg, 60, formerly regional NSW but recently moved to Canberra*
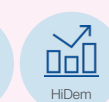
"[Peer to peer energy trading] gives the control back to the individuals, I guess... if we put new panels on the roof and generate all this power during the day and I knew that next door was home, I'd love to be able to just send a cable across and have them use the excess, that would be fine. But obviously, how you could do that, I don't really know."

– Bree, 50, inner Melbourne (no consumer group)

Trend 5: Storage is an engaging but complexifying concept for households

Home electricity storage capability is increasing energy engagement in early adopter households but may create vulnerabilities as energy storage is more widely adopted.

Owning a **home battery or electric vehicle** can increase household interest in energy use, storage, and export and tariff opportunities. In some households, a knowledgeable energy enthusiast leads the installation and system management. However, battery storage adoption also encourages other forms of energy engagement, including from other household members of an energy enthusiast-led installation project and in other households that adopt new energy technologies for environmental or financial reasons instead of as an energy or digital technology 'project'.

While households may eschew complex tariffs and other top-down initiatives from the energy sector, the tangibility of electricity generated and stored at home, and a sense of ownership and independence, can re-engage and help unify households in energy management. However, emerging constellations of energy technologies, tariffs and demand management arrangements can be a lot more complex than grid-supplied energy. This complexity creates vulnerabilities as new energy technologies enter homes with people who have low technical expertise, energy literacy, interest and/or capacity to spend time managing their energy technologies and arrangements. Subsequent owners of the home may also be far less equipped to manage and make good use of complex home energy arrangements.

"[The children] are very environmentally conscious... If I said, 'Oh, let's not do this or that because of the battery' [they would get that]… If it's run by yourself, if you have the power to use your power, then I think it's better than if the electricity company… said to you, 'Do not use your appliances between so and so'… That's big brother watching you. Whereas if we can decide, okay we want to make sacrifices, that's a different matter."

– Kelsey, 59, inner Sydney

"That is a bit of a problem with a lot of solutions being a bit… hodgepodge… Even the hot water system, I've got to get a plumber, I've got to get an electrician, then I've got to talk to the retailer to disconnect the controlled load. It's not hard [laughs], but… it's a project… When an average person moves out of this [house]... what's their handover sequence now? It's not exactly a matter of going to Origin Energy or whatever energy company and saying, 'I want to switch over'. They're not going to get all of the benefits… unless I run them through all of that (energy tech) stuff. Unfortunately… there's little nuances in a house that the new owners may or may not know."

– Peter, 50, regional NSW
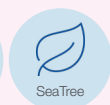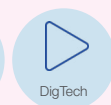
Trend 6: Participation in demand management opportunities makes increasing sense when explained

As grid issues become more apparent to households, more are willing to take part in demand management programs, primarily motivated by contributing to the common good.

Households were mostly positive about demand management programs and concepts, once these were explained to them by the research team. The people that had already signed up to a demand management program and responded were generally more interested in energy or reducing its use in the home. Participation in demand management programs was generally led by a single household member, either the more technology-savvy household member, usually a man, or the person who coordinated routines and worked to encourage participation from other family members, usually a woman.

The positive response to demand management does not necessarily reflect the level of interest and understanding in the general community as the survey recruitment strategy for Victoria included households already participating in AusNet Services' GoodGrid summer peak event program[1]. Financial rewards for responding to peak alerts were appreciated, but by far, not the only reason people took part. Some found it an important opportunity to teach their children about energy, others found it to be a challenge or game that appealed to them, and still, others were motivated by a sense of helping the collective community, including to maintain the health of others (in hot weather).

Peak demand management program participants' responses to peak events varied, but the activities reportedly shifted were similar to those undertaken to self-consume solar electricity. In addition, some households switched televisions off, turned the power off to the home at the fuse box, or left the home (went to someone else's home, a beach, a pool or a shopping centre).

Households often saw demand management programs as a better option than building more expensive electricity infrastructure. For **households with batteries**, innovative initiatives such as VPP were attractive and helped rebuild trust, including in automation and external control.

"We're part of a GoodGrid program with AusNet [Services], so there are occasions where we would try and cool down the house a lot more before we needed to wind down our energy usage and just put our air conditioner on a low power usage setting… it's quite an easy way to make some dollars, in all honesty. It doesn't inconvenience you that much… we've got four individual split systems in our home, so we can just go down to one unit and just stay in that room during that event."

– Malcolm, 36, outer Melbourne
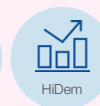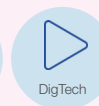
"I actually chose it [GoodGrid] not for the payment or anything like that. I wanted to educate my kids on alternatives because I think we've become too reliant on creature comforts … So I looked at it as more of an educational opportunity for them to actually slow down and to live according to the conditions, rather than trying to make our conditions fit to what we want them to do."

– Erin, 45, regional VIC

[1] Approximately half of Victorian households interviewed mentioned being part of the AusNet Services GoodGrid program.

### Trend 7: Increasing interest in transitioning to an 'all-electric' home

Some households have converted their home to 'all-electric' while others are working towards the elimination of gas appliances.

Interest in converting away from gas appliances was mainly motivated by a desire to reduce overall energy costs (the daily gas supply charge in particular), use more household solar PV electricity production, reduce the use of carbon-intensive gas, and eliminate health risks associated with gas appliances. Induction cooktops were particularly appealing to households as a safe, efficient and effective alternative to gas cooking.

Some transitions were complete, while others were ongoing processes slowed by costs, gas appliances that were not considered old enough to retire, and the availability of tradespeople. A popular Australia-based Facebook group, My Efficient Electric Home, with over 26,000 members, was used by some households for tips and inspiration for all-electric home conversions. The transition away from gas increases the home electricity needs, particularly for home heating, water heating, and cooking, however, the impact will be partially mitigated by household integration of their all-electric home transition with home solar and self-consumption of the electricity they generate.

"Over the course of the year, we produce enough solar to cover our electricity use… over the course of living here… six years or so. I've got rid of all of our gas appliances, so we don't have gas anymore."

– Murphy, 41, regional NSW

EnTech   DigTech
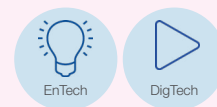
"I will be going down the path of the hot water system becoming a heat pump. That's a money issue as well though because it was probably 2 or 3 years ago that I repaired the gas system, and I also repaired the pump on the solar hot water, so I think that was about $700 all up and it seemed crazy to spend that money and then replace it again in 2 years time. So, it will probably be more the case of when it reaches the end of its life, I'll make the switch."

