MONASH University

DIGITAL ENERGY FUTURES

REVIEW OF INDUSTRY TRENDS, VISIONS AND SCENARIOS FOR THE HOME

JUNE 2020

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Published by

Emerging Technologies
Research Lab
Monash University
Caulfield campus
900 Dandenong Road
Caulfield East VIC 3145

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Acknowledgement to 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.

Acknowledgements

We gratefully acknowledge our partner organisations for their time and contribution, with special thanks to:

Lynne Gallagher – Energy Consumers Australia
Catherine Gipp – AusNet Services
Dr. Stephanie Judd – AusNet Services
Kailin O'Neill – Ausgrid
Dr. Robert Simpson – Ausgrid
Craig Tupper – Ausgrid

The research was funded by the Australian Government through the Australian Research Council's Linkage Projects funding Scheme ('Digital Energy Futures' project number LP180100203) in partnership with Monash University, Ausgrid, AusNet Services and Energy Consumers Australia.

We would also like to thank the members of the Digital Energy Futures Advisory Committee for their advice and feedback:

Kellie Caught, Australian Council of Social Service (ACOSS); Andrew Davis, Jemena; Neil Horrocks, University of Queensland's Redback Technologies Research Centre; Bronwen Jennings, Australian Energy Regulator (AER); Dean Lombard, Renew; David Markham, Australian Energy Council (AEC); Grant Stepa, Rheem; Alicia Webb, Australian Energy Market Operator (AEMO); Kate Wild, Australian Energy Market Commission (AEMC).

A partnership between:

MONASH University | Ausgrid | AusNet services | ENERGY CONSUMERS AUSTRALIA

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GLOSSARY OF TERMS

5G	The fifth-generation technology standard for cellular networks
ADM	Automated Decision-Making: when decision-making is delegated to a machine and carried out in relation to input data
AI	Artificial Intelligence: technologies that can perform tasks or solve problems using algorithms and machine learning, ideally without the direct intervention of humans
AR	Augmented Reality: a technology which projects or superimposes a digitally produced image onto the user's view of the real world
AV	Autonomous Vehicle: a driverless car or vehicle that is capable of detecting its surroundings sufficiently to navigate without a human driver
BTM	Behind the Meter: an industry term referring to distributed energy resources (energy generation, storage and management technologies) that are generally owned by the energy user, potentially impact system operation, and have limited 'visibility' to utilities and system operators
Community-owned Solar/ Battery	Refers to cooperative energy projects in which communities collectively invest in electricity generation and storage, with benefits then distributed to members
DER	Distributed Energy Resources: consumer-owned devices that can generate or store electricity or have the 'smarts' to actively manage energy demand. E.g. Rooftop solar photovoltaic (PV), battery storage, hot water systems, pool pumps, air conditioners, smart appliances and smart meters. In this report, we use DER to refer to distributed energy generation and storage and describe the specific technologies involved in delivering demand management
EV	Electric Vehicle: any vehicle, usually an automobile, that uses an electric motor for propulsion
IoT	The Internet of Things: a network of internet-connected technologies or everyday devices that are embedded with sensors that collect and share data
Microgrid	An interconnected electricity generation, storage, and distribution network within a defined boundary - either connected to the main grid or a stand-alone system
Peer-to-Peer Energy Trading	Buying, trading or selling of energy between owners of DER
Two-Way Energy Market	An energy market in which both traditional energy generators and energy consumers with DER buy and sell energy
VPP	Virtual Power Plant: coordination of DER and devices through the energy market to secure and stabilise the energy system
VR	Virtual Reality: a technology that simulates an immersive environment, primarily through the use of a headset

EXECUTIVE SUMMARY

The Digital Energy Futures project aims to understand and forecast digital lifestyle trends and their impact on future Australian household electricity demand, including at peak times.

This report presents the first stage of the research: **a desk-based review of 64 digital technology and energy industry reports** speculating on the near (2025-30) and medium-far (2030-50) futures.

The report is international in scope but focused on futures likely to affect Australian households' electricity demand. The review investigated **how digital technology futures and energy futures are currently envisioned across industry and policy reports** and examined the relationship between these different future trends and predictions (Figure A). This report summarises these findings and presents new knowledge and critical insights on the **limitations of these future visions.**

The findings of the review were synthesised into **six speculative future scenarios** that placed dominant industry visions into the home in an accessible comic strip form. Through representing the dominant industry visions within the context of household life, these aggregated industry scenarios are designed to raise new questions relating to how future household everyday practices will intersect with digital and energy futures. The scenarios also serve as translation materials which will be used in **ethnographic research with 72 participating households** for the next stage of the project.

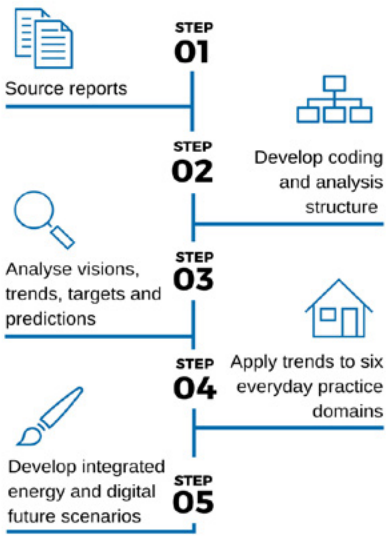


Figure A. Review process

Future ethnographic research will include:

- Observation and digital documentation of home environments **(technology and energy tours)**
- Investigation of household expectations and anxieties about their futures, including the role of emerging technologies and energy concerns **(in-home interviews)**
- Household responses and reactions to industry-envisioned futures **(scenario interrogation).**

Everyday practice domains

The content analysis of the reports was organised around the expected impacts of digital technology on six domains of everyday practice, where the majority of electricity demand is produced, or where significant change is expected.

Key claims made in the reports reviewed are identified below:

1. Heating, cooling and comfort

Smart home technologies, particularly smart appliances such as smart thermostats and hot water systems, will manage increased energy demand from heating and cooling to deliver savings for both consumers and the energy industry.

"If households take advantage of the low-cost, low-emission electricity by switching from natural gas to low-carbon electricity, electrical space heating could be up to sixfold more energy efficient than gas heating for the same result."

CSIRO 2019b Australian National Outlook

2. Working and studying from home

New technologies, such as improved telecommunications, virtual reality (VR) and augmented reality (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."

Microsoft 2018 The Future Computed

3. Caring from home

Smart home technologies will enable older people to be cared for within their homes.

"Out of necessity, robots—mechanical systems, artificial intelligence, and automated services—will act as productive, emotionally-intelligent stand-ins for a younger generation that was simply too small in numbers."

Future Today Institute 2019 Tech Trends Report

4. Entertainment and convenience

Widespread adoption of smart home technologies is 'just around the corner' bringing improved efficiencies, convenience, and immersive household entertainment.

"No more traveling to a theater to watch a movie; instead, people will "travel" into the movie itself as participants."

Accenture 2019c Technology Vision

5. Driving and charging

The transportation sector will change substantially with the increasing uptake of electric and autonomous vehicles (AVs), but considerable uncertainty remains about the timescales and accompanying mobility systems.

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

Deloitte 2018a Energy Accelerated

6. Energy management

Better data and automation will enable more efficient management of energy, reduce peak demand by load shifting, and reduce energy costs for consumers through price incentives and other demand management initiatives.

"As technology becomes cheaper, smarter and more prevalent, customers will take a lead role in shaping Australia's electricity future."

ENA 2017 Energy Networks Transformation Roadmap

Aggregated industry scenarios

The findings of the review were synthesised through the development of a set of future scenarios, in which the research team aggregated industry predictions across the six everyday practice domains. The scenarios are playful 'comic strip' representations which depict the consequences for everyday practices if these industry visions of future technologies were integrated into our future lives.

Each scenario brings together the analysis in two novel ways, by:

1. Drawing together dominant energy and digital technology narratives, which are rarely considered together.
2. Applying the findings from this review to the everyday practice domains.

The comic strip scenarios do not represent the research team's own future visions

They have been extrapolated from the review and then applied to the everyday practice domains that the Digital Energy Futures project focuses on.

As the reports analysed for this review were written prior to the **coronavirus pandemic**, the impacts and emerging trends of this international event were not anticipated or discussed.

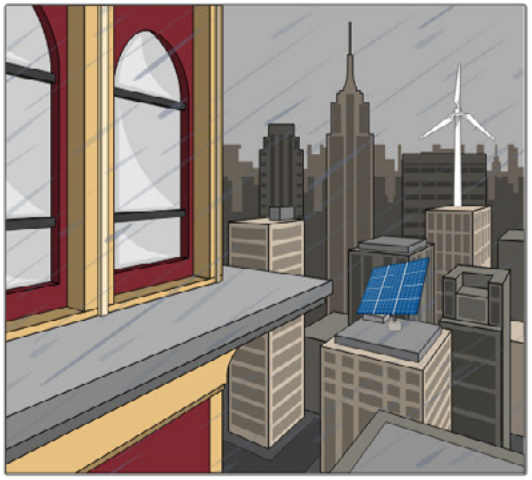
Nonetheless, the analysis provides a set of dominant technology and energy speculations currently informing directions for near and medium-far futures in Australian and other advanced Western economies, including in response to recent events such as the coronavirus pandemic and the **2019-2020 Australian bushfires.**

Scenario 1.
Staying cool and comfortable in extreme weather

The **Staying cool and comfortable in extreme weather** scenario focuses on the macrotrend of more extreme weather resulting from climate change, leading to disruptions to electricity infrastructure services and home life. In the Australian context, these framings are specifically related to the anticipation of more frequent heatwaves, extreme heat days and bushfires. In integrating the visions and trends from the reports we reviewed into this scenario, the research team identified the possibility for emerging home technologies such as air purifiers (or new routines with existing technologies such as air conditioners) to become increasingly commonplace.

Technology reports reviewed anticipate that people will spend more time in their homes as they adopt more smart home technology, which the research team has integrated with the potential for extreme weather outdoors. Energy sector reports reviewed also identified that electricity grid failures resulting from extreme weather could encourage more localised generation and storage. This comic strip scenario depicts the implications of these possible changes for people as they perform everyday life practices in the future.

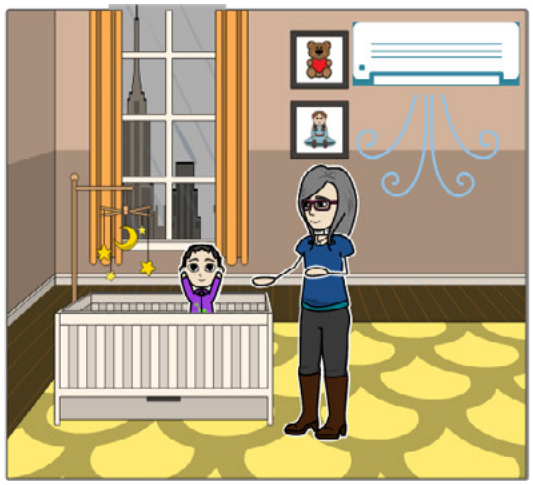
Scenario 1. Cool and comfortable in extreme weather



Australia will experience increasing days of extreme weather due to climate change.

Extreme weather may cause electricity grid failures, encouraging more people to rely on their batteries.

Air purification technology will keep the indoor air clean to breathe in poor outdoor conditions.



The increasing number of extreme weather days will increase usage of air conditioning. Air purification will be integrated into AC units.

More people will work and study from home to avoid commuting in extreme weather.

Poor air quality will encourage exercise in the home.

Home delivery services will enable you to stay in the comfort of your home.

Automatic smart lights will create the ideal atmosphere in the home.

Scenario 2.
Stay at home life

The **Stay at home life** scenario focuses on industry predictions that technological advances in telecommunication, VR, AR, and digital voice assistants will increase working and studying from home and make online shopping and delivery a seamless experience.

Everyday entertainment and leisure practices are also expected to increasingly take place in the home as they integrate with these emerging technologies.

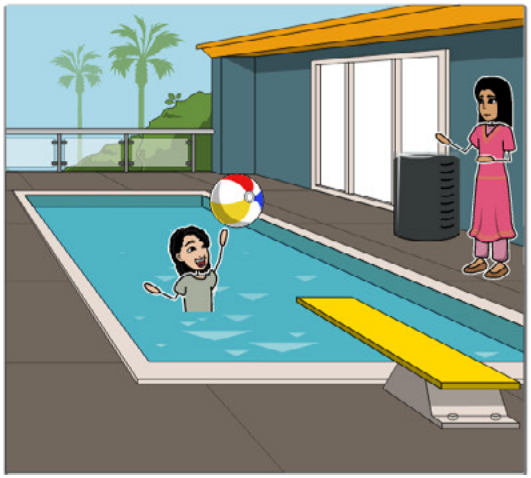
Scenario 2. Stay at home life

Working, studying, and recreation can all now take place in the home.

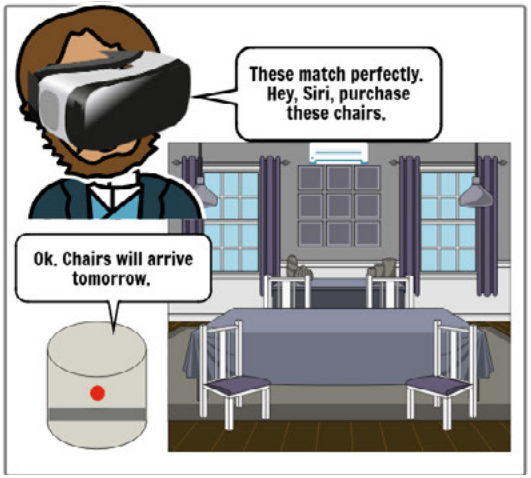
E-sports and gaming are growing in popularity and reputation. Weekend sport might not require leaving the house.

Telecommuting will be enhanced through the use of virtual reality, enabling many more professions to work remotely.

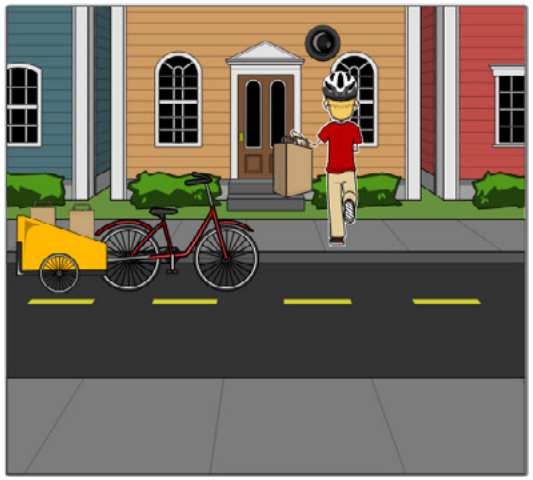
Studying from home will be more common as universities go online.



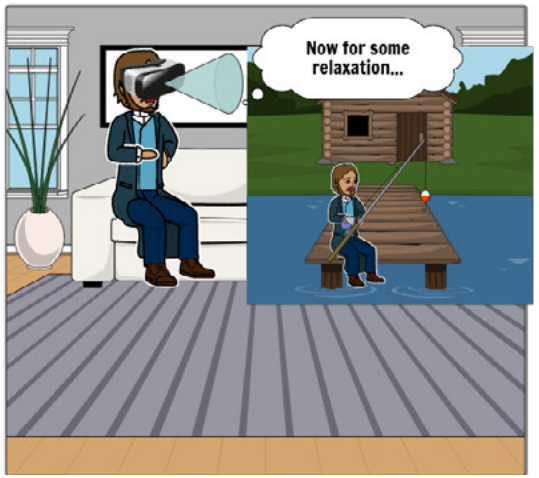
Energy management systems will optimise water heaters and pool pumps to automatically run when energy is cheapest.



Shopping will no longer require trips to the store. Augmented reality will allow you to see exactly how an object will fit into your home and orders can be placed through digital voice assistants.



Groceries and purchases will be delivered to the home, with smart locks that allow deliveries in.



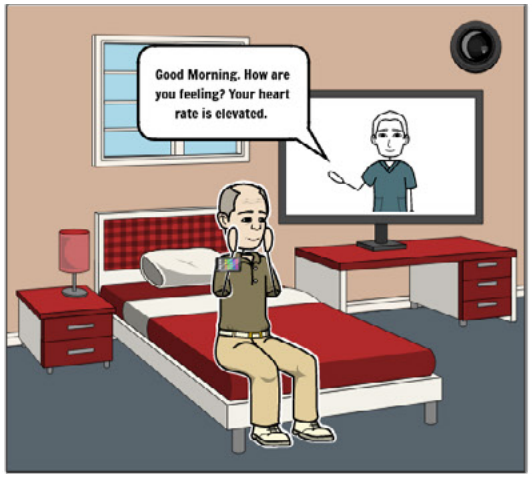
Virtual reality will allow you to travel and have immersive experiences, all without leaving home.

Scenario 3.
Ageing at home

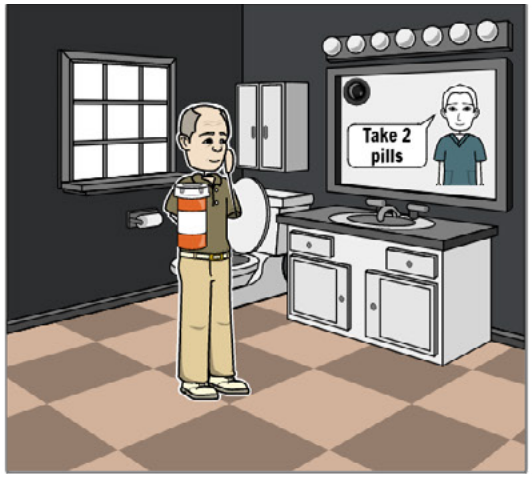
The **Ageing at home** scenario takes as its starting point the key macro trend that Australia's population is ageing and that more people will desire to stay in their homes as they age.
The reports reviewed expect that technology will help enable caring for the ageing population and predict that many emerging technologies will be integrated into the homes of older people to address health needs, ensure safety and provide companionship.

The comic strip depicts how these technologies might be used and experienced by older people within everyday practices if they were made available and accessible to them.

Scenario 3. Ageing at home

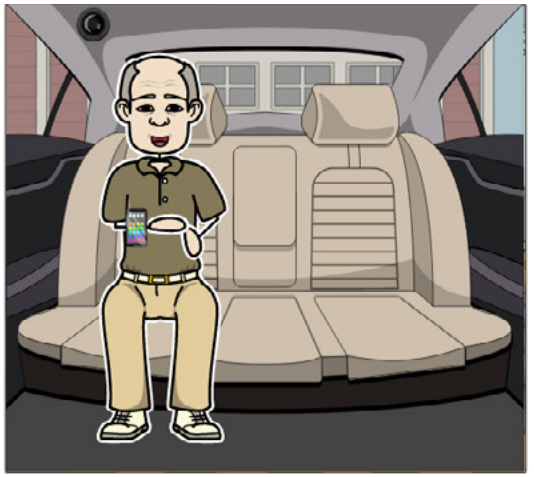


Wearable technology will monitor vital signs and alert health authorities if problems are detected.

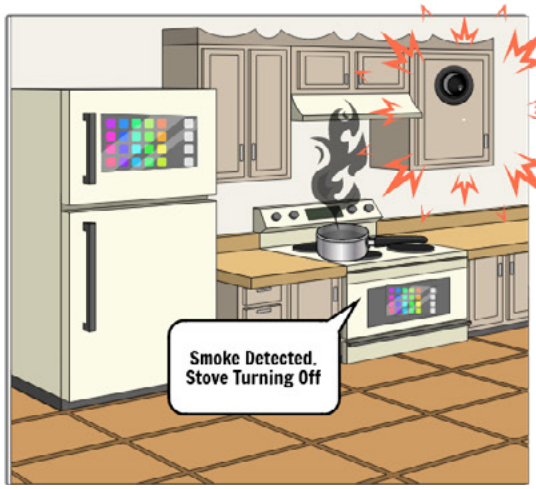


Digital voice assistants will remind people to take their medication.

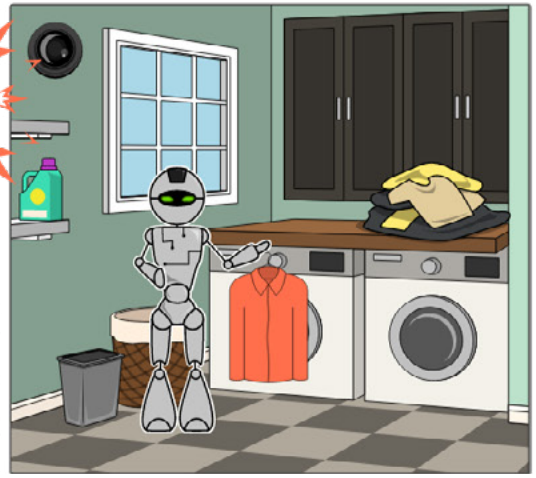
Visits to the doctor can take place virtually from the home.



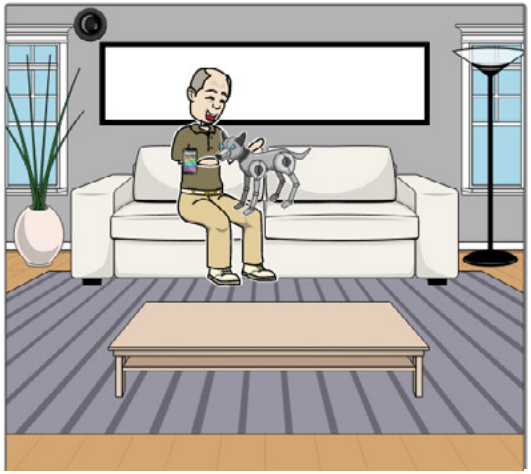
If it is necessary to travel, self-driving cars will allow the elderly to get around safely.



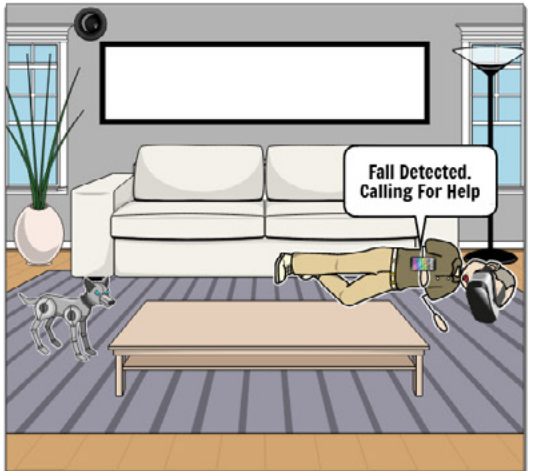
Sensors and smart appliances will communicate with each other to ensure safety.



Robotic carers will perform many household and nursing duties.



Companion robots such as robotic pets will provide comfort.



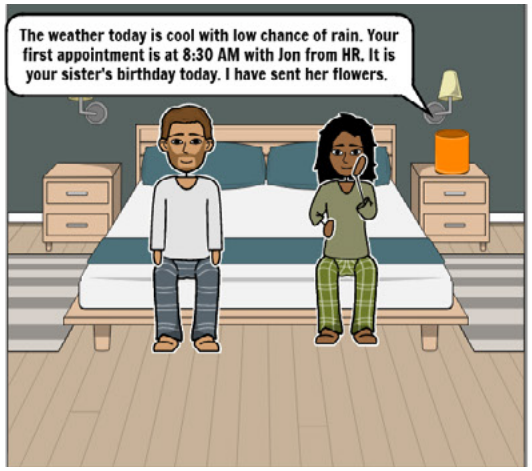
Wearable technology and sensors will be able to call for outside help when it is needed.

Scenario 4.
The smart and easy life

The **Smart and easy life** scenario takes as its starting point the prediction represented in the reports that homes will become increasingly “smart” and that this will be enabled by advances in Artificial Intelligence (AI) and Internet of Things (IoT). In this scenario, more household activities and decisions are expected to become automated, and advances in technology are expected to enable immersive forms of entertainment.

The comic strip depicts how these future devices might become part of individual and family-based everyday practices in the home.

Scenario 4. The smart and easy life



A digital voice assistant will start your day and help you plan for it.

Technolgies like a smart mirror may help you pick out your optimal outfit for the day.

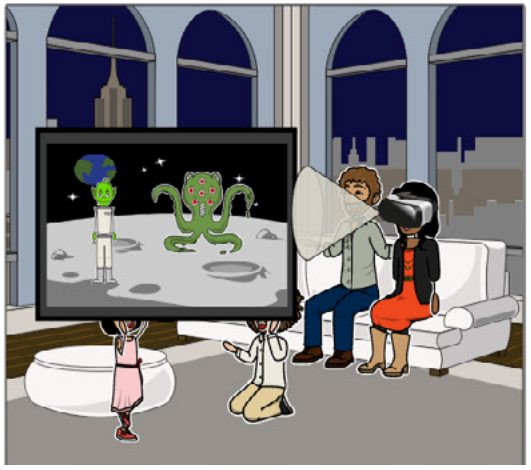
Smart sensors and wearable technologies will monitor your health.

Cameras will be installed in many locations in the house, so that children can be monitored from afar.

Smart appliances, like a smart fridge, may suggest recipes based on the contents of your fridge and your health data.

An energy monitor in a central location of your home will allow you to monitor your energy usage in real time, and allow you to automate appliances to run when energy is cheapest.

Facial scanning technologies in smart locks will know whether to let people into the house. Or in the case of unwanted visitors, to alert police.



You will no longer 'watch' a movie, but be transported into the movie, taking part in the adventure.

Scenario 5.

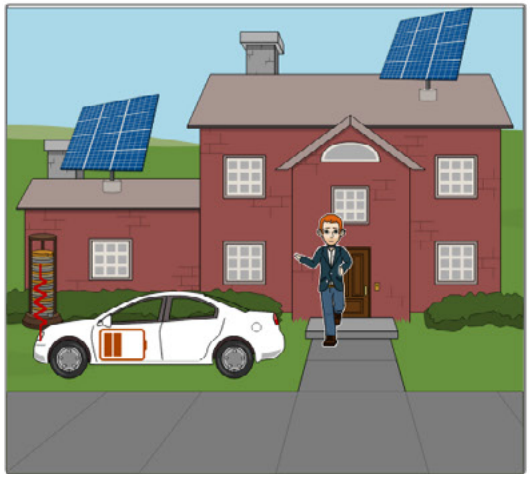
The active smart charging commuter

The **Active smart charging commuter** scenario is based on the prediction that electric vehicle (EV) ownership will increase significantly, internationally and in Australia. It is expected that this will lead to increased electricity demand for EV battery charging.

Energy sector reports reviewed emphasise that the increase in EVs has two possible implications: they could be a burden on the energy system if their charging is not efficiently managed; or if their battery storage is integrated into the electricity system through vehicle to grid connections and charging is managed and smart, they will create an opportunity for efficient home and mobility energy management.

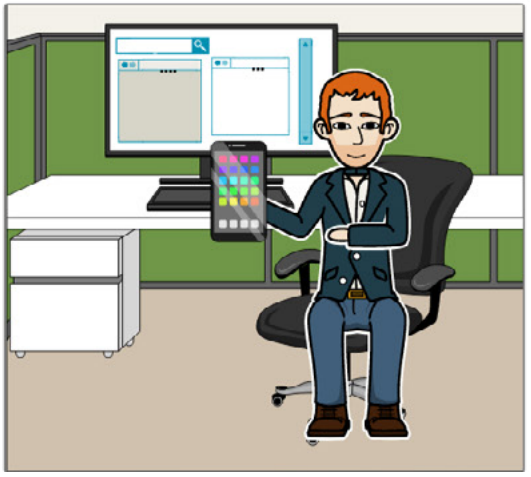
The comic strip depicts how energy related to electric car use might be used and managed across a series of physically present and remote everyday practices, at home, at work and in transit.

Scenario 5. The active smart charging commuter

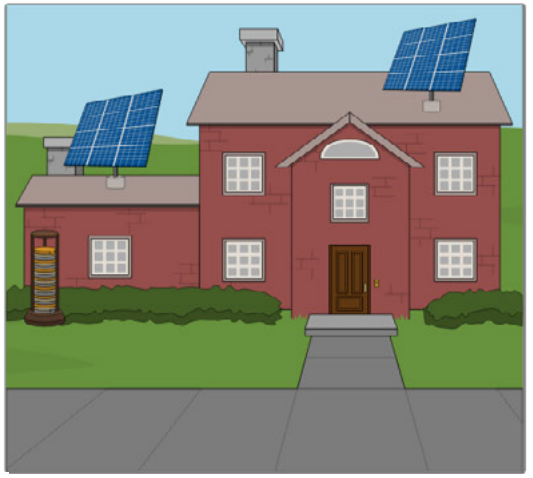


In the morning, your electric vehicle will have sufficient charge for you to commute to work.

When you arrive at work you will plug your car into a charger that will be powered by the solar energy that is plentiful during the afternoon.



You can control many household appliances remotely from your smart phone.

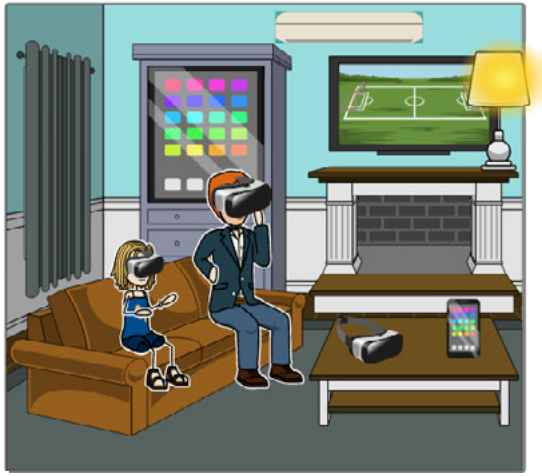


During the day, your house is powered by solar energy and either stores excess energy in your home battery or exports it to the grid when the feed-in tarriff is highest.

Many of your chores, such as the laundry, can be done when energy is coming from your solar panels, or when the feed-in tariff is lowest.

When you leave work, your car is fully charged.

After arriving home, you still have power in your car battery which you can plug into your house or export to the grid if there is a good price incentive.



Your evening activities are powered by your car battery. Because many of your chores have already been done, there is enough power leftover for you to commute to work the next morning.

Scenario 6.

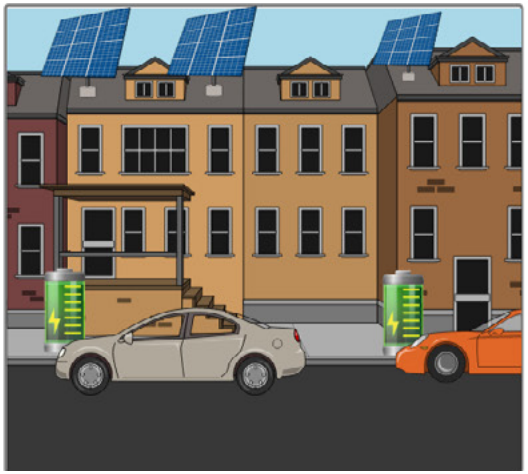
The set and forget prosumer

The **Set and forget prosumer** scenario is based on the prediction that the rise of the sharing economy, increased consumer concern with sustainability, and the availability of automated technologies will lead to the increased uptake of distributed energy resources (DER), peer-to-peer trading systems, and automated energy management.

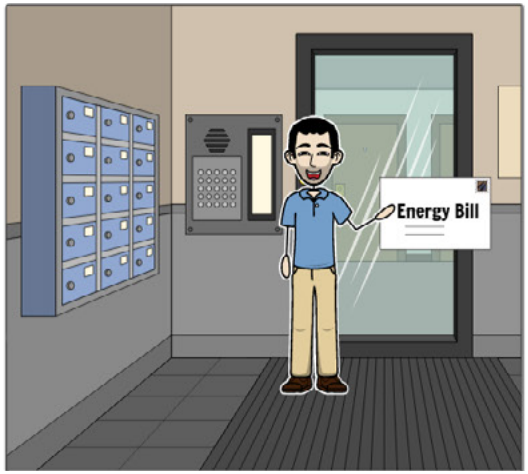
Household energy use is predicted to be optimised by the availability of real-time data as well as advances in AI and automated decision-making (ADM) to balance energy availability with household demand, creating cost savings for both consumers and the energy sector.

The comic strip depicts how these technological and energy futures possibilities might have implications for how people experience their home environments and use automated systems in the near future.

Scenario 6. The set and forget prosumer

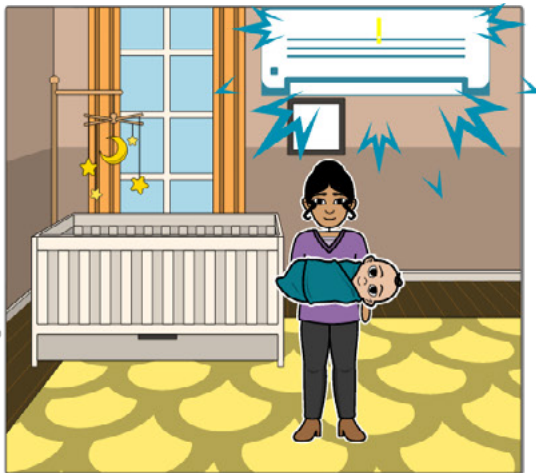


Peer-to-peer energy trading systems in ‘micro-grids’ will enable neighbours to connect to each other’s energy generation and storage including batteries in electric cars.



An automated system enabled by blockchain technology will ensure everyone pays their fair share.

Smart thermostats will automatically heat or cool a room when solar energy is available to optimise the temperature, even preparing for your arrival home.

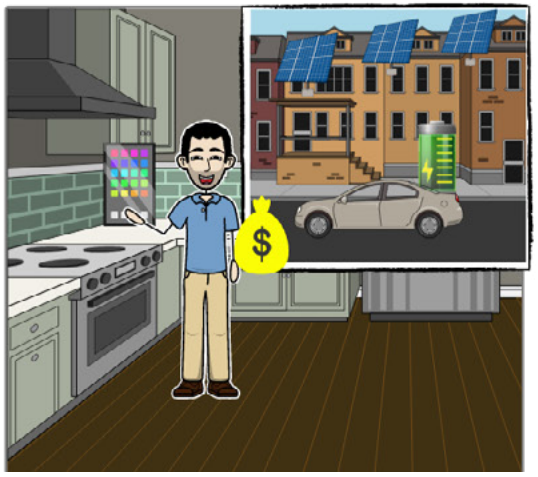


Algorithms will enable optimal temperatures based on the availability of solar energy.

Solar hot water ststems will automatically heat water when solar energy is available and store the water for later use. Technology will set an optimal temperature and shower time to ensure enough warm water.

Some appliances, such as the smart washing machine, will be automated to run when solar energy is available.

An energy monitor will enable you to see how much energy you are using and adjust your automated settings.



Any energy you produce but do not use, can be sold to your neighbours or to the grid.

Energy industry visions of technology and people

The analysis identified the following dominant claims made about people and how they are expected to relate to technology and respond to future technological change in the energy industry.

- Emerging energy technologies will respond to and alter consumers' expanding expectations of the energy system.
- Opportunities for consumers to access and participate in the energy market by using new energy technologies will give rise to the engaged consumer and prosumer.
- Consumers want more autonomy and control, but need automation in order to manage energy optimally.
- Building consumer trust will enable environmentally and economically efficient digital energy futures.
- Consumer demand for sustainable energy is strong but unpredictable.

Key macro trends

Fourteen emerging macro trends were represented in the reports reviewed as likely to impact on digital energy futures.

Large-scale technology developments

1. **Artificial intelligence (AI)** will extensively change the way we live.

2. The **Internet of Things (IoT)** will expand as more devices in our daily lives become connected.

3. **Fifth-generation technology (5G)** will speed up communication between technologies, enabling the growth of AI and IoT.

4. **Blockchain technologies** will automate trust and enable transactions without an intermediary.

Environmental/energy

5. **Decarbonisation** of the energy sector is an imperative.

6. **Two-way energy markets** and increasing DER will accelerate decarbonisation.

7. **Climate change** will increase extreme weather events in Australia.

Demographic

8. As Australia's population ages, technology will enable **more older Australians to live at home.**

9. Ongoing **immigration** will fuel population growth and cultural diversity.

10. **Home ownership** will decrease, and urban areas will become more densely populated

Economic

11. AI will enable the **automation of many jobs** and increase unemployment.

12. More people will work in the **gig economy.**

13. **Sharing** will replace ownership in some sectors.

14**. Flexible work arrangements** will alter when and where people work.

Evaluation and implications of industry predictions

The findings and scenarios identified by this review depict a baseline of industry future visions in 2020.

The predicted and anticipated futures they represent are technologically driven and many, particularly technology sector reports, focus on the potential future market for emerging technologies or offer consulting expertise to other industries regarding the disruptive potential of emerging technologies.

These reports tend to draw on futurists, market expertise, and customer surveys.

Reports with a more substantial research component, such as those by research agencies, primarily use quantitative forecasting models. These draw on historical trend data and system-level data and thus are limited by their inability to capture unpredicted events or to quantify the complexity of everyday practices.

Due to this, the reports reviewed are limited in the following ways:

- People are understood primarily as individual consumers of energy or technology. This means the contextual, contingent and unpredictable elements of their lives are not accounted for.
- The futures they depict exclude and ignore socio-economic and cultural diversity, particularly low socio-economic and linguistically diverse households.
- They maintain and promote conservative visions of the future because they largely assume the continuation of current trends, such as the improvement or greater uptake of already existing technologies.
- The impact of large-scale disruptions is not considered. In 2020 the experience of the coronavirus pandemic and bushfire crisis demonstrates how these large-scale events disrupt and potentially accelerate industry anticipated futures, and the need to plan for uncertainty and flexibility.
- Claims about the effects of macro trends like AI, 5G, and blockchain do not account for the uncertainty and failure inherent to developing and implementing technologies.

These limitations are reflected in the industry aggregated scenarios developed from this review. While the scenarios bring together novel combinations of energy and digital technology futures, applied to the everyday practice domains in the home, they only include technology that is to some degree already existing, or reflect macro trends that are already present-day concerns.

Therefore, while the scenarios reflect possible near futures (2025-2030), as well as some conservative elements of medium-far futures (2030-2050), they should primarily be considered the dominant visions of the energy or technology sector in the present.