– Malcolm, 36, outer Melbourne

EnTech   DigTech   HiDem
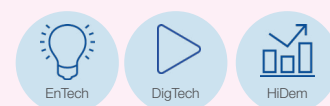
Trend 8: Energy data continues to have limited impact on use

Energy data has minimal impact on households that prioritise comfort and lifestyle, while those determined to save energy rarely depend on data insights.

Most households can now access more detailed energy data, including via distributors, retailer apps, solar and battery apps, and energy monitors. More accessible and visually appealing insights into their home energy use are often appreciated, particularly to understand home energy costs better. However, digitally-delivered energy data is rarely equally accessible and interesting to all home occupants.

Desiring or accessing energy data does not necessarily translate to energy management outcomes. Households with solar PV (and especially **battery storage**) tend to engage more with energy data than those without, at least in the early stages of adoption, and particularly to understand when and how much self-generated electricity is available. Energy technology enthusiasts (especially early adopters of batteries) often use energy data to fine-tune their system arrangements. Conversely, **digital technology and data enthusiasts** who don't have a particular interest in energy efficiency may engage with energy data for reasons other than changing energy-using activities (e.g. to identify problems and faults, to plan budgets, or to assess cost-benefits or returns on investment).

Despite the availability of energy data, many households invest time and effort in low-impact energy-saving actions such as unplugging appliances, purchasing smart plugs to avoid standby modes, and turning off lights. While there is interest in reducing these types of energy 'waste', the savings can be minimal in the context of expanding comfort and lifestyle activities that often attract less energy-saving attention or are considered essential to everyday life (like heating, cooling, clothes drying, refrigeration and cooking). In addition, some households (particularly **renters** and low-income households) do not have access to more efficient appliances or housing features that could significantly reduce their energy use.

Very energy efficient households often have no need or interest in energy data to manage usage as they have already developed the awareness and routines to manage usage (including many elderly and highly financially constrained households).

"I know that we've got a pretty high energy usage for our house and that we could probably work to reduce it more, but I'd rather be comfortable and pay what we pay. It's not astronomical. I've had worse bills before… I think it definitely will [keep going up in cost]. It's going to be a matter of making sure that you're on the right plans and stuff so that you are getting the best deal."

– Jodie, 42, regional VIC
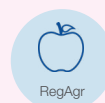
"We changed to a different [electricity] provider this year, and my husband told me their portal, their website, shows a figure of the stats that you use every day, but [he] rarely goes in … If I really need to control my spending amount, then I will definitely look into it. But I have no time now, so I didn't."

– Yuet, 34, outer Melbourne

Trend 9: Smart tech enthusiasm is diverging from an interest in energy management

Most households do not consider smart tech necessary or useful for energy management, and smart tech enthusiasts often aren't interested in using these devices for energy outcomes.

Households are struggling to see the usefulness or value of smart control for energy management. Participants committed to saving energy often found actions like manually switching off unused appliances, or planning around the weather, to be sufficient and less complicated than automated or smart systems.

Many householders already implement some of the smart device efficiency promises into their existing routines in a lower-tech way, such as using basic timers or delayed start functions. More complex smart control is often viewed as less convenient or unnecessary. Those that have tried smart technologies for energy management often find them to be less functional, practical or useful than promised and reject them for at least some applications.

There are a few enthusiasts who enjoy the novelty of experimenting with both energy and digital technologies. However, many **smart tech enthusiasts** are far more interested in the experimental, entertainment, comfort and convenience aspects of smart technology than their energy-saving potential.

A demographic disconnect also contributes to the divergence of smart and energy tech interest. Many smart digital technologies are low cost, digitally interactive and mobile, making them more accessible and potentially interesting to younger people and renters. However, new energy technology arrangements often require substantial investment and permanent installation, making them more accessible to affluent, older homeowners who are used to managing energy in non-digital ways, may have more flexibility in their daily lives and are often less inclined towards smart technology.

> *"I used to have my TV on [a smart plug], but then I took it off… because it kept freezing. The plug, I don't know, something happened to the plug. It kept freezing the TV and then the TV would just, all the power would go… Just a pain in the neck."*
>
> *– Alastair, 40, regional VIC*
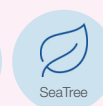
> *"I actually use a lot of smart home automation, so I have smart lights, smart aircon adapter, I have smart blinds which close and open depending on the sunshine and these kinds of appliances... I started with Google Home and one smart bulb… My chosen tariff is 'flat rate'. I hate when I need to align what I'm doing to the cost."*
>
> *– Artem, 37, inner Sydney*
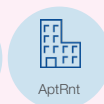
Explaining the trends

- People's busy lives, other household priorities (especially health and wellbeing), and inconsistency in tariff structures limit awareness and response to ToU tariffs.

- Lack of trust in the energy sector, high energy costs and widespread belief in the societal and environmental benefits of renewable energy contribute to households seeking a degree of energy 'independence' by making and possibly storing their own clean energy.

- Widespread dissatisfaction with low solar feed-in-tariffs and frustrations about solar exports being limited or switched off are accelerating self-consumption of solar energy and interest in battery storage.

- Exposure to rewarding demand management initiatives engages households with electricity system issues, builds trust, and reassures households that the energy sector is innovating to manage electricity prices and maintain reliable supply.

- Health concerns, high supply charges, increasing cost and growing doubts about gas being a lower carbon option contribute to an interest in eliminating gas appliances.

- Promised benefits of smart control do not outweigh the complexities, impracticalities and concerns about digital approaches to managing household life.

Digital Energy Futures: Future Home Life

Everyday future visions

- Most households aspire towards more (grid-connected) energy 'independence' or 'self-sufficiency' in the future.

- Most anticipate and desire a more sustainable energy future, enabled by a move away from fossil fuels and an increasing contribution of home solar PV towards decarbonisation.

- Many households are anxious about energy costs, future possible financial penalties or fees, or the removal of policy and tariff incentives (e.g. feed-in-tariffs) intended to encourage more solar PV integration and battery uptake.

- Frequent, localised electricity outages without explanation worry households, leading to searches for 'back up' strategies (including generators and battery storage) and expectations that underground electricity infrastructure is a ready solution.

- Alongside solar self-consumption, some households look forward to 'solar sponge' incentives to use excess solar electricity from the grid in the middle of the day.

- Most households hope they will soon be able to access lower cost, higher capacity batteries, and there is interest in advanced building materials that incorporate electricity generation and storage.

- Many households are anticipating alternative means of acquiring and sharing energy in the future, such as through peer-to-peer trading and community micro-grids, including to benefit less advantaged households and the local community as a whole.

- Households are hopeful that improved planning and home and apartment construction improvements will enable wider access to solar PV, batteries and EV charging for **apartment dwellers**, retirement villages, and renters.