The next stage of the Digital Energy Futures research project will use these industry scenarios to critically disrupt and re-imagine possible digital energy futures through ethnographic research with 72 Australian households across Ausgrid and AusNet Services electricity distribution networks.

PART 1
BACKGROUND AND REPORT OVERVIEW

Everyday practices in Australian households are changing as new digital technologies emerge and our social and work lives evolve. In addition, the 2019-20 Australian bushfires and coronavirus pandemic have illustrated how unanticipated events can shift the pace and shape of everyday life.

Changes in household practices, and the technologies and economic incentives being incorporated into them, impact electricity load profiles including average and peak residential electricity demand. To date, there has been little systematic analysis of how digital technologies and energy demand are evolving together.

The Digital Energy Futures project aims to understand and forecast changing digital lifestyle trends and their impact on future household electricity demand, including at peak times.

This report presents the first stage of this research: a desk-based review of digital technology and energy industry reports which identify emerging trends and speculate on or predict near (2025-30) and medium-far (2030-50) futures.

The near future timescale corresponds with the forecasting cycles of electricity distribution businesses (5-10 years) in order to focus on emerging trends likely to impact on electricity networks and the energy system.

The medium-far future timescale follows scenario planning timeframes adopted by many industries (10-30 years) and allows for more speculative possible futures.

Our analysis of 64 industry reports identified dominant trends, predictions and visions for digital energy futures. The review was international in scope but focused on futures likely to affect Australian households' energy usage and electricity demand. The analysis will inform subsequent stages of the Digital Energy Futures project, specifically in-depth ethnographic research with Australian households.

The outcomes of the review were:

- **Six speculative 'comic strip' scenarios** representing how the digital technology and energy industries anticipate everyday practices in the home may change in the future.
- An evaluation of the **limitations of the future visions** offered by the reports reviewed
- An **innovative method** for testing industry visions and scenarios with households in order to disrupt and re-imagine futures.

Everyday practice domains

Our analysis is organised around the expected impacts of digital and energy technologies on six domains of everyday practice, where the majority of electricity demand is produced, or where significant change is expected in near or medium-far futures (Figure B).

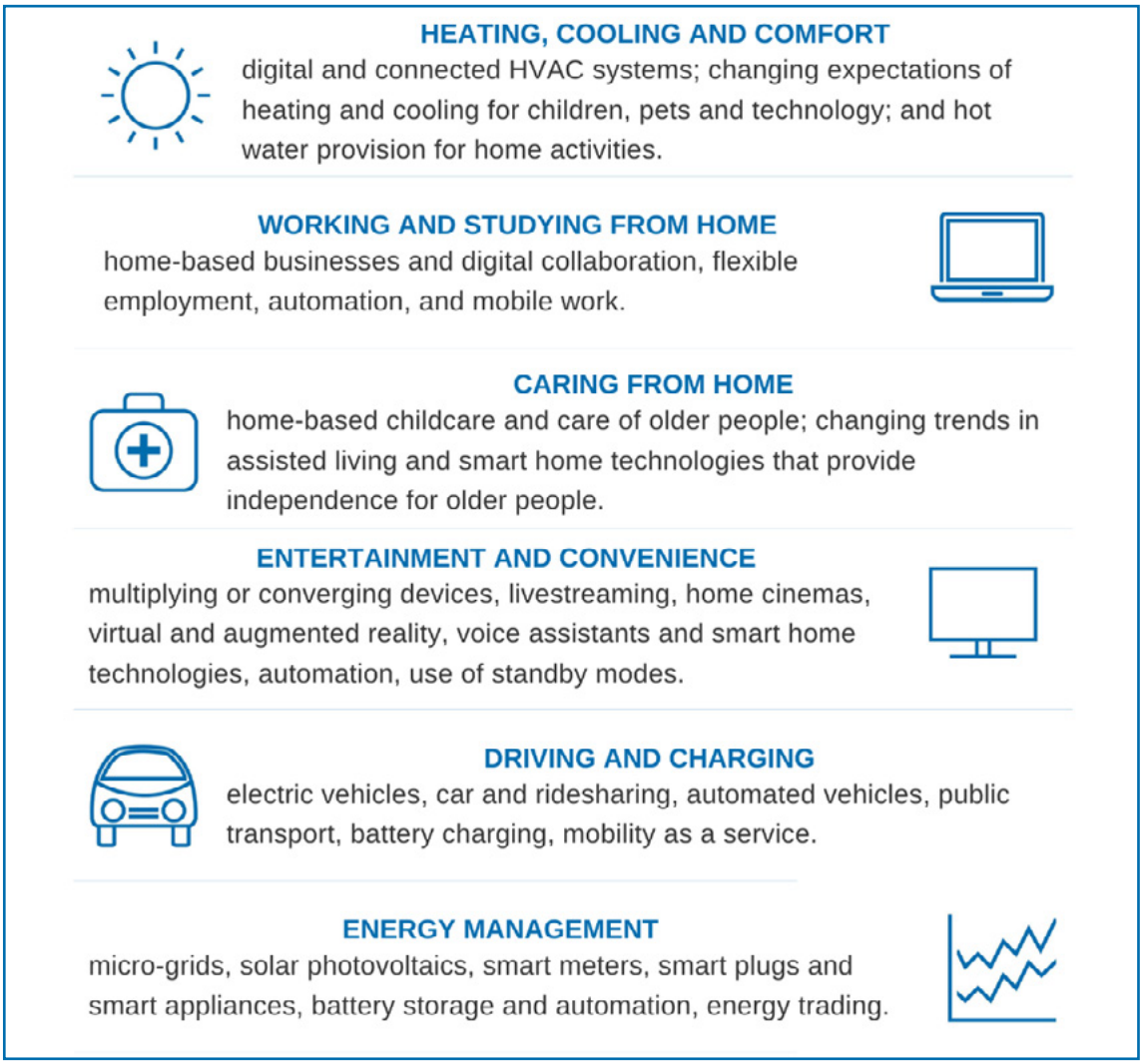


Figure B. Everyday practice domains

Structure of the report

This report is organised to reflect the key findings and outcomes from our digital energy futures review.

Part 2: Methodology

- A summary of the process followed by the research team to conduct the review and analysis.

Part 3: Energy industry visions of technology and people

- Findings relating to how the energy industry reports we analysed depict and understand people and technological change.

Part 4: Macro trends and large-scale disruptions

- Emerging and anticipated technology, environmental, demographic and economic macro trends found in the reports, and their anticipated impacts on the home and residential electricity demand.

Part 5: Applying technology trends and visions to everyday practices

- How emerging technologies are expected to be integrated into daily life in the home in relation to the six everyday practice domains.

Part 6: Industry aggregated scenarios

- Comic strip scenarios playfully depicting how the digital technology and energy trends and visions identified in the analysis of reports are anticipated to impact on everyday life in households within and across the practice domains.

Part 7: Evaluation and implications of industry predictions

- Main outcomes, implications and limitations of the dominant future visions found in our review of industry reports.
- Summary of the next stage of the Digital Energy Futures project.

PART 2
METHODOLOGY

The review consisted of a qualitative content analysis of 64 digital technology and energy sector reports to identify current industry trends, predictions and visions for how everyday practices are anticipated to change in the near (2025-30) and medium-far (2030-50) futures.

The review was international in scope but focused on trends likely to affect Australian households' electricity demand in relation to the practice domains identified in Figure B.

The review investigated digital energy futures from two distinct perspectives provided by experts, consultants, governments, industry and research agencies who authored or published the reports:

1. **Digital future trends and predictions** focused on the role of emerging digital technologies.
2. **Energy future trends and predictions** focused on the role of emerging energy technologies and service arrangements (e.g. pricing signals or other demand response opportunities).

Figure C outlines the process followed to undertake this review.

The outcome of our review was a summary of key policy and industry visions, which were synthesised into six industry aggregated scenarios, presented in Part 6.

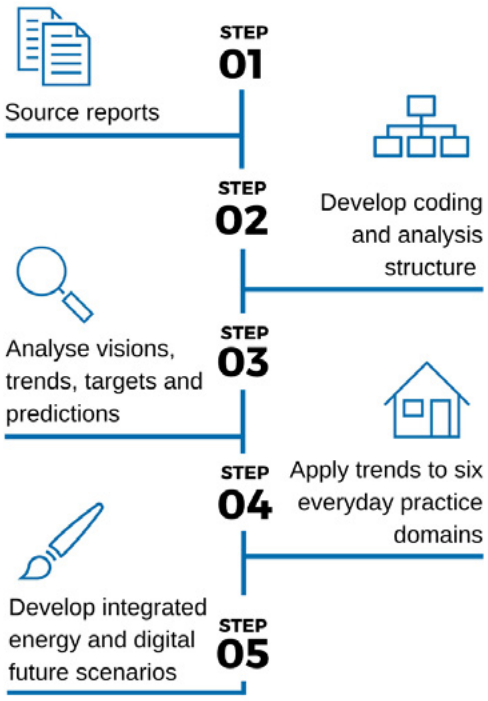


Figure C: Review process

Sourcing reports

The research team sourced a total of 64 reports for analysis. The reports were categorised as being produced by technology consultants, government departments, energy consultants, research agencies, energy industry stakeholders, or technology companies (Figure D). In this report, these are all referred to as energy and/or technology industry reports.

Twenty-eight of the reports focus specifically on Australia and are from Australian based firms and organisations. Another 11 focus explicitly on global trends. The other reports were produced by US (15), UK (14), and EU (6) based firms and organisations. The reports were sourced by the research team from mid-2019 to early 2020.

The reports were published between 2010 and 2020, with the majority of reports published in 2018 (18) and 2019 (32).

Reports were sourced using the following methods:

- Internet searches using keywords to initially identify relevant reports discussing general technology and energy trends relevant to households and residential electricity demand (e.g. tech trends report; future energy report).
- Internet searches for reports specific to the everyday practice domains (e.g. future of aged care, work, transport etc.)
- Searches on relevant government websites (e.g. European Commission) and consulting agencies (e.g. Deloitte, Accenture).
- Searches of references used in already sourced reports.
- Specific energy sector reports identified by the Digital Energy Futures research team, industry partners and advisory committee members through their professional networks or personal knowledge.

Reports were analysed progressively to achieve saturation (where no new findings arise despite continuing analysis) and to cover as many of the everyday practice domains as possible. Sourcing of reports stopped once saturation had been achieved, or where it was not possible to identify additional relevant reports for analysis.

Appendix A lists all reports that were included in the review.

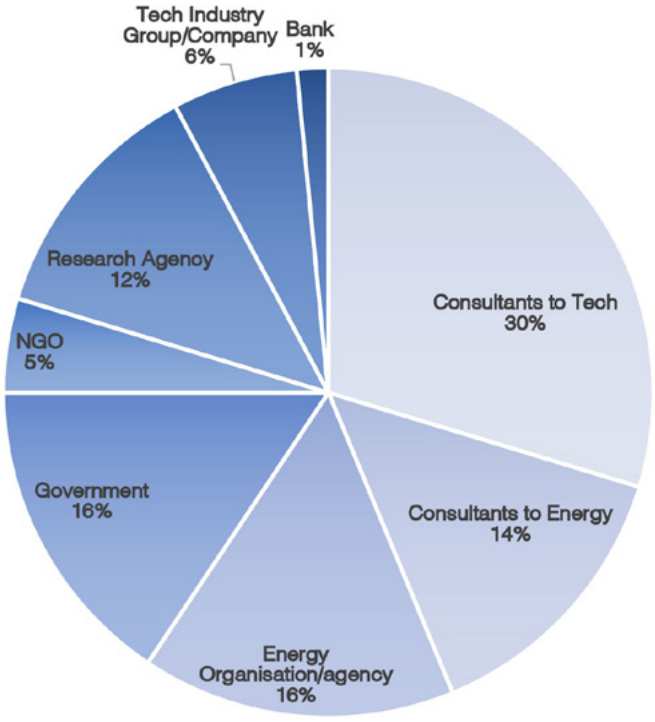


Figure D: Report sources for content analysis

Coding and analysing the reports

The reports were imported into NVivo qualitative analysis software for coding based on qualitative content analysis techniques (Schreier 2012).

The research team developed a coding structure designed to identify the emerging trends, predictions, visions and possible scenarios for digital energy futures, centred on the everyday practice domains. The coding structure was mirrored across digital futures and energy futures in order to enable cross-analysis between these sectors.

Coding was an iterative process informed by:

- The *explicit* future speculations contained in the reports.
- The *implicit* future trends identified by the research team in the documents analysed.

The analysis focused on digital energy future trends likely to impact on household electricity demand (based on the research team's and project partners' expert knowledge of the residential electricity sector in Australia or explicit links and commentary identified in the reports being reviewed).

The first stage of analysis was designed to identify:

- Visions, scenarios and predictions directly or explicitly proposed by the reports.
- Macrotrends including large-scale technology, environmental, demographic or economic trends and disruptions.
- Overlap and potential contradictions between digital technology and energy future trends, predictions and visions.

The second stage of analysis synthesised these materials to:

- Place digital and energy futures in dialogue with one another.
- Apply digital technology and energy future trends, predictions and visions to the six everyday practice domains.

Scenario production

In the final stage of the analysis, we developed six scenarios that brought together the previous stages of analysis to playfully depict possible futures centred on everyday practices and residential electricity demand (Part 6).

The scenarios reflect the visions, trends and predictions found in the industry reports. They are presented as illustrated comic strips to enable rapid access to the findings and easy householder engagement with these possible futures in subsequent stages of research.

Limitations

Report representation

The reports reviewed represent a selective sample. They are therefore not a representative sample of all energy or technology industry visions, and the review is not intended to provide a definitive account of dominant visions, trends or predictions for all technology and energy developments. We only included reports that were available for free online. Additionally, the reports reviewed do not discuss or identify emerging trends and predictions associated with the coronavirus pandemic.

Nonetheless, the analysis does provide a set of widespread and relevant dominant technology and energy visions and speculations currently informing discussions and directions for near and medium-far futures in Australian and other advanced Western economies.

Report outlook and methods

A substantial proportion of reports come from consulting agencies to the technology sector (30%). The purpose of these reports is generally to emphasise the potential future market for emerging technologies or offer consulting expertise to other industries regarding the disruptive potential of emerging technologies. The focus on potential markets means that these reports are biased towards seeing emerging technologies as products to solve a wide range of social, environmental and economic problems.

These reports tend to draw on futurists, market expertise, and customer surveys. This outlook means they are more likely to overlook the ways in which people engage with these technologies beyond purchasing them.

Reports with a more substantial research component, such as those by research agencies, primarily use quantitative forecasting models. These draw on historic data and thus are limited by their inability to capture unpredicted events or to quantify the complexity of everyday practices.

Given the review's focus on emerging digital and energy technologies, we did not include reports which focused solely on efficiencies in the built environment. This has left some potential oversights in our analysis regarding how housing stock and building efficiency will likely affect household energy demand.

Gender bias

Most reports were authored by men and are therefore likely to reflect the broader gender bias in the technology (UNESCO & EQUALS Skills Coalition, 2019) and energy industries, and in the field of futurism (Gunnarsson-Östling 2011). Only two reports were authored by women, whereas twelve reports were authored by individual men or all-male teams. Twenty-eight reports were authored by mixed-gender teams (however male authors were commonly over-represented), and 22 reports had unspecified authors. This gender bias may partly explain why social and cultural trends are less commonly identified and discussed in the reports we analysed.

Cultural diversity

The cultural diversity of the report authors was not able to be identified but is likely to reflect the dominant cultural positioning of the countries and regions where the reports were sourced (Australia, UK, US and Europe). Asian, Latin American and African nations are not represented by the reports. All members of the research team have also originated from one of the countries where the industry reports were sourced (Australia, UK or US). The perspectives of people from non-English speaking countries are therefore not significantly represented in these reports or our analysis of them.

PART 3
ENERGY INDUSTRY VISIONS OF TECHNOLOGY AND PEOPLE

Our analysis of reports revealed a series of dominant and sometimes contradictory claims and assumptions about how people are understood to relate to technology and respond to future technological change in the energy industry.

Key claims about technology and people

The claims found in our analysis of the reports constitute a consistent set of visions for digital energy futures, which are summarised in this section. Each claim is accompanied by several exemplary quotes from the reports, and the research team's observations regarding the implications of these industry claims.

Key claim of reports reviewed:

Emerging energy technologies will respond to consumers' expanding expectations of the energy system

- In addition to secure, reliable and affordable energy, consumers want energy infrastructure and services that are:
  - sustainable
  - flexible (dynamic, intelligent and connected)
  - individual and personalised
  - local and democratically managed.
- A wide array of emerging energy technologies are necessary to meet different consumer expectations.

"Customers are placed at the centre of Australia's future electricity system. They are empowered with greater choice, control and autonomy while enjoying the security and benefits of a grid connection."

ENA 2017 Energy Networks Transformation Roadmap

"Regulatory regimes ensure a minimum standard of safe, reliable, and affordable service, but evolving customer choice and individualized power products and services require incumbent stakeholders to meet an expanding list of new customer expectations:

• Sustainability: Clean and low carbon energy products and services.

• Flexibility: Dynamic, intelligent, and connected energy solutions and infrastructure.

• Autonomy: Local, distributed energy assets and democratized control over energy use.

• Individualization: Highly personalized energy products and services catering to an assortment of customers."

Navigant 2018 Energy Cloud 4.0

Observations and implications from the research team

- The reports largely ignore how people's energy use is situated in everyday practices, and how these practices are changing (Shove & Walker 2014).
- The reports do not account for the way in which experiences with other industries will influence consumer expectations in the energy sector.
- These claims respond more strongly to technologically engaged early adopters than households who are seeking 'simplicity', e.g. energy supply and services that do not require frequent attention.

Key claim of reports reviewed:

Opportunities for consumers to access and participate by using new energy technologies will give rise to the engaged consumer and prosumer

- Smart meters and energy monitoring systems will be used by the consumer to understand their energy usage, access data, and make decisions about energy usage.
- Rooftop solar PV and battery storage are giving rise to the 'prosumer', who produces and consumes their own energy. This will fundamentally restructure the traditional top-down, one-way energy market.
- Distributed Energy Resources (DER), particularly with battery storage, is enabling a two-way energy market as well as stand-alone localised power systems. These take the form of peer-to-peer electricity trading enabled by platforms and virtual net metering, microgrids (standalone or connected), as well cooperative systems such as community-owned solar/battery projects organised around the collective production and sharing of energy.
- The rise of the prosumer and the two-way energy market will further generate significant regulatory and technical challenges for the energy sector.

"Communities and consumers, large and small, are taking charge of their own energy future through their consumption and investments decisions. In doing so, they get in the driver's seat of change, voicing their own views on what success will look like for the future of the energy sector."

Deloitte 2019a Beyond the Energy Transition

"The steady, one-way flow of electricity that was the norm for more than a century is now a dynamic, two-way stream of power, shifting back and forth between the customer and the utility. Without real-time data, visibility, and control, operators can only estimate how much power these rooftop solar systems are feeding into the grid; they can't manage it and they have no way of "seeing" into circuits to identify and avert situations that can affect the safe and reliable delivery of power to customers."

Hawaiian Electric 2017 Modernizing Hawaii's Grid For Our Customers

"Growth in consumers actively engaging in the market via increasingly intelligent devices and appliances should be complemented by a market design which both encourages engagement and fully captures the efficiencies arising from such engagement. The future development of a two-sided market would be able to address challenges associated with the changing nature of the wholesale market, and more readily capture the efficiencies of greater consumer participation."

COAG Energy Council 2020 Moving to a Two-Sided Market

Observations and implications from the research team

- Ideas of active and engaged energy consumers contradict ideas of 'set-and-forget' automation being necessary.
- The emphasis on people as consumers/prosumers excludes and ignores socio-economic differences, assuming a generally affluent consumer who is culturally homogenous and knowledgeable about energy and technology.
- Framing people as consumers mean that modelling and forecasting methods have difficulty accounting for people's motivations beyond responding to prices.
- The vision for the prosumer privileges affluent, tech-savvy and engaged people (Strengers 2013).

Key claim of reports reviewed:

Consumers want more autonomy and control, but need automation in order to manage energy optimally

- Uptake of distributed energy resources (DER) indicates that consumers will increasingly desire autonomy and control in their energy futures.
- Consumers want to actively monitor their energy usage and make more decisions about their energy usage and production.
- Despite consumer interest in energy management, many don't want to think about energy and will, therefore, need automation and 'set and forget' technology.
- Automation and industry control of technologies is necessary to integrate DER, especially electric vehicles, into the electricity grid and deliver efficiency.

"Digitalisation is changing the way consumers can engage in the electricity market. These technological advances mean that consumers, instead of having to actively monitor the electricity market and decide how or when to participate, can now 'set and forget'. … Consumers can capture the benefits of participation by taking advantage of new technological developments that require very little action on their part."

AEMC 2019a How Digitalisation is Changing the NEM)

"With digitalisation, energy services in the future will be able to be bought and sold in a dynamic way and new technology, such as digitally controlled energy-consuming devices (e.g. smart air conditioning or pool pumps) will respond to consumer preferences and price signals. Battery storage and electric vehicles will add another dimension to electricity system usage. Digitalisation also provides the opportunity of managing reliability and offering new ways to manage security services and differentiated service levels."

AEMC 2019a How Digitalisation is Changing the NEM

Observations and implications from the research team

- Reports equate what they describe consumers as wanting (autonomy and control over their energy) with what the sector says is needed (set and forget automation). This overlooks how diverse people will respond to the automation of everyday practices in the home.
- The reports assume that automation requires minimal input from people and doesn't require any maintenance or technical ability to operate successfully, which is not always the case (Strengers & Nicholls 2018).
- Many consumers are unlikely to be able to afford or access an automated future of the kind described in the reports.

- Reports rarely take into account the possible wider societal impact of important macro trends that may significantly disrupt both technology adoption and energy futures. For example, although automation and AI are discussed in energy sector reports for their potential to help manage electricity, the impact they may have on social life, such as the changing nature of work, is not considered in energy sector reports.

Key claim of reports reviewed:

Building consumer trust will enable environmentally and economically efficient digital energy futures

- Consumer trust in the energy sector is low.
- Low levels of trust in the energy sector are a barrier to consumer engagement with demand management and acceptance of automation.
- Building trust requires increased consumer knowledge of the electricity sector.
- Trust is comprised of three elements:
  - Trust in institutions and their management of technology
  - Trust in the data collected by emerging energy technologies and how it will be used
  - Trust in the technology to function as intended.

"Consumers are not confident that the National Electricity Market (NEM) is working in their interests – only 25 per cent think it is. This is down eight per cent from a year ago."

Deloitte 2019a Beyond the Energy Transition

"Meeting these goals involves building a common understanding of the challenges, opportunities, and tradeoffs involved with enhancing the electric grid to meet customer service expectations and achieve the state's renewable goals."

Hawaiian Electric 2017 Modernizing Hawai'i's Grid For Our Customers

Observations and implications from the research team

- Trust is recognised as important but conceptualised only in terms of interactions and transactions between consumers and institutions or consumers and technologies.
- This ignores the important social dimensions of trust, how trust in new and emerging technologies is experienced in everyday life, and how trust is not necessarily rational or transactional (Pink et al 2018, Pink et al 2020).

Security, comfort, and trust in smart home technologies: an alternative perspective from digital technology reports

Most technology sector reports we reviewed also adopt a narrow view of people as consumers of technology. However, we identified two reports about smart homes that displayed a more complex understanding of issues around these technologies:

1. Accenture (2019b), Putting the Human First in the Future Home
2. Starcom Futures (2019), Future of Connected Living

These reports draw on ethnographic research which studied how people used technology in their homes. This method led the reports to recognise the **emotional aspects** that were central to the home, particularly around feelings of safety and comfort, which were attached to mundane household objects like blankets rather than smart security systems. These reports also recognised that technologies in the home were primarily embedded in everyday routines. While technology was found to change the tools through which routines were performed, they didn't change the fundamental practices.

"The result of installing so many connected devices in households was therefore primarily one of comfort. Helping people to 'feel' better at home in a range of small but significant ways."
Starctarcom Futures 2019 Future of Connected Living

"A typical technological approach to make people feel safer in the home, for example, may be to sell them an alarm system. Yet people's feelings of safety are much more nuanced. For example, some of our respondents said that being surrounded by their personal items such as blankets and candles evoked a sense of safety more than security cameras."
Accenture 2019b Putting the Human First in the Future Home

"Routines give people control over their lives in the home. So if companies design products that adapt to existing routines— rather than trying to change routines with their products—they will help deliver on people's fundamental need for control."
Accenture 2019b Putting the Human First in the Future Home

The Accenture (2019b) Putting the Human First in the Future Home report also revealed that people's feelings about smart home technologies were full of tensions, such as between technology making them feel connected but also isolated, or making life easy but also encouraging laziness. People were also found to be simultaneously trustful and fearful of technology. This report thus recognised some of the complexities of trust around emerging technologies, particularly in the home where smart home technologies: collect data within private domestic spaces in which security and comfort have strong emotional resonance; and assist in everyday practices and routines that are crucial parts of people's lives.

"To be a pioneer of trust in this space, companies need to understand how the home is sacred to their users, and be transparent about how they are using their customers' data to deliver a tangible, relevant, and immediate benefit."
Accenture 2019b Putting the Human First in the Future Home

Key claim of reports reviewed:

Consumer demand for sustainable energy is strong but unpredictable

- Early adoption of technologies that do not yet yield clear financial returns on investment indicates that consumers have concerns other than price, including sustainability.
- Non-financial motivators around adoption and charging of batteries and electric vehicles are difficult to quantify and predict, but alternative metrics can be used to approximate.

"The cost of energy products are no longer the key driver of decision-making, rather consumers are individually and collectively making key decisions based on considerations beyond cost, including environmental impact and views about how corporations are exercising their corporate responsibility agenda and social licence."

Deloitte 2019a Beyond the Energy Transition

"Customers purchase of [electric] vehicles are driven by emotive and non-financial reasons. Historical data suggests model availability is, therefore, a key driver of adoption."

Energeia 2019 Distributed Energy Resources and Electric Vehicle Forecasts

Observations and implications from the research team

- Although there is growing recognition that consumers are motivated by sustainability concerns, people are still considered to be little more than adopters of technology.
- Difficulties quantifying, and therefore predicting, non-financial factors result in the use of alternative metrics that fail to reflect the complexity of consumer decision-making.
- The use of simple metrics, such as EV model availability, as a placeholder for complex human motivations, reveals the sector is challenged by changeable and less quantifiable consumer concerns.

PART 4
MACRO TRENDS AND LARGE-SCALE DISRUPTIONS

The review of digital technology reports (and to a lesser extent, energy reports) identified a range of emerging and anticipated technological, environmental, demographic and economic trends expected to inform or disrupt digital energy futures at the macro scale.

In this part, we summarise the anticipated trends most relevant to and potentially disruptive for digital energy futures and residential electricity demand. The trends are as follows:

- **Large-scale technology developments:** AI, IoT, 5G, blockchain.
- **Environmental and energy:** decarbonisation, two-way energy markets and climate change.
- **Demographic:** ageing population, immigration, home ownership, housing pressure.
- **Economic:** automation of jobs, gig economy, sharing economy, flexible work arrangements.

Each anticipated trend is illustrated by quotes from the reports, a summary of key claims about its anticipated impact on digital energy futures, and the research team's observations about the implications of these trends.

The anticipated trends subsequently inform Part 5 of this report, which ties their potential impact to forecasted digital energy futures in each everyday practice domain.

As the review reported on here was conducted prior to the **coronavirus pandemic**, the impacts and emerging trends of this international event were not anticipated or discussed in any of the reports we reviewed.

Large-scale technology developments

Key claim of reports reviewed:

Artificial intelligence (AI) will change the way we live

AI is a broad descriptor for technologies that can perform tasks or solve problems using algorithms and machine learning, ideally without the direct intervention of humans. AI enables forms of automated decision-making (ADM) in which a decision is made by technology in relation to a series of input data. Therefore, AI is the technology underlying many so-called "smart" technologies that are central in this report, including smart home appliances, digital voice assistants and autonomous vehicles (AV).

Anticipated impact of AI on digital energy futures

- Improvements in AI are predicted to enable the more seamless integration of smart home technologies and allow them to perform many tasks, even without direct human command.
- Smart technologies in the future are expected to be able to anticipate and automatically respond to our preferences and routines.
- Improvements in AI are expected to accelerate the adoption of smart or automated technology.
- AI is projected to drive innovation and unlock social, environmental and economic value.

"AI has the potential to automate repetitive or dangerous tasks, increase productivity and allow the development of innovative consumer products. It is forecast to add trillions of dollars to the global economy in the coming decades."

Australian Government 2018a Australia's Tech Future

"Artificial Intelligence (AI) is one of those technologies, like advances in gene editing or quantum computing, which has the power to change life itself. It has the potential to transform economies, unlock new societal and environmental value and accelerate scientific discovery. With AI estimated to generate $13 trillion in economic activity globally by 2030, the global race to lead in AI is well and truly underway."

CSIRO 2019a Artificial intelligence: Solving problems, growing the economy and improving our quality of life

Key claim of reports reviewed:

The Internet of Things (IoT) will expand as more devices in our daily lives become connected

IoT refers to a network of internet-connected technologies or everyday devices that are embedded with sensors that collect and share data. Many smart home technologies are also part of the IoT.
AI functionality requires inputs of extensive data, including from IoT.

Anticipated impact of IoT on digital energy futures:

- IoT is expected to grow as more and more devices become embedded with sensors.
- The data gathered from IoT is projected to enable greater efficiencies in many aspects of life, including traffic management, health care, energy management, even household upkeep and repairs.

"This new era of sensing will keep us safer and healthier and it will be unobtrusive, only demanding our attention when it is warranted. For example, moisture-sensitive sensors in a basement that detect a flood early."

KPMG 2017 The Home of the Future

"The internet of things (IoT) is the network of physical devices, such as home appliances or vehicles, and other items, which include electronic components, software and sensors. They are interconnected, which allows the devices to collect and exchange data. This connectivity, in turn, creates opportunities for more direct integration of the physical world into computer-based systems and can result in efficiency improvements and economic benefits. As of 2017, there were 8.4 billion IoT devices; their number is projected to grow to 30 billion by 2020, bringing their global market value to USD 7 trillion."

European Commission 2019 AI: The Future of Work? Work of the Future!

Key claim of reports reviewed:

5G will speed up communication between technologies, enabling the growth of AI and IoT

The plethora of data generated and shared by IoT requires fast and reliable wireless communication technologies. 5G is the newest generation of wireless telecommunication technology, which delivers improved Internet speeds and the ability to handle increased data transfer capability.

Antitpated impact of 5G on digital energy futures:

- 5G is considered much more than a faster wireless connection; it is expected to revolutionise connectivity by enabling increased communications between IoT devices, particularly in public spaces.
- 5G is expected to enable technologies such as AVs.
- 5G is expected to enable the growth of the IoT and AI and facilitate the widespread adoption and uptake of these technologies.

"Far beyond the controlled factory, office, or home environments that IoT devices are largely confined to today, 5G will provide the basis for a truly intelligent network of cars, robots, drones, and more—all of which will be able to communicate and react in real-time, wherever people need them."

Accenture 2019c Technology Vision

"As we predicted at the start of 2018, autonomous vehicles are enjoying plenty of research and validation both on and off public roads – but these technologies require a huge amount of data to make the decisions that human drivers handle without thinking, and all cars that have access to this data are able to learn from it. Sharing this data in real-time requires high speed, pervasive connectivity – a perfect use case for the extra capacity and performance of 5G services."

Telstra 2019 Our predictions for 2019's Biggest Tech Trends

Key claim of reports reviewed:

Blockchain technologies will automate trust and enable transactions without an intermediary

Blockchain or distributed ledger technologies provide a digital ledger of transactions that are verified by a distributed and anonymous network of peers, using various forms of cryptography. This enables a ledger of transactions or data to be maintained without the use of an intermediary such as a bank.

Anticipated impact of blockchain on digital energy futures:

- Blockchain is expected to generate trust and potentially replace many central authorities, including those in the management of electricity markets.
- Blockchain is expected to enable more peer-to-peer trading networks, such as those emerging in the energy sector.

"The hype around blockchain, or distributed ledger technologies (DLT) more generally, is based on the fact that it offers a game-changing possibility: the ability to provide assurance and trust across a system without a centralized authority. Whether the system is one of financial exchange, voting or land registry of contracts, this represents a powerful alternative to the models of centralized authority that have been used throughout history."

World Economic Forum 2018 Our Shared Digital Future

"Enhancing established processes with Blockchain technology opens new opportunities to create transparency between unknown participants and also to improve security on a global scale. This can be achieved by end-to-end encryption within a network of distributed ledgers in which every transaction needs to be approved by the majority of the network."

Deloitte 2018b IoT Powered by Blockchain

Observations and implications from the research team on large-scale technology developments

AI, IoT, 5G, and blockchain technologies are part of a 'solutionist' paradigm (Morozov 2013) that positions technology as solving a wide range of social, environmental and economic problems, without recognising the false starts and failed promises that are part of technological development (Dafoe 2015). Reports describe these technologies as top-down trends that will impact on social life, rather than being disrupted, or transformed by people's incorporation or rejection of these technologies into their everyday lives.

For example, the assumption that blockchain will generate human and organisational trust has not been proven in everyday life situations. Or, consider how public scepticism about 5G—a technology that has been the focus of a wide range of criticism and activism – demonstrates how social choices can impede technology rollouts. Further, these technologies are highly energy-intensive; the increased energy consumption and the redistribution of energy resources are not accounted for in the potential expansion of these technologies.

Environmental and energy trends

Key claim of reports reviewed:

Decarbonisation of the energy sector is an imperative

Many energy sector reports recognise the need to decarbonise Australia's electricity sector through the integration of renewable sources of energy. Decarbonisation is progressing largely as a result of large-scale renewable projects, and consumers' enthusiasm to adopt small-scale Distributed Energy Resources (DER) including rooftop solar and battery storage. The electrification of vehicles and heating (away from petroleum and gas fuels respectively) also paves the way for further decarbonisation.

Anticipated impact of decarbonisation on digital energy futures:

- The reports reviewed recognise that the decarbonisation process has already begun and is likely to continue. However, the reports also describe considerable uncertainty surrounding the trajectory, speed and technology mix as the transition progresses. Future technological advances, as well as shifting consumer priorities may accelerate, stall or reshape this process.
- There is uncertainty around government leadership on decarbonisation, particularly around renewable incentives and carbon policy.

"In signing up to the Paris Agreement, Australia committed to a reduction in economy-wide greenhouse gas emissions of 26 to 28 per cent on 2005 levels by 2030. The electricity sector contributes 35 per cent of Australia's total emission and so will need to play a key role in order for the Australian economy to meet this commitment."

Deloitte 2018a Energy Accelerated

"We know that we are facing a once in a lifetime energy transformation. The 'energy trilemma' – namely securing an environmentally responsible, reliable and affordable energy sector – is being increasingly challenged as the market shifts from firm synchronous and centralised generation to variable asynchronous distributed generation."

Deloitte 2019a Beyond the Energy Transition

Key claim of reports reviewed:

Two-way energy markets and increasing DER will accelerate decarbonisation

The increasing affordability of DER, particularly rooftop solar and battery storage, will disrupt the top-down models of energy production and distribution, as consumers take a more active role. This is leading to innovations as DER is incorporated into the energy system, enabling decarbonisation while maintaining reliability and reducing network costs.

Anticipated impact of DER and two-way markets on digital energy futures:

- DER is expected to rapidly increase at the residential level.
- The reports reviewed predict that technologies and emerging interconnected systems such as virtual power plants will ensure reliability despite the intermittent nature of DER.
- Interconnected DER in the form of microgrids is similarly expected to increase reliability, particularly for areas at the margins of the current grid where they can become standalone power systems which reduce network costs.
- New community energy generation models are emerging and expected to increase as more communities are expected to collectively invest in energy production and sharing, such as community-owned solar/batteries.

"As technology becomes cheaper, smarter and more prevalent, customers will take a lead role in shaping Australia's electricity future. Customers, rather than traditional utilities, are likely to determine more than a quarter of all system investment decisions between now and 2050."

ENA 2017 Energy Networks Transformation Roadmap

"Community energy projects have obvious environmental benefits through the reduction of greenhouse gas emissions, but they also offer economic, social and technological benefits."

Parliament of Victoria 2018 Inquiry into Community Energy Projects

"In the future, consumers with access to DER may interact with the electricity system in one or a combination of the following ways:

- *Drawing electricity from the grid*
- *Generating electricity for their own consumption only (becoming less reliant on grid supply)*
- *Buying, trading or selling energy, either to a retailer or through other platforms such as peer-to-peer trading*
- *Participating in new services markets such as providing demand response, network support or ancillary services to the wholesale energy market*
- *Supplying energy (or other services) to community projects such as a community battery."*

AEMC 2019b Integrating Distributed Energy Resources for the Grid of the Future

Key claim of reports reviewed:

Climate change will increase extreme weather events in Australia

The energy sector is concerned about the impacts of climate change on the electricity system.

Anticipated impact of decarbonisation on digital energy futures:

- Extreme weather, such as powerful storms, are predicted to increase the incidence of energy supply disruptions. This is expected to increase the uptake of DER, particularly battery storage as consumers respond to the increased unreliability of the grid.
- The increasing numbers of hot days projected as a result of climate chang will likely increase air conditioning demand and increase peak demand.

"Climate changes in Australia are also projected to result in less snow, more intense rain events, more extreme fire weather, fewer but stronger cyclones, continued sea-level rise and ocean acidification. Together these changes will have a significant effect on agriculture, forestry, fisheries, water security, energy security, infrastructure, transport, health, tourism, finance and disaster risk management."

CSIRO 2019b Australian National Outlook

"Small consumers, fearing the effects of extreme weather events on their property and their livelihoods, invest in small-scale renewable energy technologies that reduce their reliance on the relatively emissions intensive grid."

Deloitte 2018a Energy Accelerated

Observations and implications from the research team on decarbonisation, two-way markets, and climate change

Other than increased cooling demand and uptake of DER, climate change is not discussed in reports as having wider implications for everyday practices, including those that would affect energy demand. For example, the 2019-20 Australian bushfires reveal how everyday routines might need to respond to extreme weather events, such as families spending more time inside or using air purification technologies.