- Some households aspire towards more energy-efficient and/or smaller homes in the future — particularly some owners of unnecessarily large **New estate homes** that were chosen primarily to maximise financial gain when the home is sold.

"For not a very good reason, they're increasing the pricing every year. Sometimes twice in a year... there has to be a certain propensity that people have to learn to create [energy] for themselves in the near future."

– Vadish, 40, outer Melbourne (no consumer group)

"The good thing is the longer you wait, the better [batteries] get, the price comes down. Literally, after I got mine, the Powerwall 2 came out at the same price with a double capacity... the Powerwall 3 will come out. It will be twice the Powerwall 2, very soon … The fridge alcove is there. There's no reason why you can't have a Tesla Powerwall alcove because it can be stored anywhere pretty much… Some scientists have got polymers into bricks that can allow the bricks to store energy."
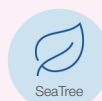
– Peter, 50, regional NSW

Complications and resistances

- Low solar feed-in-tariffs are discouraging some households from adopting new energy technologies.

- There are disagreements, differing priorities and different levels of understanding within households that can undermine or thwart energy management efforts.

- As solar PV, **battery storage** and associated programs and incentives become more common, the resulting complexification of household energy supply may conflict with many householders' desire for a simpler energy market that does not require significant amounts of household time, attention and learning to access fair and financially desirable outcomes.

- Some people doubt that community batteries or microgrids will be effective and have concerns about potentially complex contractual arrangements.

- Some have concerns about the environmental impacts of battery and solar panel disposal at the end of life, leading them to doubt the value of this technology.

- There are concerns about being unable to export home-generated solar electricity into the grid and rare concerns that excess home solar electricity generation negatively impacts the grid.

- Demand management programs are less appealing when perceived to be likely to compromise other critical needs, particularly for caring for children or others with health issues.

- Renters and **apartment dwellers** are often unable to get solar PV, battery storage or EVs (lack of charging infrastructure).

- Some households are experiencing delays in energy efficiency and technology installations or upgrades due to COVID-19, with subsequent impact on access to tradespeople and technology availability.

- Upfront costs and consumer reluctance to replace or retire appliances, such as gas water heaters, before the end of their life slows **'all-electric' home conversions**.

- Moves away from home internet (towards phone-based hot spot or other access to the internet) to reduce costs or increase internet reliability (including increased capacity from 5G) may reduce household access to energy monitoring data (e.g. portals and apps for viewing solar generation and export information) and other energy innovations.

"There is scientific evidence that coal has a negative environmental impact, negative like health impact and so on. And there is evidence that, of course, like with solar and wind, there are no such impacts. So logically, that is the future, and that's the way forward, and I don't see the reason why you need to explain that or prove that… that that is the future… it's common sense… if we were to buy a house, we would put solar, straight away."

– Olga, 27, inner Sydney
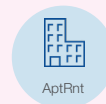
"I just don't need an extra computer cost [of a home internet connection]... I'm quite happy with just the internet connection I get with my mobile and tablet… I've got solar panels... when I got the solar panels, they said 'It's all run by wifi, so you can always have a look at how much energy you use whenever you like'... I've never been able to get access to it."

– Mark, 60, regional VIC

Comparison to industry visions

Key claim from Stage 1 analysis of industry reports

Better data and automation will enable more efficient energy management, reduced peak demand, and reduced energy costs for consumers.

"Smart meters can allow householders for the first time to understand their home energy usage patterns.– Better information allows more informed decisions to be made around using and saving energy. – Additional data analytic services offered by companies can provide tailored advice to help households to save energy." (DELTA-EE 2019, 7).

Comparison with ethnographic findings

Consumers have limited interest in technology for energy management, and some householders' enthusiasm for digital technologies is likely to increase their energy demand. Very few participants showed long term engagement with their energy data, and many continued their high energy demand practices despite awareness of their high energy usage.

Key claim from Stage 1 analysis of industry reports

Consumers are primarily motivated by financial incentives, and ToU tariffs enable price signals and encourage load shifting.

"The challenge to demonstrate value [of smart appliances] is understandable; without time-of-use, tariff information from a smart meter (which is only currently available to small set of customers), users are not able to benefit from smart functionality to choose an optimal time to operate and save money in the process."
(Tech UK 2018, 11).

Comparison with ethnographic findings

Many digital technologies or smart appliances are of more interest as hobbies or for the improved comfort and entertainment they offer, which may end up increasing electricity consumption or undermine load-shifting efforts. Energy-saving interest and action is determined by a much more diverse set of considerations than price, including educational opportunities, desires to share energy with others in the community, and aspirations towards self-sufficiency.

# MAKING, SAVING, STORING AND SHIFTING ENERGY
CASE STUDY 1

"Wow, that's huge!"
Energy load awareness and shifting in Naomi's home

NewEst

Naomi lives in a Melbourne outer-suburban **New estate home** with her three children and husband. The couple chose to build a much bigger new home (now 10-years-old) than needed to maximise its "resale value" and installed a small solar PV system (approx 2.5kW). Their energy use is high despite Naomi's interest in reducing consumption, her awareness of their ToU tariff, and her efforts to shift load to self-consume solar electricity or utilise off-peak tariffs. Her husband does not share her interest in saving energy, and she feels that energy management is much harder with children. Before they had children, Naomi and her husband reduced heating use by using blankets or putting on more clothes. Now they prioritise their children's comfort and entertainment.

The home has ducted evaporative cooling and a split system air conditioning unit to use "as a last resort". When looking at her load profile for the hot, smoky weekday, Naomi was shocked at the high electricity use, "Wow, that's huge!... everyone's home, it's a Tuesday… at night as well, it's a lot of energy. We wouldn't really have the evaporative cooling on, on a smoky day…"
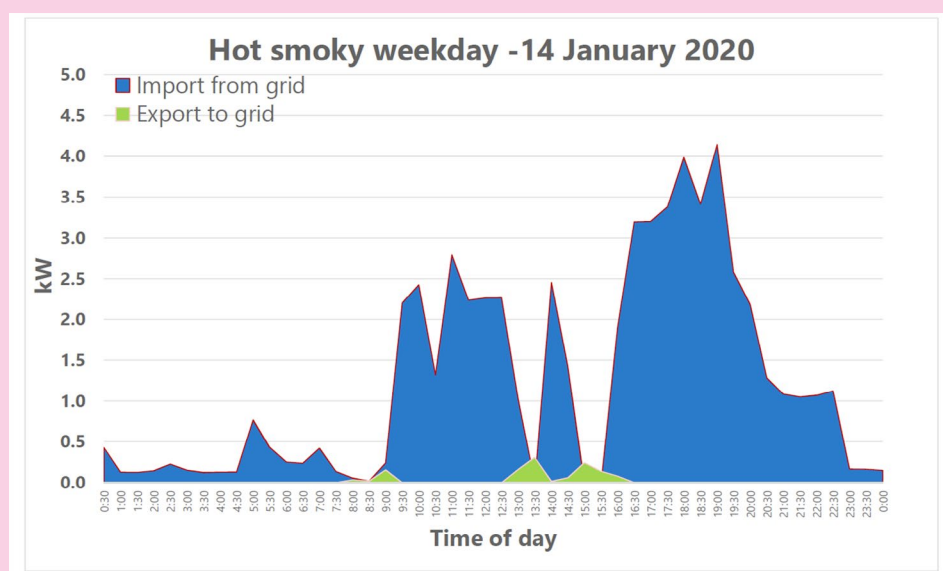
NAOMI'S LOAD PROFILE ON A HOT DAY IN SUMMER