The reports on decarbonisation and two-way energy markets tend to focus on the technology and the systems themselves, principally their technical feasibility, market, and regulatory hurdles. There is little recognition of how people will live with these systems, and how they are incorporated into or alter existing everyday practices.

Demographic trends

Key claim of reports reviewed:

As Australia's population ages, technology will enable more older Australians to live at home

Improvements in healthcare have extended life expectancy but coupled with decreased birth rates, this is leading to a proportional increase in the aged population. This trend is countered somewhat by increased immigration (generally a younger population), but still, the proportion of working-age people (15-64 years) is projected to fall from 66 per cent in 2018 to 60 per cent in 2060 (CSIRO 2019b Australian National Outlook).

Anticipated impact of Australia's ageing population on digital energy futures:

- Older people are expected to want to continue living in their own homes, as opposed to aged care facilities or multigenerational households.
- Older Australians are expected to embrace digital technologies to enable their independent living.
- Australia's growing ageing population is expected to increase residential heating and cooling demand as older people are more at risk from heat and cold.

"Today, family care is the predominant model of support for older people. The trend to single-generation and single households leads to a crisis of family support. Considering the anticipated demographic changes, there will be a tremendous lack of formal infrastructure available to provide support in future. Nonetheless, to enable independent living for elderly people means for them living within their familiar homes as long as possible. The gap might be compensated by home care solutions and assistive technology."

IIT 2010 ICT Enabled Independent Living for the Elderly

"More than 3.8 million Australians are over the age of 80 years and many are having to consider the possibility of needing to leave the family home and move into a care facility. AI is already helping to support ageing Australians to stay in their homes longer."

CSIRO 2019a Artificial intelligence: Solving problems, growing the economy and improving our quality of life

Key claim of reports reviewed:

Ongoing immigration will fuel population growth and cultural diversity

Alongside falling birth-rates and Australia's ageing population, overseas migration is anticipated to continue to contribute significantly to projected population growth. Immigration policies, which have targeted young and skilled migrants, mean that new migrants to Australia are typically more highly educated than the existing population.

Anticipated impact of immigration on digital energy futures:

- The increase in educated new migrants to Australia is expected to contribute to increased urbanisation. Migrants are expected to continue to prefer living in Australia's cities, discussed further below.

"The ABS projects that Australia's average annual population growth rate will be 1.6 per cent over the decade to 2027 under current projections compared to 0.5 per cent without continued migration."

Australian Government 2019b Planning for Australia's Future Population

"In 2016, 68 per cent of recently arrived migrants, aged between 25 and 44, were educated to a diploma level or higher compared to 42 per cent of Australians of the same age."

Australian Government 2019b Planning for Australia's Future Population

Key claim of reports reviewed:

Home ownership will decrease and urban areas will become more densely populated

Increased pressure on housing supplies is anticipated as a result of high numbers of younger immigrant workers and older people preferring to age in their own homes. Much of this pressure on housing is anticipated to occur in cities such as Melbourne and Sydney. Due to the age and wealth disparities, this is set to increase the proportion of renters. ABS census data shows that home ownership has steadily declined for the last 15 years, particularly amongst young people (25 to 34) and this trend is expected to continue (CSIRO 2019c Projections for Small Scale Embedded Technologies).

Anticipated impact of home ownership on digital energy futures:

- Lower rates of home ownership are expected to potentially reduce the uptake of energy efficiency upgrades and DER installation.
- Dense urbanisation with smaller dwellings is expected to reduce energy use and possibly enable district heating and cooling systems.
- New high-density housing stock is noted as providing opportunities for increasing energy efficiencies through sustainable design principles.
- Urbanisation is predicted to affect transportation patterns, especially in relation to electric vehicles and charging.

"Over two-thirds of our population increase in the past decade has occurred in Sydney, Melbourne and South East Queensland, driving demand for infrastructure, and services such as housing. At the same time, other jurisdictions and regional centres are calling for more people to support their economies and fill critical gaps to ensure regional communities thrive."

Australian Government 2019b Planning for Australia's Future Population

"Owing to rising land costs in our large cities where most residential customers live, there has been a trend towards faster building of apartments compared to detached houses (also referred to as separate dwellings in housing statistics). As a result, we expect the share of separate dwellings to fall over time in all scenarios...While not a hard constraint, home ownership increases the ability of occupants to modify their house to include small-scale embedded technologies."

CSIRO 2019c Projections for Small Scale Embedded Technologies

Observations and implications from the research team on demographic macrotrends

The reports reviewed pay significant attention to the impact of an ageing population on technology adoption as well as potential energy and technology developments from increased urbanisation. However, the reports ignored how immigration may change energy and technology use through culturally diverse understandings of energy and technology, culturally diverse everyday practices, and linguistic diversity.

The reports reviewed did not account for the possible impact of recent climate and public health crises (e.g. coronavirus and the 2019-20 Australian bushfires) on home ownership or migration.

Economic trends

Key claim of reports reviewed:

Artificial Intelligence (AI) will enable the automation of many jobs and increase unemployment

Advances in computing and robotics have already enabled the automation of many jobs, particularly those involving repetitive tasks, such as on assembly lines. Improvements in AI are expected to enable automation in many more professions as technology continues to more closely mimic human cognitive abilities. This is predicted to lead to job losses in the economy and across sectors.

Anticipated impact of job automation on digital energy futures:

- Digital technology reports anticipate substantial changes in the characterisation of the workforce including AI-enabled technologies replacing human workers in many sectors.
- With fewer jobs available, some reports predict a drastic reorganisation of society potentially involving a universal basic income (guaranteed regular payment given to all citizens).

"By the end of the 2020s, automation may eliminate 20% to 25% of current jobs, hitting middle- to low-income workers the hardest."

Bain & Company 2018 Labor 2030 [referencing the United States]

"The idea of an unconditional guaranteed income for everyone within a country is now being discussed again both as a means of encouraging entrepreneurial innovation and in the wake of automation, advanced robotics, and artificial intelligence."

Future Today Institute 2019 Tech Trends Report

Key claim of reports reviewed:

More people will work in the gig economy

The gig economy is expanding in Australia and across the globe and involves work delivered on an irregular, task-by-task basis. As independent contractors, gig economy workers use a technology platform to acquire clients and find individual 'gigs' such as the delivery of restaurant food (e.g. Deliveroo) or completion of household tasks (e.g. Airtasker). These workers do not have traditional employment contracts or many of the usual benefits and protections. However, gig economy jobs are often celebrated for their flexibility, allowing workers to set their own hours and respond to other demands on their time, such as caring for others.

Anticipated impact of the gig economy on digital energy futures:

- The gig economy is predicted to grow and become a more dominant form of employment.
- The gig economy is expected to change traditional work patterns, commutes and routines as people engage in more flexible work schedules.

"Proponents of these digital earning platforms argue that they offer important benefits, such as the freedom and flexibility to work at a time and place of one's choosing or the ability to turn a hobby or pastime into a source of income. But others worry that this emerging "gig economy" represents a troubling shift in which workers face increased financial instability and are required to shoulder more of the burden for ensuring their own pay and benefits."

Pew 2016 Gig Work, Online Selling, and Home Sharing

"The economy of the last century was dominated by strict work schedules, hierarchies and repetitive tasks: a job meant a permanent contract attaching a worker to a firm. Today, work relations are becoming more fluid. They are based on peer-to-peer transactions and flexible work arrangements, and are driven not by tasks but by projects that unite groups of people until they are completed, with the latter then moving to the next project."

European Commission 2019 AI: The Future of Work? Work of the Future!

Key claim of reports reviewed:

Sharing will replace ownership in some sectors

The technology platforms that enable the gig economy will also contribute to the rise of the sharing economy. The sharing economy refers to a growing trend in individuals sharing their assets or services with other users (usually for a fee) via platforms such as Airbnb, Uber and Car Next Door.

Anticipated impact of the sharing economy on digital energy futures:

- As consumers become increasingly familiar with the sharing concept, it is expected to expand into other sectors, such as the energy sector.
- Peer-to-peer energy trading utilising blockchain technology is expected to become more widely available and used by households.
- Sharing models are expected to alter the potential driving and charging patterns for electric vehicles.

"People are increasingly comfortable renting goods and services versus needing to own them. Across various industries service providers or communities have begun to pool resources for a fee."

Future Today Institute 2019 Tech Trends Report

"The key to the future is not ownership but access."

Marcel Bullinga, futurist cited in Pew 2014 Digital Life in 2025)

Key claim of reports reviewed:

Flexible work arrangements will alter when and where people work

Traditional structures of employment including employer-employee relationships, work schedules, and workplaces are expected to change through increased part-time work, flexible schedules, and working from home.

Anticipated impact of flexible working arrangements on digital energy futures:

- Emerging technologies, particularly improvements in telecommunications, will lead to increased working from home.
- The increase in part-time and flexible work will create less standardised working schedules and alter the times and ways in which the home is used to conduct work.

"A few decades ago, workers in many countries mostly enjoyed traditional employer-employee relationships and worked in offices or manufacturing facilities. Technology has helped upend this model as more workers engage in alternative work arrangements through remote and part-time work, as contractors or through project-based engagements. And most studies suggest that these trends will continue."

Microsoft 2018 The Future Computed

Observations and implications from the research team on economic macro trends

The reports reviewed do not account for the potential impacts of increased unemployment and workforce changes on residential electricity demand including more time spent at home resulting in altered load profiles and peak demand, increased heating and cooling demands (including cooking and hot water), and increased use of digital technologies for entertainment and leisure. The reports reviewed also do not recognise how these economic trends disrupt society unevenly.

Past research indicates that the distribution of benefits and impact tends to follow existing economic and social inequalities (Sadowski 2020). The recent impact of coronavirus, and the massive job losses and workplace flexibility it has induced on Australia's economy, may further transform energy demand as well as to pave the way for faster realisation of these macro trends, such as the adoption of universal basic income-related policies.

PART 5
APPLYING INDUSTRY VISIONS AND TRENDS TO EVERYDAY PRACTICES IN THE HOME

In this section we discuss how the anticipated digital energy future trends found in the reports reviewed are expected to impact on daily life in the home, within the six everyday practice domains responsible for the majority of electricity demand in households.

Everyday practice domains

For each practice domain the overarching claims, specific emerging technology trends, and the key oversights and limitations of the perspectives and predictions provided by the reports are discussed. Illustrative quotes from the reports we reviewed are used throughout.

Key claims made in the reports reviewed are identified below.

1. Heating, cooling and comfort

Smart home technologies, particularly smart appliances such as smart thermostats and hot water systems, will manage increased energy demand from heating and cooling to deliver savings for both consumers and the energy industry.

2. Working and studying from home

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

3. Caring from home

Smart home technologies will enable older people to be cared for within their homes.

4. Entertainment and convenience

Widespread adoption of smart home technologies is ‘just around the corner’ bringing improved efficiencies, convenience, and immersive household entertainment.

5. Driving and charging

The transportation sector will change substantially with the increasing uptake of electric and AVs, but considerable uncertainty remains about the timescales and accompanying mobility systems.

6. Energy management

Better data and automation will enable more efficient management of energy, reduce peak demand by load shifting, and reduce energy costs for consumers through price incentives and other demand management initiatives.

Heating, cooling and comfort

Heating and cooling, along with hot water for showering, laundering and cooking, constitute the majority of household energy demand, making this a crucial practice domain for the energy sector. However, technology pertaining to this domain was only addressed in passing in the digital technology reports we analysed.

Key claim of reports reviewed:

Smart home technologies, particularly smart appliances, will manage increased energy demand from heating and cooling to deliver savings for both consumers and the energy industry

- **Climate change** is likely to increase the number of extreme weather days, thus leading to greater demand, particularly for cooling.
- Demographic changes such as an **ageing population**, are predicted to increase heating and cooling demand as older people are generally more sensitive to heat and cold.
- **Smart home technologies**, particularly smart thermostats and other smart appliances, are predicted to help manage increased electricity demand, delivering savings for energy consumers as well as the energy sector through load shifting to reduce peak demand.

Emerging technology trends and predictions:

- The **smart thermostat** market is predicted to grow and allow personally tailored controls that enable consumers to conserve energy and increase their comfort. Energy providers also see the demand management potential of the technology and are expected to further promote uptake.

> *"Some utility companies, including British Gas, Engie and Scottish and Southern Energy, are also offering their own smart thermostats. The entry of these non-traditional product suppliers into the smart thermostat market reflects a growing business opportunity, which can also help to secure competitive advantage for utility providers offering better controls to customers. Encouraging the use of smart thermostats could also help to reduce their need to invest in additional power generation capacity."*
>
> IEA 2017 Digitalization and Energy

- The **electrification of heating** (switching from gas to electric heating systems) will add to electricity loads, but this can be beneficial to customers and decarbonisation if matched with DER capacity.

> *"In the Outlook Vision, by 2060 industry and households are able to use more affordable and reliable electricity for greater energy productivity. For example, if households take advantage of the low-cost, low-emission electricity by switching from natural gas to low-carbon electricity, electrical space heating could be up to sixfold more energy efficient than gas heating for the same result."*
>
> CSIRO 2019b Australian National Outlook

- **Grid-independent cooling** directly couples solar PV panels with energy-efficient technologies (such as evaporative coolers) and is predicted to deliver home comfort without drawing electricity from the grid.

"Due to their grid-independent operation, these systems can reduce the network peak demand during hot summer days. Moreover, these systems can operate whenever there is radiation availability, resulting in a 'guilt-free' cooling solution... two or three PV modules may be sufficient (depending on the system size) to operate these systems during summer days with or without electrical storage"

COOLGAIA 2018 Solar Heating and Cooling Roadmap

- **Solar cooling** is an emerging technology that uses heat from the sun to directly generate cool air or water and is expected to reduce peak air conditioning demand.

"Solar cooling is an emerging technology that holds the promise of providing an economically attractive source of cooling with zero or very low emissions, with a number of attractive features when compared with other cooling alternatives. It can also help to alleviate peak power load associated with cooling."

IEA 2018 The Future of Cooling

- **DER-responsive technologies**, which link operation of air conditioning or hot water systems to the high availability of solar or other renewable electricity, are expected to grow in demand and uptake, and minimise grid impacts.

"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 2019a How Digitalisation is Changing the NEM

- **Precinct-level hot water, heating and cooling services** can deliver energy efficiencies and are more commonly used in the Northern hemisphere and in commercial buildings. In tandem with localised generation and storage, district cooling and heating are proposed for evaluations of viability in Australia but are not yet expected to be widely deployed for residential developments.

"From a technology perspective, large-scale precinct-level solar heating and cooling provide opportunities for the integration of solar energy generation systems."

COOLGAIA 2018 Solar Heating and Cooling Roadmap

"As global energy systems become more complex, district cooling networks with storage could form part of a broader integrated energy system. For instance, district cooling networks could "charge up" cooling capacity during periods of surplus electricity generation, allowing for greater integration of variable renewable energy sources such as solar photovoltaic (PV) into the electricity network and reducing the risk of curtailment – the forced disconnection of capacity due to a lack of network capacity."

IEA 2018 The Future of Cooling

- **Building design** and thoughtful **integration of technologies** can achieve optimal energy efficiencies while delivering comfort. Recent work in residential buildings has experimented with innovative approaches that combine large installed systems and efficiently designed buildings with smaller personal comfort systems like specially designed work chairs. These systems balance the heating and cooling of air and water alongside controlled ventilation and light. Such a holistic approach has been trialled in commercial buildings.
  It is not currently discussed in reports as a likely future for Australian households.

"To achieve the radical improvements in building energy efficiency being called for by the State of California, it will be necessary to apply an integrated approach involving new designs, new technologies, new ways of operating buildings, new tools for design, commissioning and monitoring, and new understanding of what comprises a comfortable and productive indoor environment."

California Energy Commission 2013 Advanced Integrated Systems Technology Development

Key oversights and limitations about heating, cooling and comfort

The reports analysed for this review overlook or downplay:

- How household heating and cooling relate to complex understandings and sensations of comfort that have a strong effect on people's sense of home.
- Low-tech alternatives through which household comfort can be achieved (Nicholls & Strengers 2018).
- The potentially increased role of air purification technologies resulting from climate change macro trends.
- The increasing use of heating and cooling for pets (Strengers et. al. 2019).

Air purification to minimise indoor air pollution caused by bushfire smoke

The recent Australian summer bushfires revealed a notable increase in the purchase of air purifiers (Farrer 2019) in areas affected by significant levels of bushfire smoke.

Air purification was not commonly mentioned in reports discussing heating and cooling. However, due to the macro trend of climate change and thus the potential for increased bushfires and smoke to reduce indoor air quality, we included several reports in the analysis that looked specifically at air purification.

Air purification technologies take two main forms, either as filters installed through existing heating, ventilation, and air conditioning (HVAC) systems or as portable units. Regardless of the type, air filtration systems must be running to be effective. Therefore, the electricity demands of this technology are likely to be significant if they are more widely used. For systems within existing HVAC systems, this may encourage more frequent and sustained use of the entire heating or cooling system.

"The recent publications by the governmental agencies showed signs of an increase in the particulate matter in air, specifically PM2.5, which is quite hazardous. The country has also been facing the deterioration of air quality due to the bushfire events that increased the smoke haze. All these factors coupled with increasing consumer awareness about benefits of good indoor air quality are expected to increasing [sic] sales of air purifiers in Australia in the coming years"

TechSci Research 2019 Australia Air Purifier Market By Filter Type

"The amount of time that an air cleaner operates influences its ability to reduce pollutant concentrations and associated health risks. If they are not operating, they will not be effective. This limits the effectiveness of both categories of air cleaners"

EPA 2018 Residential Air Cleaners – a Technical Summary 3rd edition

Working and studying from home

Technology reports we reviewed predict increased working and studying from home as technology enables more work to be performed remotely. Reports also indicate that online study is expected to continue to grow. If households spend more time at home as opposed to at offices, schools and universities, this will likely affect residential electricity demand to power the digital technologies used in remote work as well as household heating and cooling.

Key claim of reports reviewed:

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

- The **nature of work** is expected to change due to technological innovations in VR, AI and improved connectivity through 5G.
- The **sharing economy, gig economy** and **flexible working arrangements** are predicted to change work routines, including working and studying from home.

Emerging technology trends and predictions:

- **VR and AR** are predicted to enable more industries to be able to work remotely, including unexpected sectors such as health care and mining.

"Augmented and virtual reality have made remote work possible in positions like design and analysis; BMW is now using VR during the development stages of new vehicles, such that workers can design new cars from anywhere."

Accenture 2019c Technology Vision

- **Improved telecommunications** are expected to enable working from home with more reliable and faster internet connections, including through the NBN, and wirelessly through 5G.

"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 The Future Computed

"The NBN will be a potential catalyst for growth in teleworking. The ubiquity and capacity of the NBN technology mean that there will be greater certainty of the technological capacity of teleworkers. This reduces uncertainty about whether an employee can retain their productivity levels when working from home. This also provides greater remote monitoring certainty to employers, as worker output differences more clearly relate to productivity differences."

Access Economics 2010 The Impacts of Teleworking under the NBN

- **Studying online** is projected to increase as online education services improve. Due to the changing nature of the workforce, the rise of AI and the automation of many tasks, workers are expected to need to continually re-skill.
- **Short courses and retraining programs** are anticipated to grow. Online models are considered the most efficient way to offer workforce retraining programs, particularly in fields such as IT.

"Students are increasingly using digital tools to access information and educational resources, many are completing qualifications largely online. As well as increasing access, particularly for people in regional and remote locations (see Mobile Black Spot Program case study), digital tools can provide all students with more tailored educational solutions that meet their particular needs."

Australian Government 2018a Australia's Tech Future

Key oversights and limitations about working and studying from home

The reports analysed for this review:

- Equate the ability to work from home with the desire to work from home.
- Overlook the sensations involved in working from homes, such as the importance of comfort and control and their implications for energy demand (Hampton 2017).
- Overlook issues of social isolation associated with working and studying at home.
- Do not account for the coronavirus pandemic, which is accelerating this existing trend through the increased requirement to work and study from home, and rising unemployment.
- Assume that most or all households have or will have access to a suitable home working environment, and access to necessary infrastructures and services such as a reliable internet connection. The most recent data from the Australian Bureau of Statistics show 13.9 per cent of Australians do not have access to the internet at home (ABS 2018).

Caring from home

Technology reports are particularly bold in their predictions about how emerging technologies will enable aged care in the future. Reports present technology as a potential solution to the problems of caring for an ageing population. Energy reports do not directly reference caring practices, however, the large number and expansive nature of these emerging technologies have the potential to increase or shift energy demand.

Key claim of reports reviewed:

Smart home technologies will enable older people to be cared for within their homes

- Due to demographic macro trends resulting in a reduction in the relative population of working-age adults to perform caring duties, **technology is expected to play an increased role in caring for an ageing population.**
- Older people are expected to **trust technology** and feel positive about their ability to improve their lives as they age.

Emerging technology trends and predictions:

- **Wearable technology** (worn on the body) is expected to monitor the health of people. Data is intended to be accessible by healthcare providers, and it will even alert health authorities or carers if it detects dangerous health conditions.

"For instance, an Alexa-like device could alert a patient of an elevated heart rate (detected on a wearable) and advise them to sit down and rest. In more acute cases, the technology would alert a caretaker or healthcare provider to intervene."

Accenture 2018 Digital Health Tech Vision

- **Automated vehicles** and ride-sharing will enable older people to stay mobile without the need to drive.

"Using a rideshare or driverless car could allow impaired drivers to stay socially engaged."

Deloitte 2019d The Future of Aging

- **Smart home sensors** and **smart appliances** are anticipated to monitor people to improve safety and reduce accidents, such as detecting falls or other hazardous conditions. For example, a smart fire detector could automatically turn off the smart oven if smoke is detected.

"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 2019a Artificial intelligence: Solving problems, growing the economy and improving our quality of life

- **Robotic companions** such as robotic pets are expected to provide companionship to the older people in their homes.

"Out of necessity, robots—mechanical systems, artificial intelligence, and automated services—will act as productive, emotionally-intelligent stand-ins for a younger generation that was simply too small in numbers."

Future Today Institute 2019 Tech Trends Report

- **VR and health teleconsultations** will enable healthcare to take place remotely via improved technology such as virtual and AR.

"Imagine an elderly patient in a rural setting has a consult with a world-class expert without ever leaving his or her own home."

Accenture 2018 Digital Health Tech Vision

Key oversights and limitations about caring from home

The reports analysed for this review:

- Overlook the attachment to routines and everyday practices that underlie older people's varied desires to stay in their homes (Lariviere 2018).
- Downplay the social and mental health needs of older people who are less emphasised than their physical safety.
- Underestimate the trust required for widespread adoption and effective application of the technology, particularly the use of health data (Lupton 2017) and the reliability of the technology used to monitor a vulnerable population.
- Overlook the potential energy implications of this future, including the increased importance of electricity reliability.
- Potentially overestimate the digital skills and interest of older people in smart and emerging technologies (Nicholls et al. 2017).
- Do not account for how wearable technologies are used in everyday life circumstances (Fors et al. 2019)
- Assume that caring for an ageing population is best delivered individually and privately rather than being integrated into wider civil society through, for example, the redesign of housing and cities (Wajcman 2017).

Emerging technologies in childcare

The reports we reviewed contained very limited discussion regarding the role of emerging technologies in caring for children as part of digital energy futures. Where content was found, it was more likely to discuss concerns with the impact of technology and 'screen time' on children's development.

"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 2019b Putting the Human First in the Future Home

Entertainment and convenience

The digital technology reports reviewed note that smart home technologies have not been as widely adopted as anticipated. Slow uptake is often attributed to insufficient integration (incompatibility) between the various technologies, which has undermined the promise of increased convenience. Poor design and data concerns are also cited as reasons for lack of consumer enthusiasm which is expected to eventually be overcome.

Key claim of reports reviewed:

Widespread adoption of smart home technologies is 'just around the corner', bringing improved efficiencies, convenience, and immersive household entertainment

- AI is expected to enable a more seamless smart home experience and contribute to the wider adoption of smart home technologies.
- Several emerging technologies are predicted to become increasingly prevalent for entertainment and household convenience.
- One of the key anticipated values of entertainment and convenience technologies is their ability to capture data and automate appliances in the home

Emerging technology trends and predictions:

- **Smart televisions (TVs)** are already widely adopted and are most people's first internet-connected appliance. Growth is anticipated to continue.

"Smart TVs are most popular with 47% of households owning one Smart TV and only 6% claimed that they are not interested in buying or using smart TV capabilities"

Tech UK 2018 State of the Connected Home

- **Streaming services** are widely used and are expected to become the primary means to access entertainment content in the near future.

"Streaming services no longer serve as just a platform for movies and TV shows—they are also investing in producing and licensing their own content. This places them in direct competition with the traditional TV and video industry. At the same time, TV channels and media organizations are starting their own on-demand offerings. Also, large content producers are setting up their own streaming services. From another perspective, on-demand services have quickly changed consumers' demand for TV and video consumption."

Deloitte 2019e The Future of the TV and Video Landscape by 2030

- **E-sports** (competitive digital video gaming) and other online gaming is already a major industry and is expected to continue to gain a more mainstream presence.

"The stakes are now such that eSports is a legitimate full-time job for many top competitors—many of whom employ coaches, endure rigorous training regimens, compete in national leagues and rake in seven-figure sums—and the industry is poised to define a new paradigm in competitive entertainment for generations to come."

Future Today Institute 2020 Trend Report for Entertainment, Media, and Technology

"Through 2028, conversational platforms, which change how users interact with the world, and technologies such as augmented reality (AR), mixed reality (MR) and virtual reality (VR), which change how users perceive the world, will lead to new immersive experiences."

Gartner 2019 Top 10 Strategic Technology Trends for 2019

- **VR** and **AR** for entertainment are expected to grow and provide immersive entertainment experiences, such as virtual travel, virtual forms of socialisation, and experience-based gaming and videos.

"No more traveling to a theater to watch a movie; instead, people will "travel" into the movie itself as participants."

Accenture 2019c Technology Vision

- **Online shopping** and **home delivery** are expected to become a larger share of retail purchases. AR is anticipated to facilitate online shopping by projecting a digitally produced image onto the user's view of the real world.

"In future [sic] when we buy, it will primarily be online. Orders will be fulfilled by artificially intelligent warehouse robots and systems familiar with our preferences, and deliveries facilitated within the hour across our cities as economies of scale grow."

Westpac 2018 Smart Industry Report: Emerging Industries

"With a range of available apps, a mobile or laptop camera can be used to superimpose digital objects such as interactive avatars or household furnishings into the physical space of one's living area, or overlay clothing, beauty products, or even alterations to one's physical features onto the image of their body."

Future Today Institute 2020 Trend Report for Entertainment, Media, and Technology

- **Smart home security technologies**, including smart locks and connected security cameras, allow people to monitor their homes remotely and are projected to become increasingly popular.
- **Smart locks** with **facial recognition** technology can detect who is at the door and will automatically let authorised visitors or deliveries in, or alert authorities if unwanted people are detected.
- **Cameras** on many other connected devices in the smart home, such as televisions, or smart appliances, are expected to enable a full home **video surveillance system.**

"Amazon developed new technology to connect doorbell cameras with its facial recognition databases, with the ability to automatically recognize who's at the door and to call the police if anyone suspicious is detected."

Future Today Institute 2020 Trend Report for Entertainment, Media, and Technology

- **Digital voice assistants**, often embedded within **smart speakers**, are growing rapidly and expected to become the hub of the smart home as well as taking a larger role in how we make online purchases. The AI underlying these devices is projected to improve substantially enabling them to take a more active role in the household, performing more functions automatically, without being asked.

"Shopping by voice in particular means we are more likely to request our home AI to pick up the brands we already know, posing a great opportunity for brands that make themselves memorable, but potentially threatening those who don't get inside our heads, says Simon Gosling, Futurist at agency Unruly."

KPMG 2017 The Home of the Future

"Twenty years from now, what will your morning look like? At Microsoft, we imagine a world where your personal digital assistant Cortana talks with your calendar while you sleep. She works with your other smart devices at home to rouse you at the end of a sleep cycle when it's easiest to wake and ensures that you have plenty of time to shower, dress, commute and prepare for your first meeting. As you get ready, Cortana reads the latest news, research reports and social media activity based on your current work, interests and tasks, all of which she gleaned from your calendar, meetings, communications, projects and writings. She updates you on the weather, upcoming meetings, the people you will see, and when you should leave home based on traffic projections."

Microsoft 2018 The Future Computed

- **Smart appliances, connected devices** or **smart controls** are discussed in technology reports as a way to improve the convenience of everyday routines, such as the smart fridge's integrated digital voice assistant. However, these conveniences are not expected to substantially change the way that people live in their homes. The emphasis across sectors is often on the value of the data produced through these technological add-ons or improvements.

"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 Tech Trends Report

"The real promise, instead, is in the data generated by connected devices and many of these will be virtually invisible to the consumer. It will seldom be the occupier of the connected home that makes use of it, says Schacker. 'It will be manufacturers and lots of other actors: utilities, market researchers, retailers, other service providers. Everyone potentially has a stake in that data, although if you do not get consumers to accept that proposition the data never goes anywhere.'"

KPMG 2017 The Home of the Future

- **Smart appliances for energy management** are emphasised in energy sector reports as behind the meter (BTM) assets which are expected to enable better peak demand management.

"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 Energy Cloud 4.0

Key oversights and limitations about entertainment and conveniance

The reports analysed for this review:

- Tend to assume that household activities are a 'burden' to be automated away or made more 'convenient', with limited recognition of the complex value derived from everyday practices, e.g. satisfaction gained from doing some chores, or parents' interest in involving and training children in household tasks (Strengers & Nicholls 2017).
- Overlook or downplay the important privacy and security concerns associated with handing over data to technology or energy companies, including issues of social trust.
-
- Prioritise individual entertainment options, or socialisation with people outside the household, rather than sociality within the household or shared entertainment activities.
- Assume a future that prioritises affluent and culturally homogenous consumers and households.
- Overlook growing concerns about 'screen time' in households with children, and parents' desires to encourage children to participate in non-technology related entertainment activities (Nicholls & Strengers 2015).

Driving and charging

Reports predict that the transportation sector will change significantly in the near and medium-far futures, both through the uptake of emerging technologies such as automated vehicles and through transformations in vehicle ownership models.

Key claim of reports reviewed:

The transportation sector will change substantially with the increasing uptake of electric vehicles and autonomous vehicles (AV), but considerable uncertainty remains about the timescales and accompanying mobility systems

- It is unclear how emerging transport models and mobility systems are likely to eventuate in the medium-far future. Speculations range from the further continuation of individual vehicle ownership models through to transport as a shared service.
- Several emerging vehicle technologies, such as electric and hydrogen fuel cell vehicles, are expected to enable new electricity grid integration and management possibilities.

Emerging technology trends and predictions

- **Electric vehicles (EVs)** are becoming an increasing percentage of new vehicle purchases and are expected to overtake combustion engine vehicles in the coming decades.

"EVs could replace traditional vehicles, despite the portion of EVs being less than 0.1% of new car sales in Australia, according to a new field of evidence. Bloomberg New Energy Finance predicts that the purchase price of EVs will be cost-competitive with traditional vehicles by 2024. A number of international car manufacturers have announced they will cease production of internal combustion cars. And the Clean Energy Finance Corporation suggests that in Australia EVs will account for 100% of all new vehicles sold by 2040, and 95% of all vehicles by 2050."

KPMG 2018a Electric Vehicles is the Energy Sector Ready

- Key **barriers to EV adoption** are identified in the reports as their relatively high **purchase price** and **range anxiety**. Prices are expected to go down through technology improvements and increased competitiveness. Range anxiety is also expected to be overcome through a combination of improved battery capacity and the wider availability of charging infrastructure, particularly public fast-charging stations.

"The increase in electric vehicle charging infrastructure is significant to electric vehicle adoption in Australia, given the positive correlation between the number of publicly accessible chargers, and the number of electric vehicles sold. The provision of public charging infrastructure can help to alleviate range anxiety for Australian consumers who are considering an electric vehicle as their next car purchase."

Electric Vehicle Council 2019 State of Electric Vehicles

- **Charging for EVs** must be managed and smart, according to the energy sector reports we analysed. Because EVs will increase electricity demand, when and how they are charged is crucial to the future energy system. There is a recognition that the success of a well-managed EV charging system depends on:
  - how people use and drive their cars
  - where and when people will be able to charge EVs
  - whether individual ownership of EVs continues
  - what incentives are put in place to encourage charging at specific times?

Reports usually conclude that this is hard to predict or is variable.

"Charging patterns and consumer behaviour may also influence the daily load, including the timing and sharpness of peak demands. 'Smart' charging of electric vehicles can help to shape electricity load around solar and wind generation, supporting the efficient use of renewable energy. By contrast, if business models, market design and technology do not align consumer incentives with efficient behaviour, even a modest increase in electric vehicles could strain our generation and network infrastructure."

Deloitte 2018a Energy Accelerated

- **Vehicle to grid** represents an EV charging scenario where the batteries in electric vehicles may be plugged into homes and/or the electricity grid. This technology is already available. Reports suggest that the batteries in EVs represent a potential energy storage resource if charging and usage are managed efficiently.

"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 Modernizing Hawai'i's Grid For Our Customers

- **Hydrogen fuel cell** vehicles are another emerging technology that has the potential to alter the transportation sector. These vehicles are not expected to be as widespread as EVs, but they could place increased requirements on electricity infrastructure depending on the centralisation of the electrolysis that produces the hydrogen.

"If hydrogen supply is based on electrolysis this will also mean increased requirements for electricity infrastructure but its location depends on whether the electrolysis is on-site (e.g. at a service station) or centralised (where the location might be a prospective renewable energy zone or fossil fuel resource)."

CSIRO 2019c Projections for Small Scale Embedded Technologies

- **Mobility as a service (or transportation as a service)** describes the rise of the sharing economy in the realm of transport and mobility. Traditional models of individuals owning their own vehicles are expected to change, particularly in relation to AVs, which are deemed particularly amenable to this model.

"Transportation as a service business model is beginning to take hold in customers [sic] minds and are changing the way transportation assets are owned, operated and managed. The business models supporting transportation are starting to change as more and more players are providing pay per use structures with ride, bike, scooter, car sharing services becoming more common."

Future Today Institute 2019 Tech Trends Report

- **AVs or self-driving cars** promise safety benefits by reducing human error and therefore car accidents. Depending on the ownership models, they are expected to also improve traffic congestion through optimised traffic management and parking availability. However, if a private ownership model is adopted, it could also increase traffic as more people would choose the convenience of an individual autonomous car, potentially increasing the number of cars on the road at the expense of public transport options.

"AVs help with congestion, but not if we send them home or just let them drive by itself on roads empty to avoid parking fees. Without regulating empty trips, Melbourne could face serious congestion."

KPMG 2018b Rethinking the impact of autonomous and zero-emission vehicles

"Traffic congestion, which is estimated to cost Australia $53 billion by 2031, could be proactively reduced by smart city traffic management systems that are informed by machine-to-machine communications with autonomous vehicles. Improved road safety is also expected to be a key outcome of autonomous vehicles, as the majority of car accidents involve human error. In the 12 months to July 2017, there were 1,235 deaths on Australian roads with road trauma costing the Australian community an estimated $27 billion annually. Autonomous vehicles can have a valuable role not just in terms of financial savings, but in saving human lives."

Australian Government 2017 5G- Enabling the Future Economy

- **Micro-mobility** refers to smaller forms of transport such as **electric scooters** and **bicycles**. Reports suggest that these mobility devices will become more common on city streets. They are expected to be enabled by the rise of the sharing economy.

"The "next big thing" in shared mobility could be rather small: micro-mobility. It involves the use of shared electric scooters, bicycles, and other simple conveyances, facilitated via special apps."

McKinsey & Co 2018 Reserve a Seat-The Future of Mobility is Arriving Early

Key oversights and limitations about driving and charging

- The reports analysed for this review don't take into account potential future changes in mobility practices and routines (e.g. when and where people will need to travel in the future, and at what times of the day/week). Changes in these practices, such as increased working from home or distributed working arrangements, could affect the charging management capability of EVs and other vehicles.
- The reports reviewed do not account for the fact that there is ethnographic evidence that existing users of EVs do not experience range anxiety because they integrate EVs into their everyday practices in such a way that it is not relevant.
- Car share models (transportation as a service model) do not recognise how people use their vehicles beyond transportation (e.g. for electricity storage), or how vehicle charging is predicted to increase in other reports analysed for this review.

Energy management

The energy sector reports we analysed primarily engage with technology, particularly AI and automated decision-making (ADM), to help manage anticipated increases and fluctuations in energy demand resulting from other technology, environmental, demographic and economic macro trends (Part 4).

Key claim of reports reviewed:

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

- Emerging residential technologies of particular concern or interest to the energy sector include increased heating and cooling demands, electric vehicle charging, and increased uptake of DER.

Emerging technology trends and predictions

- **Smart meters** are already considered to be the most basic necessary infrastructure for smart energy management, providing the usage data necessary for efficient energy management by households in many of the practice domains discussed in this section.

"– 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 Smart Meter Benefits

- **EV adoption** is expected to require **strong price signals** or **automated technology** to encourage charging at low demand and high supply times.

"Eighty per cent of electric vehicle owners are predicted to charge their car at home, creating a major new electricity load. Dynamic price signals can specifically benefit these electric vehicle owners if it helps them shift this load to use cheap electricity overnight."

DELTA-EE 2019 Smart Meter Benefits

- **Smart appliances** and **smart thermostats** are predicted to enable energy savings and load shifting. Eventually, customers are expected to realise the return on investment of the energy efficiencies of smart home appliances, thus increasing their willingness to purchase and use these devices.

"Smart appliances: 28% of people find this category very appealing, it is one where people are most reluctant to buy due to concerns over value with 49% of people stating cost is a barrier to purchase.
The challenge to demonstrate value 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.
Coupled with the potential development for consumer's participation in demand-side response schemes, we still believe that the outlook for smart appliances is a bright one."

Tech UK 2018 State of the Connected Home

- **Demand management incentives** and **gamification of energy data** are expected to encourage customers to reduce energy use during peak times.

"Making energy savings into a game has also been used in research trials and more recently by energy company loop… to increase energy savings by challenging individuals or groups of people to use less energy than another group."