Digital Energy Futures: Future Home Life

She then checked the date in her calendar to see if she could explain the high usage. Although Naomi would avoid using the split system, the load profile revealed that her husband likely had the split system running the majority of the day while she was at work, "I wasn't even home on that day – that was when I was working in the city, and my husband was home with the girls."

Naomi signed up to AusNet Services GoodGrid peak demand management program and responded to peak events by going to the beach [about 30 minutes drive] or her parent's house, "or if I was home, the TV wasn't on, the theatre projector wasn't on, the air conditioning wasn't on. I can recall delaying the use of those things so that I could get a reward." She understood the GoodGrid program to be "about saving energy at those times when we're likely to use more energy… doing good for the environment, that's the way my brain thought about it. And you were rewarded financially as a result." Naomi was unaware that the GoodGrid program aimed to address peak demand issues until we explained this to her, and thought this should be more widely communicated:

> "I don't think we think about it as though there's a certain point where they can't actually handle the amount of usage that people are using in their homes. So I don't think it's been shared enough with people… I think if they explained it in that sense, people wouldn't feel so negative towards them doing something like [rolling power interruptions]."

Despite being a high energy use household, and her scepticism of ToU tariffs as "profit-making" strategies for energy companies, Naomi was very supportive of demand management programs: "Rather than building more infrastructure to generate more power, I'd be looking at the alternative which is what can we do to reduce our use?" She was open to direct load control, particularly "if you have many, many people opt into it, and potentially everyone opts into it, then we can share that burden of having our air conditioners switched into economy mode… it would interest me particularly if it were a more fair system in the sense that it was a large number of people engaging in the program."

Naomi, 41, outer Melbourne

NewEst   HiDem

# MAKING, SAVING, STORING AND SHIFTING ENERGY
CASE STUDY 2

"Always looking at the new technology that's coming out."

Dylan's enthusiasm for smart tech but not energy management

At 20 years old, Dylan moved to Australia just before the COVID-19 pandemic to take up a traineeship in the auditing and consulting sector. With few rental properties available in Sydney in his price range and wanting to move straight in on arrival, he viewed the apartment from his home country via the real estate agent's video tour and signed the lease.

Living alone in an all-electric apartment, his electricity was significantly higher due to COVID-19 lockdowns and ongoing working from home. Heating was the major contributor to his energy use, "working from home... the heater was running throughout the day… a [2000 watt] Smart heater which I can control from my phone".

Dylan is very interested in smart appliances,"Kogan do a really big range of products that are all smart devices... my plan is to slowly start buying more and more... I'm always looking at them and always looking at the new technology that's coming out." He aspires to buy a detached suburban

Cold COVID weekday - 15 May 2020
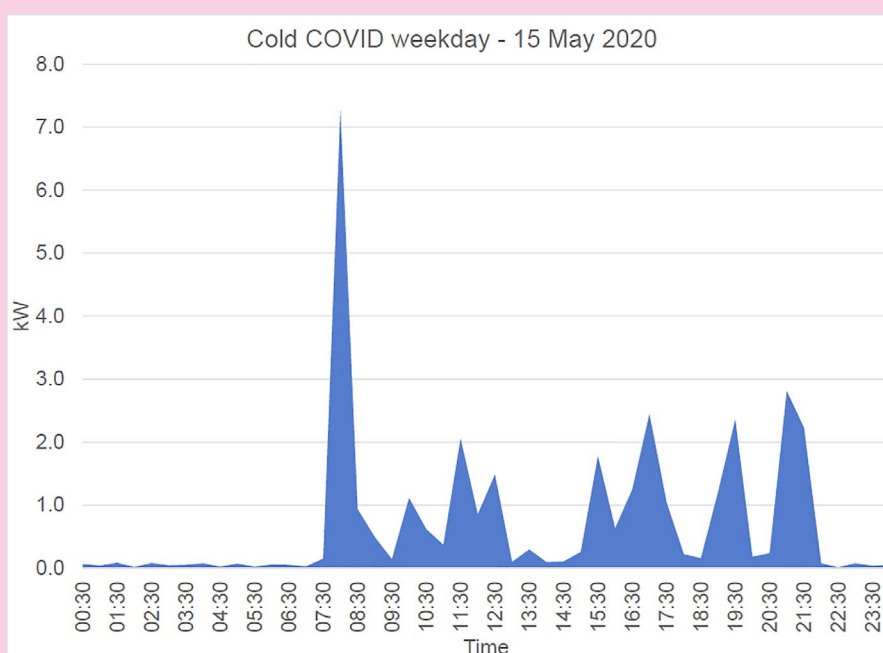
DYLAN'S LOAD PROFILE ON A COLD DAY WORKING FROM HOME DURING THE PANDEMIC

home where he can install more fixed smart technologies but currently limits his purchasing to smart devices to take to his next home. Dylan likes the convenience of his smart kettle and is keen on voice control of devices:

> "I can wake up in the morning and boil [the smart kettle] while I'm in bed so I can get up and my coffee's pretty much ready to go… you can connect all the Kogan products up… once I actually get a fair few of the things then I can actually get a Google Home and hook it all up and use voice activation as well… I guess that's something that I'd just do for the sake of it, because why not?"

Dylan is aware that he has a three-part ToU electricity tariff but does not know the times for different rates. He says:

> '[Electricity] is not something I live around. It's a necessity. You've got to pay for it anyway. It's no point stressing too much about it if that makes sense… things like that you can't control… I'm very relaxed when it comes to that sort of thing'.

Dylan does "ring the electricity company every kind of six months and see if there's a better rate", but his "relaxed" approach to energy use is clearly considered and responds to his assessment that the time involved in understanding and closely managing energy costs cannot be justified by financial savings. He spends time on more "controllable" financial costs in other areas of his life, for example, spending Sundays bulk cooking meals for the week: "I'll be quite financially conscious when it comes to things like takeaways or eating out or that sort of thing because I can control that".