DELTA-EE 2019 Smart Meter Benefits

- Emerging forms of **DER** with associated demand management are expected to enable consumers to use and provide a growing range of **electricity services**, such as providing reliability through **virtual power plants** or through connections to **microgrids.**

"Networks will play a key role in the delivery and connection of an expanding range of innovative products and services to customers. New products and services will be needed to reflect changing technologies and opportunities for customer benefits, including network support services for micro-grids, standalone power systems, peer to peer trading and electric vehicles. Networks may forge new collaborations and partnerships with non-network market actors to empower all customer types with access to the energy solutions they value most."

ENA 2017 CSIRO Energy networks transformation roadmap

Key oversights and limitations about energy management

The reports analysed for this review:

- Assume that householders have a high interest in energy usage data and price signals, and a willingness and ability to make changes in response to these data and incentives, which past research indicates is not always the case (Strengers 2013; Hargreaves 2018).
- Assume that the majority of people's energy usage is flexible. However, social research indicates that many everyday practices can be difficult to shift through data and price signals or are considered essential and non-negotiable activities (Nicholls & Strengers 2015).
- Overlook issues of consumer trust, particularly around automating what are considered essential everyday practices.

PART 6
AGGREGATED INDUSTRY SCENARIOS

The findings of the review were synthesised into six ‘comic strip’ scenarios, which playfully depict how the digital technology and energy trends and visions identified in the analysis of reports are anticipated to impact on everyday life in households within and across the practice domains.

As aggregated versions of the future trends and visions found in the reports reviewed, the scenarios do not represent the research team’s own future visions, but those that have been extrapolated from the review and then applied to the everyday practice domains that the Digital Energy Futures project focuses on (Part 5).

Each scenario brings together our analysis in two novel ways by:

1. Drawing together dominant energy and digital technology narratives, which are rarely considered together.
2. Applying the findings from our review to the everyday practice domains.

The scenarios focus on anticipated technology and energy trends likely to affect household consumption and are therefore intended to inform forecasts for residential electricity demand in subsequent stages of the research.

A full description of the methodology, analysis and findings that led to the development of these scenarios are presented in Part 2 of this report.

Scenarios as research method

In the Digital Energy Futures project, the aggregated industry scenarios connect the outcomes of this first stage of research and analysis to the subsequent research with households.

As indicated earlier in the report, the industry predictions and future visions we have reviewed and identified have substantial limitations related to the absence of research into how they will be shaped.

In response to this, comic strip scenarios have been designed and selectively tested by the research team for use in the next stage of the Digital Energy Futures project, where they will be discussed with participating households during in-depth ethnographic research in order to better understand:

- How householders imagine themselves and other people in these anticipated future scenarios.
- What anxieties, hopes or expectations householders feel about the implications of the scenarios for their future lives.
- How householders' understandings, expectations and visions for their own futures differ from or disrupt the industry trends and visions depicted in the scenarios.
  by everyday practices of future people.

The remainder of this section presents the six scenarios

1. Staying cool and comfortable in extreme weather
2. Stay at home life
3. Ageing at home
4. The smart and easy life
5. The active smart charging commuter
6. The set and forget prosumer

Scenario 1.
Staying cool and comfortable in extreme weather

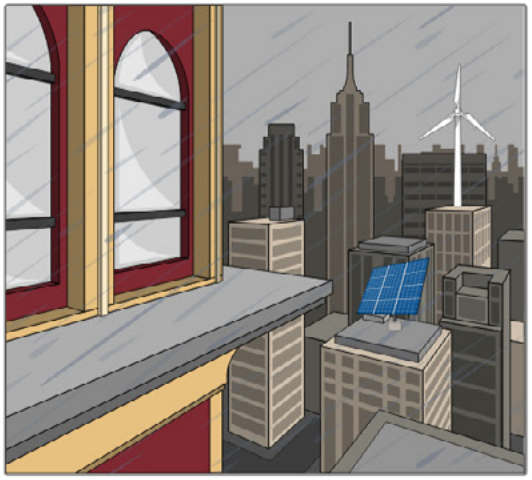
The **Staying cool and comfortable in extreme weather** scenario focuses on the macrotrend of more extreme weather resulting from climate change, leading to disruptions to electricity infrastructure services and home life. In the Australian context, these framings are specifically related to the anticipation of more frequent heatwaves, extreme heat days and bushfires.

In integrating the visions and trends from the reports we reviewed into this scenario, the research team identified the possibility for emerging home technologies such as air purifiers (or new routines with existing technologies such as air conditioners) to become increasingly commonplace.

Technology reports reviewed anticipate that people will spend more time in their homes as they adopt more smart home technology, which the research team has integrated with the potential for extreme weather outdoors. Energy sector reports reviewed also identified that electricity grid failures resulting from extreme weather could encourage more localised generation and storage.

This comic strip scenario depicts the implications of these possible changes for people as they perform everyday life practices in the future.

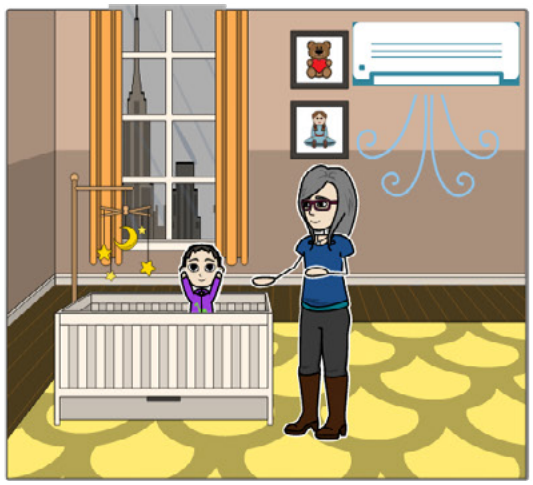
Scenario 1. Cool and comfortable in extreme weather



Australia will experience increasing days of extreme weather due to climate change.

Extreme weather may cause electricity grid failures, encouraging more people to rely on their batteries.

Air purification technology will keep the indoor air clean to breathe in poor outdoor conditions.



The increasing number of extreme weather days will increase usage of air conditioning. Air purification will be integrated into AC units.

More people will work and study from home to avoid commuting in extreme weather.

Poor air quality will encourage exercise in the home.

Home delivery services will enable you to stay in the comfort of your home.

Automatic smart lights will create the ideal atmosphere in the home.

Scenario 2.
Stay at home life

The **Stay at home life** scenario focuses on industry predictions that technological advances in telecommunication, VR, AR, and digital voice assistants will increase working and studying from home and make online shopping and delivery a seamless experience.

Everyday entertainment and leisure practices are also expected to increasingly take place in the home as they integrate with these emerging technologies.

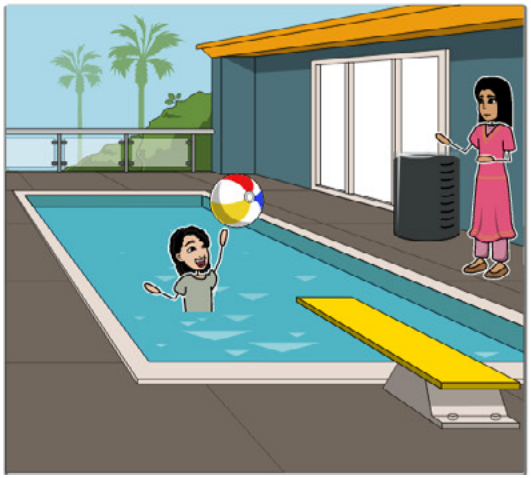
Scenario 2. Stay at home life

Working, studying, and recreation can all now take place in the home.

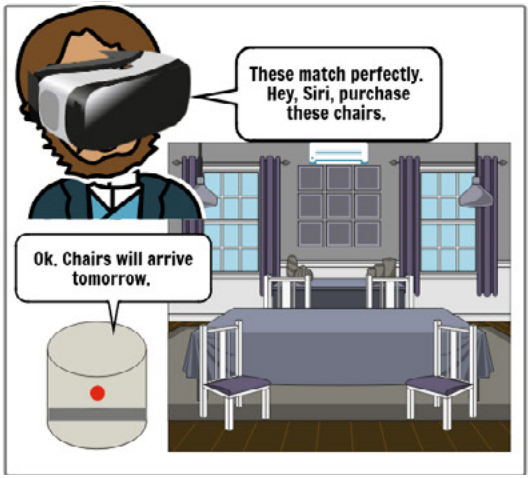
E-sports and gaming are growing in popularity and reputation. Weekend sport might not require leaving the house.

Telecommuting will be enhanced through the use of virtual reality, enabling many more professions to work remotely.

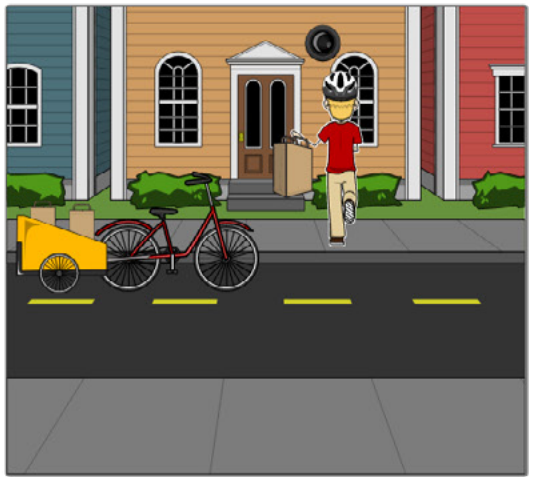
Studying from home will be more common as universities go online.



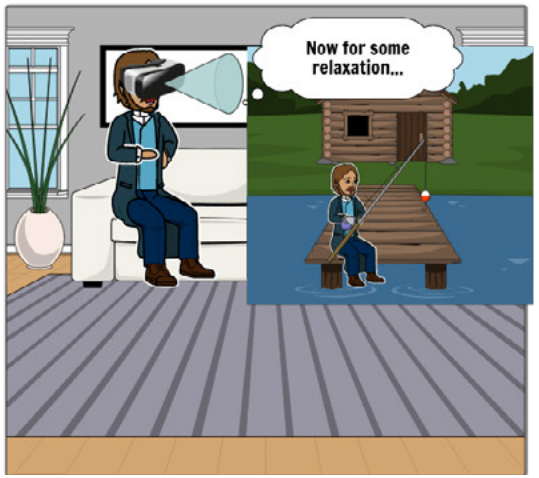
Energy management systems will optimise water heaters and pool pumps to automatically run when energy is cheapest.



Shopping will no longer require trips to the store. Augmented reality will allow you to see exactly how an object will fit into your home and orders can be placed through digital voice assistants.



Groceries and purchases will be delivered to the home, with smart locks that allow deliveries in.



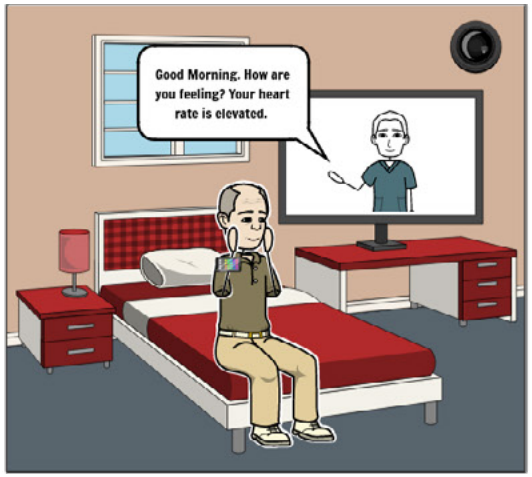
Virtual reality will allow you to travel and have immersive experiences, all without leaving home.

Scenario 3.
Ageing at home

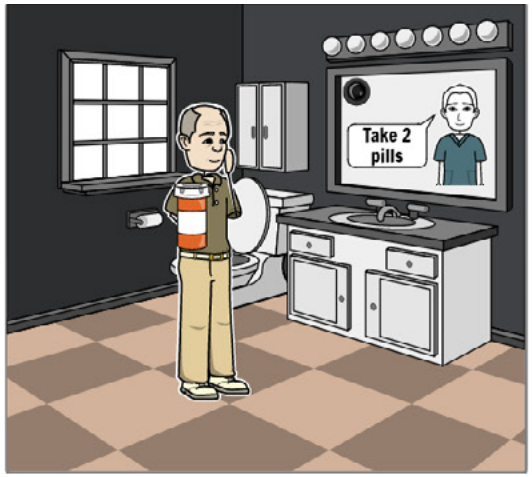
The **Ageing at home** scenario takes as its starting point the key macro trend that Australia's population is ageing and that more people will desire to stay in their homes as they age. The reports reviewed expect that technology will help enable caring for the ageing population and predict that many emerging technologies will be integrated into the homes of older people to address health needs, ensure safety and provide companionship.

This comic strip depicts how these technologies might be used and experienced by older people within everyday practices if they were made available and accessible to them.

Scenario 3. Ageing at home

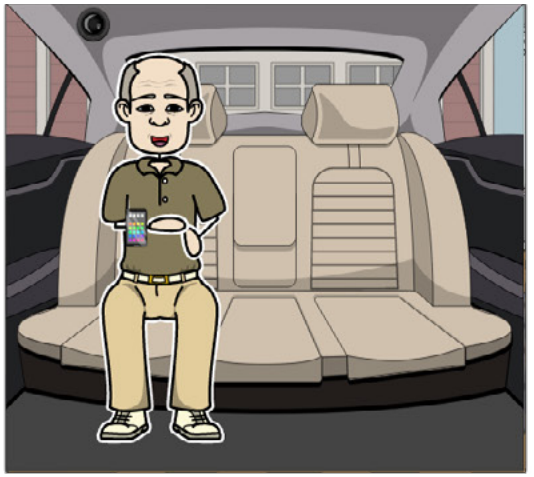


Wearable technology will monitor vital signs and alert health authorities if problems are detected.

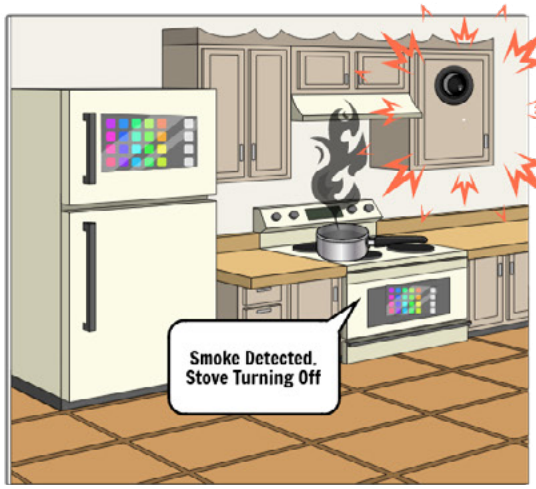


Digital voice assistants will remind people to take their medication.

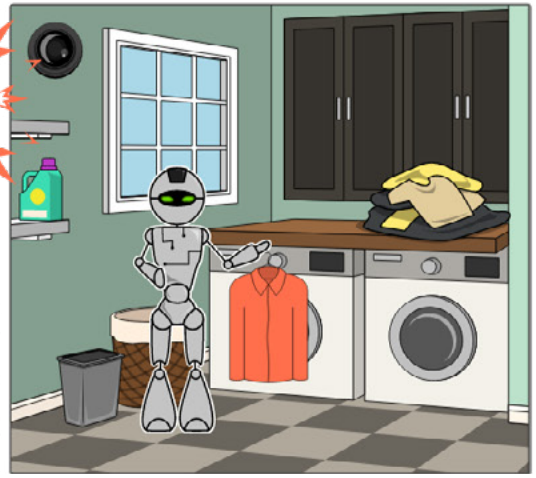
Visits to the doctor can take place virtually from the home.



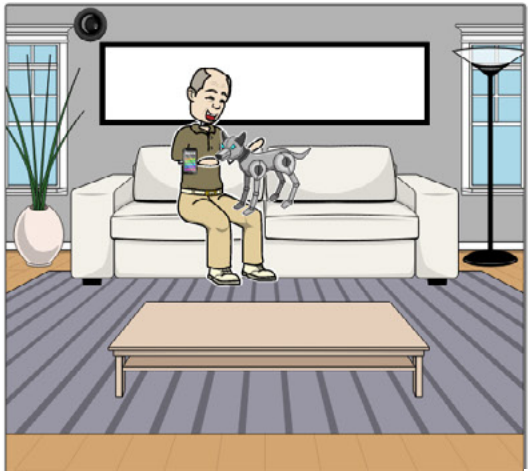
If it is necessary to travel, self-driving cars will allow the elderly to get around safely.



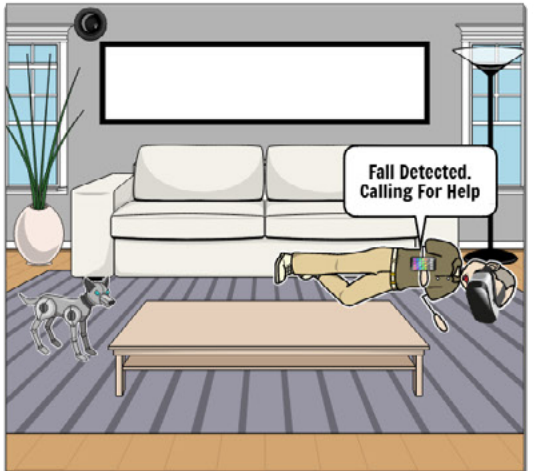
Sensors and smart appliances will communicate with each other to ensure safety.



Robotic carers will perform many household and nursing duties.



Companion robots such as robotic pets will provide comfort.



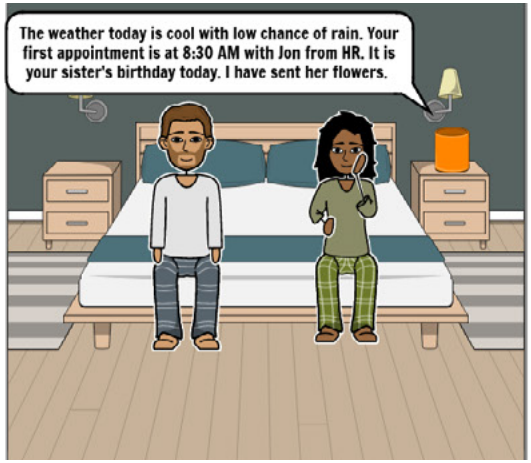
Wearable technology and sensors will be able to call for outside help when it is needed.

Scenario 4.
The smart and easy life

The **Smart and easy life** scenario takes as its starting point the prediction represented in the reports that homes will become increasingly “smart” and that this will be enabled by advances in AI and IoT. In this scenario, more household activities and decisions are expected to become automated, and advances in technology are expected to enable immersive forms of entertainment.

This comic strip depicts how these future devices might become part of individual and family-based everyday practices in the home.

Scenario 4. The smart and easy life



A digital voice assistant will start your day and help you plan for it.

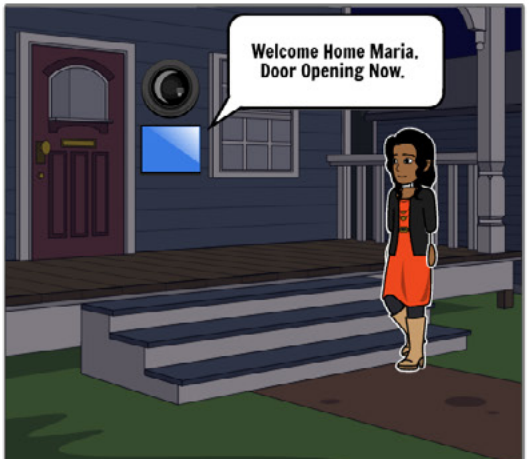
Technolgies like a smart mirror may help you pick out your optimal outfit for the day.