Dylan, 20, inner Sydney

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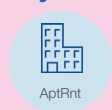
# MAKING, SAVING, STORING AND SHIFTING ENERGY
CASE STUDY 3

"The hot water system's still going crazy"

Hot water upgrade to further optimise energy efficiency

Four years ago, Peter and his partner moved from a one-bedroom apartment in inner Sydney to a five-bedroom house in a small town on the NSW Central Coast. As a software engineer working from home two to three days per week, fibre-to-the-premises internet was a priority. Peter is optimising energy efficiency and securing supply to his home via new energy technologies:

> "Because I've got the EV car, I can charge during the day. Triple charge off the solar. Five kW wasn't enough, I wanted 10kW. I also got a battery back-up system so when the power goes out, I'm not going to be offline."

Peter opted for an EV-oriented electricity tariff which enabled him to charge cheaply after midnight and export excess solar electricity during the day. Peter starts work about 5:00 am to "sync up" with colleagues in other parts of the world, so a fast charger ensures his EV is ready to drive to the office at 4am. There is no access to EV charging near his office but he says "that's got to improve in the future".
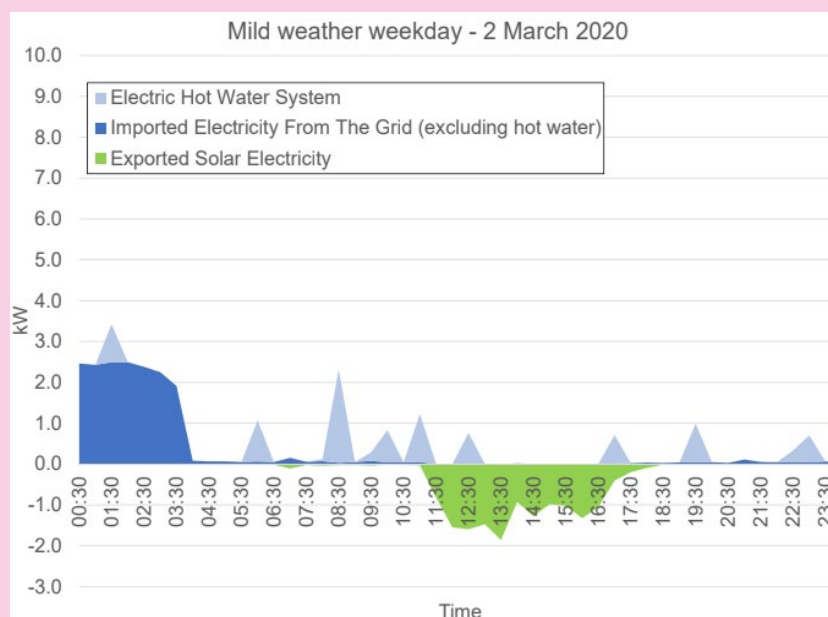
PETER'S LOAD PROFILE ON A MILD WEATHER DAY

Digital Energy Futures: Future Home Life

Peter would "love to go off-grid but it's not the right thing… I'm in a house with diamond grid already, that's not too bad. And I can provide systems that are lowering the cost". With a Reposit box and a VPP via his retailer, Peter has developed trust in the automated external control, "I think their algorithm's pretty smart".

However, Peter has not proceeded with voice control or automation of his heating and cooling, "I have looked at things like Z-wave ZB, Google Home Assistant… all that sort of stuff. It's just a mishmash of stuff right now". He uses "an old rotating timer" for his pool pump, "it's getting close to spring. So I manually went out and adjusted the timers on the switches and it's still kicking along… I can't talk to it. I'm sort of in control".

Peter looks out for further energy efficiencies and long-term savings. He switched to direct current (DC) ceiling fans, used in combination with open windows to stay cool in hot weather and minimise use of air conditioning. Peter noted the home's hot water system as:

"the most expensive part of the electricity bill, the controlled load water system – crazy! I mean it's not expensive, it's super off-peak and super cheap compared to other water systems but I've looked around at ways to get that onto solar, it's tricky."

Peter's concerns were heightened when shown his load profiles, "electric hot water system… in the morning … the hot water system's still going crazy… maybe it is worth revisiting whether I should get that switched out somehow".

Before the follow up interview, Peter engaged an electrician and determined that:

> "the controlled load had two elements, so the thermostat is just running on whatever the backup one's called… doing the peaks during the day … would have been doing the big increase in the bills."

As a result, Peter had replaced the system with a "super low energy usage" heat pump hot water system and was looking forward to switching it away from controlled load, "as soon as it goes across to the solar sort of circuit, it will be super cheap, if not free, hopefully". He was also working through some issues with his new inverter, and getting reconnected to his Reposit system and the VPP. Peter's case illustrates some of the challenges with increasingly complex energy options and arrangements – even for highly engaged early adopters of technology:

> "Dealing with multiple [organisations and suppliers] … Even the hot water system, I've got to get a plumber, I've got to get an electrician, then I've got to talk to the retailer for disconnect the controlled load. It's not hard [laughs] but… It's a project, yeah… it would be nice if it was just done in one day instead of taking weeks or maybe months."

PETER'S NEW HEAT PUMP FOR HOT WATER

Peter, 50, regional NSW

EnTech   DigTech   SeaTree

PART 4
PRINCIPLES FOR FUTURE HOME LIFE

Accounting for the pandemic

Most of the ethnographic research for this project was conducted in 2020 during the COVID-19 pandemic when Australians experienced lockdowns and periods of physical distancing restrictions that impacted on normal life. In particular, households living in Melbourne were affected by an extended 112-day lockdown that lasted from early July to late October 2020. The virtual household visits were conducted during and immediately after this period (September-December 2020). While Australia returned to a 'new normal' and relatively free society in early 2021, many of the changes to household routines that occurred during this period are likely to have a lasting impact on people's everyday lives and energy demand. These changes are summarised below.

- **Working and studying from home:** More households had more occupants working and studying from home during and after the COVID-19 lockdowns and physical distancing restrictions. Most participants with jobs that could be undertaken from home (especially **New estate home** residents and others living long distances from their workplace) were reluctant to return to their pre-COVID-19 daily commutes and hoped to remain partly working from home for the foreseeable future.

- **More people at home more often:** COVID-19 meant that most homes were occupied more than usual. This was due to lockdowns and physical distancing restrictions as well as anxiety about going into public settings, loss of employment, and financial stress. While some of these effects are likely to ease over time, the trend towards spending more time in the home has been accelerated by the pandemic. This has also increased people's interest (and investment) in making the home a comfortable, attractive and work-friendly environment.

- **Increased focus on physical health and wellbeing:** The pandemic has accelerated a focus on health and wellbeing for households and their families. This extends the existing focus on health (and, in particular, air quality) that was prominent during the 2019-20 bushfires. This focus on health and wellbeing is likely to continue, as indicated by the increasing interest in technologies and appliances such as air purifiers and personal health monitoring devices.

- **Ongoing impact on mental health:** The impact of the pandemic and associated lockdowns on mental health is now widely documented. Some households in our research indicated that they had experienced high levels of stress and/or loneliness during 2020 as a result of COVID-19. Personal computing devices and apps were more prevalent during this period to help alleviate some of these impacts and are likely to continue to be a key feature of many people's lives.

- **Questioning apartment living:** While normally considered a highly convenient and desirable housing option, some **apartment dwellers** were questioning this style of living because of the pandemic. These households mentioned concerns about the risk of COVID-19 transmission in shared spaces and the lack of space or garden to help alleviate the impacts of lockdowns. It is unclear whether this will result in a longer-term preference and trend towards more spacious (detached or semi-detached) housing.

- **Increasing interest in regional relocation:** The COVID-19 pandemic, associated lockdowns, and opportunities to work from home had initiated or increased some householders' interest in moving to **regional areas** that would be less densely populated, allow them access to a larger home and garden, and/or provide more access to space and nature.

Principles for future home life

Our research indicates a series of key principles that suggest the conditions and circumstances which will frame future home life and how digital energy futures are likely to unfold. The principles are based on, and emerge from, what the participants in this research told us they hope for and aspire towards both now and into their futures, as well as their anxieties about what the future might hold for them and their households. They are also informed by this project's Stage 1 report Digital Energy Futures: Review of industry trends, visions and scenarios, as well as our ongoing desktop research into future home life.

Together, they form a set of recommendations regarding the change processes we must attend to in order to orient energy planning and forecasting for future home life in both near (2025-2030) and medium-far futures (2030-2050). As key principles, these recommendations apply beyond specific technological developments or disruptive events. They describe general guiding considerations shaping everyday social practices in the home and thus are likely to continue to evolve as part of far futures.

1. Increasing insecurity and ongoing transition

People's futures will become (or be increasingly perceived as) more insecure and/or transitional.

- It will become increasingly difficult to meaningfully segment energy consumers or attach definitive characteristics or attributes to specific households.

- Insecurity and transitions will be accelerated by ongoing movement through life stages, changing employment and study circumstances, shifting housing arrangements and locations, ongoing renovations and repairs, and more frequent digital technology and energy upgrades or changes.

- Older women and sole parents face more insecure housing and financial futures, and different cohorts will upsize (for investment and financial return) or downsize (for less travel, housework and expense).

2. Tailored digital and energy systems

Diverse forms of Digital Do-It-Yourself (DDIY) will likely be just as common as conventional DIY in the future.

- Most people are creative, improvisational and adaptive. With varying degrees of technical competence and interest, they want to put together, understand and control smart home, automation and energy technologies themselves. They will continue to do this in the future.

- Many people's engagement with future digital and energy systems will involve their own DIY solutions to their frustrations about the usefulness, practicality, security and privacy implications, and energy impacts of technology.

- There will be increasing variability and flexibility in digital and energy systems in the future, ranging from high tech automated smart home systems through to manual systems (e.g. by using sensory evaluations of comfort and the manual timers in charging routines in place of automated temperature control and or charging).

3. Care as a moral imperative to ensure health and wellbeing

Care will continue to be a central and evolving feature of everyday life, resulting in new digital technology trends and energy demand implications.

- Care of oneself, the home and others is a central feature of home life and is evolving as a key response to climate change, health and other events and circumstances that are affecting populations globally. Care will continue to be central in the future.

- Household practices will continue to become increasingly oriented towards delivering care, such as through the provision of healthy comfort (e.g. air conditioning and air purification for infants, children, pets, guests to the home and adult occupants).

- Digital and emerging technologies that offer and deliver modes of practical and remote care (including health and aged care) will be of interest to households in the future.

4. Accelerating work-life flexibility and home-based working

Working from home will continue to be a desirable option for many households, with increasing diversity and flexibility in working hours.

- International collaboration and employment enabled by digital technologies will require increasing flexibility in working hours and ongoing use of digital platforms.

- Ongoing casualisation and the growing importance of the gig economy will lead to more fragmented and sporadic working hours.

- Families with young children are likely to prefer and take advantage of flexible working hours.

- Urban housing pressure and changing preferences away from **apartment dwelling** towards **regional lifestyles** will encourage working from home rather than long commutes to urban centres.

- More regional residential electricity demand is likely as new and temporary housing is built to respond to the current shortage of housing for regional workers and the surge in **Sea- or Tree-changer** demand.

- Improved digital technologies and improvements in internet connectivity and speeds will enable working from home, but also cause increased need for reliable electricity (including battery storage), internet and phone services in **regional areas**.

- Some kinds of work cannot be undertaken from home or during flexible hours, and new labour market inequalities will emerge as a result.

AptRnt

RegAgr

SeaTree

RegAgr

5. Predictable routines with sporadic variation

Household routines will continue to follow patterns, but will always be subject to occasional and sporadic variations that have implications for peak demand.

- Households generally follow relatively stable routines throughout their days and weeks but will continue to adapt to disruptive circumstances and events, including extreme weather, school and public holidays, celebrations and family functions, periods of sickness or ill health, and guests to the home.

- Routines involving cooling systems will continue to be seasonally and climatically based, with variations occurring on very hot days corresponding with peak electricity demand.

- New digital and emerging technologies will both be integrated into and will impact on existing routines. It will be important to monitor how these shifts evolve.

6. New opportunities for sharing and peer trading, including energy and mobility services

The platform economy has introduced new opportunities for sharing and peer trading, and these will continue to grow in the future. However, interest in and uptake of sharing and peer trading systems for energy and mobility services will vary.

- Households are increasingly interested in sharing and peer-trading energy, particularly in stable local neighbourhoods with strong community ties and this will increase as uptake of solar and batteries grows.

- People living in cities will continue to find value and flexibility in car-sharing and ride-share services. However, those living in rural situations will not find these services as currently offered to be viable, accessible or sufficiently flexible for their lifestyles.

- Existing forms of sharing will evolve and will offer the strongest basis upon which to grow future energy sharing and trading to balance supply and demand in the electricity grid.

7. Expanding expectations of the home and property

Households will continue to retrofit, renovate or transition their homes and properties to cater for more of their needs, practices and desires. The home will become an increasingly important site for energy demand.

- Accelerated by the need for self-sufficiency during the COVID-19 pandemic and the increasing value of housing in Australia, the home and property will increasingly be able to take on an expanding array of social, material and technological functions.

- The home is expected to perform the roles of an office, school, entertainment hub, cinema, guest house, recreational area and/or restaurant. This is likely to continue in the future as the home becomes consolidated as the key site for these everyday practices and experiences.

- Energy demand will continue to extend into new areas of a property, through automated systems, security cameras, recreational and aesthetic toys and devices, outdoor lighting, heating and cooling, and electric tools and vehicles (e.g. lawnmowers and bicycles). This expansion of energy consumption will likely undermine and sometimes outstrip energy efficiency gains.

- Social, economic, housing and digital inequities will mean that some groups are excluded from the benefits associated with these expanded uses of the home.

8. Strong demand for transition to renewables and opportunities to participate in a sustainable energy future

There will continue to be widespread household demand for the transition to renewables, including for non-financial reasons, and households will pursue innovative and affordable opportunities to participate in sustainable energy futures.

- Households will continue to expect Australia's energy system to transition to renewables because they are concerned about carbon emissions and climate change and/or because they see a central role for renewable energy generation and storage as practical and sensible central components of a modern electricity grid given the technologies available and Australia's suitability for their deployment.

- Households will participate in energy generation, storage, sharing (including micro-grids) and demand management where they see benefits for their own household and the wider community, with value for money and financial incentives continuing to be important for most households' initial installation of renewable technologies.

- More people will transition towards an all-electric home as they seek to utilise solar electricity and reduce their carbon footprint; electric vehicles will be a key component as concerns about affordability and the sustainability of grid-supplied electricity and battery manufacturing are addressed.

- Young families living in rural locations are likely to pursue sustainable energy technologies but may be less interested in digitally-enabled and shared aspects of digital energy futures.

9. Continuing digital and energy divide and equity challenges

Policymaking, regulation and industry standards will need to accommodate a continuing and possibly widening divide between digitally-enabled households and those who cannot access increasingly digitised lifestyles or new energy technologies, or prefer to preserve less tech-dependent home lives.

- There is considerable variation within and between households in regards to their digital and energy technology skills and interest. This will continue to be gendered and require further sensitivity in regards to policies and programs that move beyond the idea of a 'one-size-fits-all' consumer.

- Some households will continue to desire and maintain less digitised lifestyles, including to provide privacy and security, ensure equal access to the home and its appliances, avoid potential complications and vulnerabilities arising from technology dependence, avoid waste and environmental pollution, keep their minds and bodies active by performing tasks manually, and ensure children realise the benefits of exercise, being outdoors and learning practical skills.

- Some households will continue to face specific challenges in accessing and using digital and energy technologies because of their age, housing format, location, cultural background, English language proficiency, education or other circumstances.

- Equitable outcomes will require approaches and policies that treat digital futures as an option rather than an inevitability, avoid treating digital resistance as a deficiency to be corrected, and ensure less digitally and energy tech-enabled households are not financially or otherwise disadvantaged.

10. Futures will shift as everyday life, technology and energy trends evolve and intersect

Energy planners and forecasters must continue to be attentive to the unpredictability of the future and the need to create flexible and future-proofed propositions in plans and designs. The energy sector should consider new ways to co-design future digital and energy technologies that people can be productively involved and engaged with.

- Services that support and enable the co-design of tailored home energy management systems with consumers could be developed within an energy-as-a-service model.

- The evolving ethics of emerging technologies and their energy use will need to be brought together, rather than being seen as part of separate industries.

- Energy forecasting and planning will need to account for the ongoing and dynamic co-evolution of energy and digital trends.

PART 5
CONCLUSION

In this report, we have synthesised our ethnographic research with 72 Australian households into a series of emerging digital energy futures trends focused on the everyday practice domains where the majority of energy consumption and peak demand occurs, and where changes to demand are predicted to occur in the future.

These trends indicate a set of principles, which highlight the conditions and circumstances of future home life and how digital energy futures are likely to unfold. The principles are intended to guide residential electricity planning and forecasting for the near and medium-far futures.

Together this research is one of the first attempts to explore emerging futures through the perspectives of energy consumers. Uniquely, the research both accounts for household views and experiences of energy technologies and the energy industry; and places these in dialogue with household views and experiences of digital technologies, locating these within their everyday practices and routines.

This rich body of work forms Stage 2 of the Digital Energy Futures project. In addition to this report, Stage 2 of the project will also produce:

- A *Demand Management Opportunities* report, to translate the key trends and principles into tangible residential demand management approaches for the sector.

- A documentary film *The Personalisation Myth* which reveals the realities of how technologies and energy are experienced and understood in homes. To achieve this the film explores how charging, comfort and control are part of everyday life and imagined futures in the homes of five participating households.

Stage 3 takes these insights and uses them to inform and apply a future-focused lens to Energy Consumers Australia's Energy Consumer Behaviour Survey. The survey will test and explore these trends with a wider sample of Australian consumers and track change over time.

The Stage 2 ethnographic research additionally informs a further in-depth phase of the project (Stage 4) with Australian energy consumers drawn from Ausgrid and AusNet Services distribution networks. Through futures workshops, we will use the insights from this report to innovate and explore possible and speculative digital energy futures with energy consumers. This will deliver a set of qualitative scenarios about what a consumer-focused future might look like.

In the final stages of this project, we will develop an interdisciplinary forecasting methodology and further demand management recommendations.

REFERENCES

Accenture (2019) Putting the Human First in the Future Home. Available at: https://www.accenture.com/_acnmedia/pdf-98/accenture-putting-human-first-future-home.pdf

AEMC (2019) How Digitalisation is Changing the NEM. Available at: https://www.aemc.gov.au/sites/default/files/2019-11/How%20digitalisation%20is%20changing%20the%20NEM.pdf

CSIRO (2019) Artificial intelligence: Solving problems, growing the economy and improving our quality of life. Data 61. Available at: https://data61.csiro.au/en/Our-Research/Our-Work/AI-Roadmap

Deloitte (2018) Energy Accelerated: A Future Focused Australia. Available at: https://www2.deloitte.com/au/en/pages/energy-and-resources/articles/energy-accelerated.html

DeltaEE (2019) Smart Meter Benefits: Cost Savings Households Could Make Within a Smart Energy Future. Available at: https://www.smartenergygb.org/en/resources/press-centre/press-releases-folder/delta-ee-cost-savings

Hawaiian Electric (2017) Modernizing Hawai'i's Grid For Our Customers. Available at: https://www.hawaiianelectric.com/Documents/about_us/investing_in_the_future/final_august_2017_grid_modernization_strategy.pdf

Future Today Institute (2019) 2019 Tech Trends Report. 12th edition. Available at: https://futuretodayinstitute.com/2019-tech-trends/?platform=hootsuite

Leder Mackley, K. and S. Pink (2013) 'From Emplaced Knowing to Interdisciplinary Knowledge: Sensory Ethnography in Energy Research' for Senses and Society, 8(3): 335-353

Maller, C. J., & Strengers, Y. (2011). Housing, heat stress and health in a changing climate: promoting the adaptive capacity of vulnerable households, a suggested way forward. Health Promotion International, 26(1), 100-108. doi:10.1093/heapro/dar003

Maller, C., & Strengers, Y. (Eds.) (2018). Social Practices and Dynamic Non-Humans: Nature, Materials and Technologies. London: Palgrave Macmillan.

Martin, R. (2020). Making sense of renewable energy: Practical knowledge, sensory feedback and household understandings in a Scottish island microgrid. Energy Research & Social Science, 66, 101501.

McKinsey (2019) There's No Place like a [Connected Home]. Available at: https://www.mckinsey.com/spcontent/connected_homes/index.html

Microsoft (2018) The Future Computed. Redmond Washington: Microsoft Corporation. Available at: https://news.microsoft.com/futurecomputed/

Mitchell, V., K. Leder Mackley, S. Pink, G. Wilson et al (2015) 'Situating digital interventions: mixed methods for HCI research in the home' Interacting with Computers 27 (1): 3-12. doi: 10.1093/iwc/iwu034

Navigant (2018) Energy Cloud 4.0: Capturing Business Value through Disruptive Energy Platforms. Available at: https://guidehouse.com/insights/energy/2018/energy-cloud-4

Nicholls, L., & Strengers, Y. (2013). Air-conditioning and antibiotics: Demand management insights from problematic health and household cooling practices. Energy Policy, 67(April), 673-681. doi:http://dx.doi.org/10.1016/j.enpol.2013.11.076

Nicholls, L., & Strengers, Y. (2015). Peak demand and the 'family peak' period in Australia: Understanding practice (in)flexibility in households with children. Energy Research & Social Science, 9, 116-124. doi:http://dx.doi.org/10.1016/j.erss.2015.08.018

Nicholls, L., Strengers, Y., & Tirado, S. (2017). Smart home control: exploring the potential for enabling technologies in households. Retrieved from Melbourne, Australia: https://gallery.mailchimp.com/b38874b25e686137780eb836e/files/5d00ecfb-2098-4148-89dc-49b72b98d0aa/ECA_SHC_Final_Report_CURRENT.pdf

Nicholls, L., & Strengers, Y. (2018). Heatwaves, cooling and young children at home: Integrating energy and health objectives. Energy Research & Social Science, 39(Supplement C), 1-9. doi:https://doi.org/10.1016/j.erss.2017.10.002

Nicholls, L., & Strengers, Y. (2019). Robotic vacuum cleaners save energy? Raising cleanliness conventions and energy demand in Australian households with smart home technologies. Energy Research & Social Science, 50, 73-81. doi:https://doi.org/10.1016/j.erss.2018.11.019

Pink, S. (2011a) 'Ethnography of the invisible: how to 'see' domestic and human energy' Ethnologia Europaea: Journal of European Ethnology, 117-128

Pink, S. (2011b) 'Images, Senses And Applications: Engaging Visual Anthropology', Visual Anthropology, 24(5): 437-454

Pink, S. (2021) Doing Visual Ethnography. 4th Edition. London: Sage.

Pink, S. and K. Leder Mackley (2012) 'Video as a Route to Sensing Invisible Energy' Sociological Research Online, February 2012, on line at http://www.socresonline.org.uk/17/1/3.html

Pink, S. and K. Leder Mackley (2013) 'Saturated and Situated: rethinking media in everyday life' Media, Culture and Society 35(6): 677-691. doi 10.1177/0163443713491298

Pink, S. and Leder Mackley, K. (2015) 'Social science, design and everyday life: refiguring showering through anthropological ethnography', J. Design Research, Vol. 13, No. 3, pp.278–292.

Pink, S. and K. Leder Mackley (2016) 'Moving, Making and Atmosphere: routines of home as sites for mundane improvisation' Mobilities 11(02

Pink, S. K. Leder Mackley, V. Mitchell, C. Escobar-Tello, M. Hanratty, T. Bhamra and R. Morosanu (2013) 'Applying the Lens of Sensory Ethnography to Sustainable HCI' Transactions on Computer-Human Interaction 20(4). Article no. 25. http://dl.acm.org/citation.cfm?doid=2494261

Pink, S., Leder Mackley, K. Morosanu, R., Mitchell V. & Bhamra, T. (2017) Making Homes: ethnographies and designs. Oxford: Bloomsbury

Shove, E., Pantzar, M., & Watson, M. (2012). The dynamics of social practice: everyday life and how it changes. London: Sage.

Shove, E., & Walker, G. (2014). What Is Energy For? Social Practice and Energy Demand. Theory, Culture & Society, 31(5), 41-58. doi:10.1177/0263276414536746

Strengers, Y., & Maller, C. (2011). Integrating health, housing and energy policies: the social practices of cooling. Building Research & Information, 39(2), 154-168.

Strengers, Y. (2013). Smart energy technologies in everyday life: Smart Utopia? London: Palgrave MacMillan

Strengers, Y., & Maller, C. (Eds.). (2014). Social practices, intervention and sustainability: Beyond behaviour change. Oxon: Routledge.

Strengers, Y., & Nicholls, L. (2017). Convenience and energy consumption in the smart home of the future: Industry visions from Australia and beyond. Energy Research & Social Science, 32, 86-93.

Strengers, Y., & Nicholls, L. (2018). Aesthetic pleasures and gendered tech-work in the 21st-century smart home. Media International Australia, 166(1), 70-80.

Strengers, Y., Pink, S., & Nicholls, L. (2019). Smart energy futures and social practice imaginaries: Forecasting scenarios for pet care in Australian homes. Energy Research & Social Science, 48, 108-115. doi:https://doi. org/10.1016/j.erss.2018.09.015

Strengers, Y., Hazas, M., Nicholls, L., Kjeldskov, J., & Skov, M. B. (2020). Pursuing pleasance: Interrogating energy-intensive visions for the smart home. International Journal of Human-Computer Studies, 136(April).

Strengers, Y. Duque, M. Mortimer, M. Pink, S. Eugene, A. Martin, R. Nicholls, L. Horan, B. Thomson, S. (2021). Smart Homes for Seniors: Intelligent Home Solutions for Independent Living. Final research evaluation report, McLean Care, Monash University and Deakin University, Melbourne, Australia.

Tech UK (2018) The State of the Connected Home Report. Available at: https://www.techuk.org/connected-home/

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