Smart sensors and wearable technologies will monitor your health.

Cameras will be installed in many locations in the house, so that children can be monitored from afar.

Smart appliances, like a smart fridge, may suggest recipes based on the contents of your fridge and your health data.

An energy monitor in a central location of your home will allow you to monitor your energy usage in real time, and allow you to automate appliances to run when energy is cheapest.



Facial scanning technologies in smart locks will know whether to let people into the house. Or in the case of unwanted visitors, to alert police.

You will no longer ‘watch’ a movie, but be transported into the movie, taking part in the adventure.

Scenario 5.

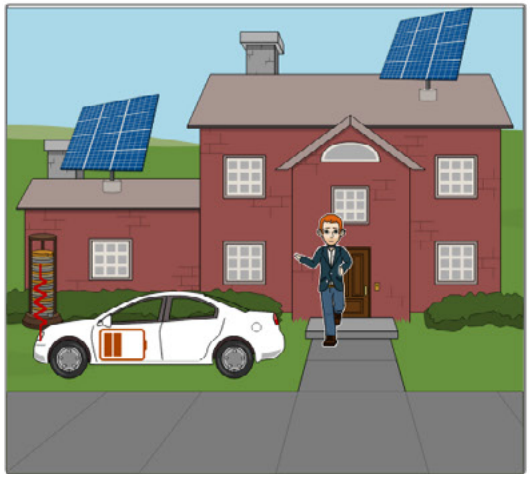
The active smart charging commuter

The **Active smart charging commuter** scenario is based on the prediction that electric vehicle (EV) ownership will increase significantly, internationally and in Australia. It is expected that this will lead to increased electricity demand for EV battery charging.

Energy sector reports reviewed emphasise that the increase in EVs has two possible implications: they could be a burden on the energy system if their charging is not efficiently managed; or if their battery storage is integrated into the electricity system through vehicle to grid connections and charging is managed and smart, they will create an opportunity for efficient home and mobility energy management.

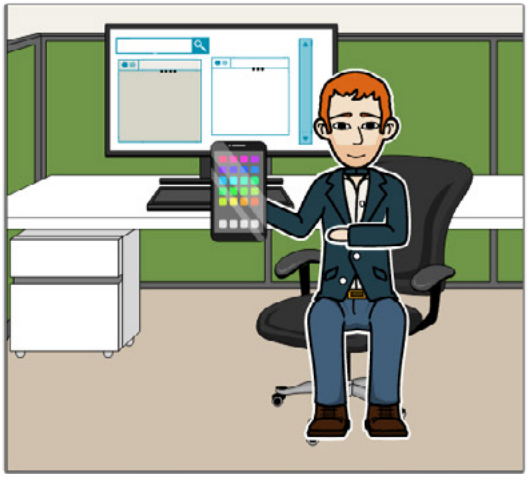
This comic strip depicts how energy related to electric car use might be used and managed across a series of physically present and remote everyday practices, at home, at work and in transit.

Scenario 5. The active smart charging commuter

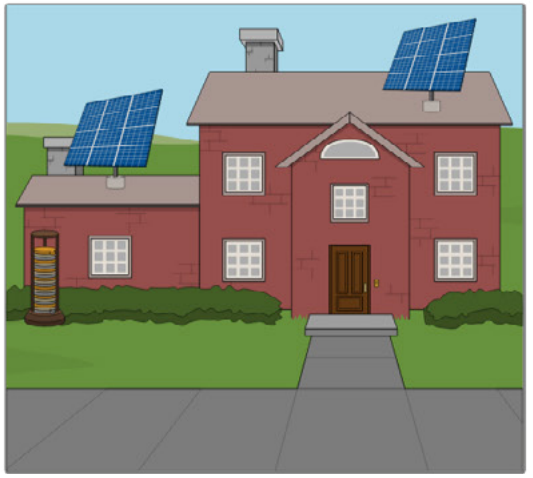


In the morning, your electric vehicle will have sufficient charge for you to commute to work.

When you arrive at work you will plug your car into a charger that will be powered by the solar energy that is plentiful during the afternoon.



You can control many household appliances remotely from your smart phone.

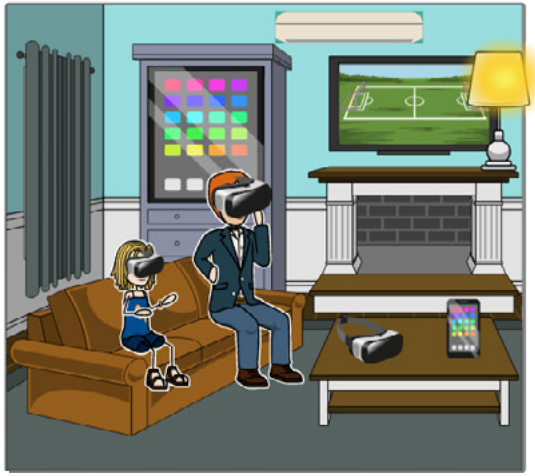


During the day, your house is powered by solar energy and either stores excess energy in your home battery or exports it to the grid when the feed-in tarriff is highest.

Many of your chores, such as the laundry, can be done when energy is coming from your solar panels, or when the feed-in tariff is lowest.

When you leave work, your car is fully charged.

After arriving home, you still have power in your car battery which you can plug into your house or export to the grid if there is a good price incentive.



Your evening activities are powered by your car battery. Because many of your chores have already been done, there is enough power leftover for you to commute to work the next morning.

Scenario 6.

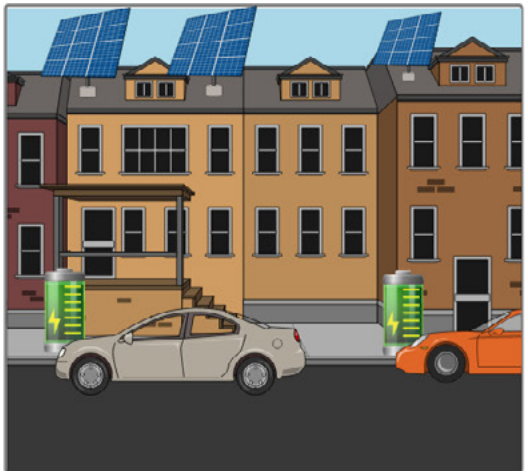
The set and forget prosumer

The **Set and forget prosumer** scenario is based on the prediction that the rise of the sharing economy, increased consumer concern with sustainability, and the availability of automated technologies will lead to the increased uptake of distributed energy resources (DER), peer-to-peer trading systems, and automated energy management.

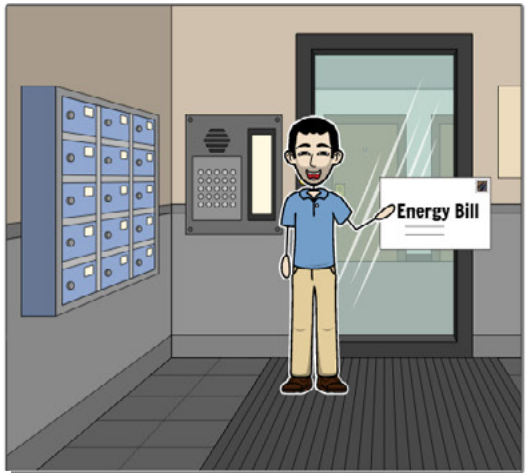
Household energy use is predicted to be optimised by the availability of real-time data as well as advances in AI and automated decision-making (ADM) to balance energy availability with household demand, creating cost savings for both consumers and the energy sector.

This comic strip depicts how these technological and energy futures possibilities might have implications for how people experience their home environments and use automated systems in the near future.

Scenario 6. The set and forget prosumer

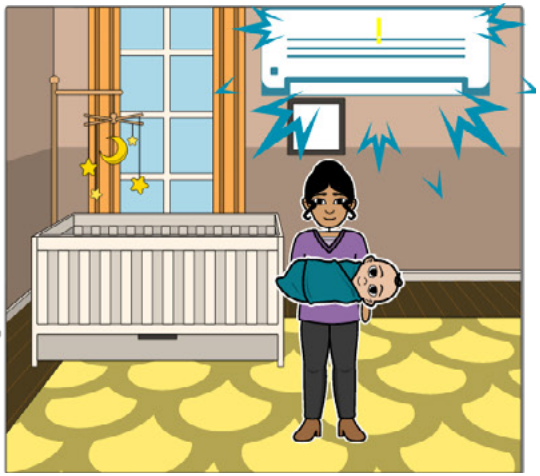


Peer-to-peer energy trading systems in ‘micro-grids’ will enable neighbours to connect to each other’s energy generation and storage including batteries in electric cars.



An automated system enabled by blockchain technology will ensure everyone pays their fair share.

Smart thermostats will automatically heat or cool a room when solar energy is available to optimise the temperature, even preparing for your arrival home.

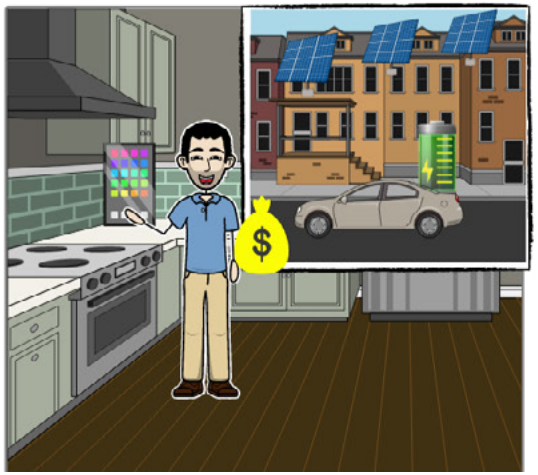


Algorithms will enable optimal temperatures based on the availability of solar energy.

Solar hot water ststems will automatically heat water when solar energy is available and store the water for later use. Technology will set an optimal temperature and shower time to ensure enough warm water.

Some appliances, such as the smart washing machine, will be automated to run when solar energy is available.

An energy monitor will enable you to see how much energy you are using and adjust your automated settings.



Any energy you produce but do not use, can be sold to your neighbours or to the grid.

PART 7
EVALUATION AND IMPLICATIONS OF INDUSTRY PREDICTIONS

The review and scenarios constitute a baseline of industry future visions and trends, which our subsequent research will test and expand upon.

This report has presented an analysis of 64 reports discussing the future trends, visions and predictions for digital and energy technologies as they relate to the Australian residential electricity sector. It has provided six aggregated industry scenarios that embed the findings from our analysis into the home (Part 6).

The analysis and scenarios produced through this review provide a useful starting point for identifying:

- How the digital technology and energy industries understand technological and social change.
- The key emerging technologies and macro trends that are likely to inform near and medium-far digital energy futures.

The anticipated futures we have identified in these reports contain the following **overarching implications**, which are partly informed by the limitations of the reports available for analysis (Part 2).

- The impact of digital technology visions on the energy sector, and energy future visions on the digital technology sector, are rarely considered. As such, **digital energy futures are not currently being understood or analysed as co-evolving influences on the home.**
- People are understood almost exclusively as individual **consumers of energy or technology.** This means the contextual, contingent and unpredictable elements of their lives are not accounted for.
- The futures they depict **exclude and ignore socio-economic and cultural diversity.** They primarily focus on:
  - An assumed affluent ‘consumer’ who can afford to purchase technologies
  - A culturally homogenous, primarily English-speaking customer
  - Tech-savvy and -interested consumers who are interested and willing to learn, operate and integrate new technologies into their lives

  - Individual operation and control of technologies, overlooking consideration of how technologies are incorporated into households as social groups often containing a mix of adults, children and pets
  - The repetitiveness of everyday routines, rather than the constant change, variations, and ongoing exceptions that are part of everyday life.
- Unlike scenario planning, which is meant to prepare industries through "thinking about the unthinkable" (Kahn 1962), the reports maintain and promote **conservative visions of the future.** They rarely take into account either broader societal transformations, changing everyday practices, or disruptive and unforeseen emerging technologies. The reports approach medium-far futures as:
  - Improved versions of already existing technology
  - Greater uptake of already existing technology.
- The impact of **large-scale disruptions** is not considered. In 2020, the experience of the coronavirus pandemic and bushfire crisis demonstrates how unprecedented large-scale events disrupt industry anticipated futures, and the need to plan for uncertainty and flexibility.
- Claims about the effects of macro trends like AI, 5G, and blockchain do not account for the **uncertainty and failure** inherent to developing and implementing technologies. These trends have all experienced significant delays and detours throughout their development, yet the reports' predictive statements obscure these realities.

These limitations are reflected in the industry aggregated scenarios we developed from this review (Part 6). While the scenarios bring together novel combinations of energy and digital technology futures, applied to the everyday practice domains in the home, they only include technology that is at least to some degree already existing, or reflect macro trends that are already present-day concerns.

Therefore, while the scenarios reflect possible near futures (2025-2030), as well as some conservative elements of medium-far futures (2030-2050), they should primarily be considered the dominant visions of the energy or technology sector in the present.

Subsequent research

The next stage of the Digital Energy Futures research project will use these industry scenarios to critically disrupt and re-imagine possible digital energy futures through ethnographic research with 72 Australian households across Ausgrid and AusNet Services electricity distribution networks.

This research will develop insights with householders regarding how their practices are changing in relation to the domains identified in this report, and to investigate their hopes, aspirations and anxieties for the future. It will identify how industry visions differ from or are disrupted by the everyday lives of six different types of households:

1. Apartment dwellers

2. Early adopting technology enthusiasts

3. New and estate homes

4. Seachangers and treechangers

5. Regional agricultural households

6. High demand and occupancy households.

The sample will also capture demographic, housing and cultural diversity.

Ethnographic household research will involve the following steps:

1. **Demographic, energy and digital technology information** about each household
2. **Household interviews** regarding their expectations and worries for their futures; understandings and concerns about energy use and affordability; and experiences and visions for emerging energy technologies and demand management strategies.
3. **Home technology and energy tours** which will allow researchers to observe householders' home environment, share visual material with the team and provide footage for a video documentary.
4. **Industry aggregated scenarios**, as presented in this report (Part 6), will be used as prompts to enable the research team to discuss the industry scenarios with participating households during in-depth ethnographic research in order to better understand:
   - How householders see themselves in these anticipated future scenarios. What anxieties, hopes or expectations households have about the scenarios
   - How householders' understandings, expectations and visions for their own futures differ from or disrupt the industry trends and visions depicted in the scenarios.

Through this ethnographic research and subsequent research stages, the Digital Energy Futures project will respond to the implications of the industry predictions and aggregated scenarios presented in this report.

More specifically, it will bring digital technology and energy industry visions together with householders' own expectations for their futures to rework the scenarios and develop a forecasting methodology for near and medium-far futures in the Australian energy sector.

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APPENDIX A: LIST OF REPORTS

Report	Organisation	Year	Source Type	Country/Region of Focus
Accenture 2018 Digital Health Tech Vision	Accenture	2018	Consultants	United States
Accenture 2019a Human Centred Care in the Digital Age	Accenture	2019	Consultants	Australia
Accenture 2019b Putting the Human First in the Future Home	Accenture	2019	Consultants	International
Accenture 2019c Technology Vision	Accenture	2019	Consultants	International
Access Economics 2010 The Impacts of Teleworking under the NBN	Access Economics	2010	Consultants	Australiaw
AEMC 2019a How Digitalisation is Changing the NEM	AEMC	2019	Energy Organisation/ Agency	Australia
AEMC 2019b Integrating Distributed Energy Resources for the Grid of the Future	AEMC	2019	Energy Organisation/ Agency	Australia
AEMO 2019a Draft 2020 Integrated System Plan	AEMO	2019	Energy Organisation/ Agency	Australia
AEMO 2019b Forecasting and Planning Scenarios Inputs and Assumptions	AEMO	2019	Energy Organisation/ Agency	Australia
Australian Futures Project 2018 What's the Future, Australia	Australian Futures Project	2018	NGO	Australia
Australian Government 2017 5G-Enabling the Future Economy	Australian Government	2017	Government	Australia
Australian Government 2018a Australia's Tech Future	Australian Government	2018	Government	Australia
Australian Government 2019b Planning for Australia's Future Population	Australian Government	2019	Government	Australia
Bain & Company 2018 Labor 2030	Bain & Company	2018	Consultants	United States
Bloomberg NEF 2019 New Energy Outlook	Bloomberg NEF	2019	Consultants Energy	International
California Energy Commission 2013 Advanced Integrated Systems Technology Development.	California Energy Commission/ UC Berkeley	2013	Government	United States

Report	Organisation	Year	Source Type	Country/Region of Focus
COAG Energy Council 2020 Moving to a Two-Sided Market.	COAG Energy Council	2020	Government	Australia
COOLGAIA 2018 Solar Heating and Cooling Roadmap	Coolgaia	2018	Consultants Energy	Australia
CSIRO 2019a Artificial intelligence: Solving problems, growing the economy and improving our quality of life	CSIRO	2019	Research Agency	Australia
CSIRO 2019b Australian National Outlook	CSIRO	2019	Research Agency	Australia
CSIRO 2019c Projections for Small Scale Embedded Technologies	CSIRO	2019	Research Agency	Australia
Deloitte 2018a Energy Accelerated	Deloitte	2018	Consultants Energy	Australia
Deloitte 2018b IOT Powered by Blockchain	Deloitte	2018	Consultants	European Union
Deloitte 2019a Beyond the Energy Transition	Deloitte	2019	Consultants Energy	Australia
Deloitte 2019b Energy Management: Balancing Climate, Cost, and Choice	Deloitte	2019	Consultants Energy	United States
Deloitte 2019c How Advanced Tech is Reshaping Mobility	Deloitte	2019	Consultants	United States
Deloitte 2019d The Future of Aging	Deloitte	2019	Consultants	United States
Deloitte 2019e The Future of the TV and Video Landscape by 2030	Deloitte	2019	Consultants	European Union
DELTA-EE 2019 Smart Meter Benefits	Delta-Energy and Environment	2019	Consultants Energy	United Kingdom
Electric Vehicle Council 2019 State of Electric Vehicles	Electric Vehicle Council	2019	Tech Industry Group or Agency	Australia
ENA 2017 Energy Networks Transformation Roadmap	Energy Networks Australia	2017	Energy Organisation/ Agency	Australia
Energeia 2019 Distributed Energy Resources and Electric Vehicle Forecasts	Energeia	2019	Consultants Energy	Australia
EPA 2018 Residential Air Cleaners- a Technical Summary 3rd edition	US Environmental Protection Agency	2018	Government	United States
Euroheat DHC+ 2019 Digital Roadmap for District Heating and Cooling	Euroheat/DHC+ Technology Platform	2019	Energy Organisation/ Agency	European Union

Report	Organisation	Year	Source Type	Country/Region of Focus
European Commission 2019 AI: The Future of Work? Work of the Future!	European Commission	2019	Government	European Union
Fraunhofer Institute 2019 Study on Energy Savings Scenarios 2050	Fraunhofer Institute	2019	Research Agencies	European Union
Future Today Institute 2019 Tech Trends Report	Future Today Institute	2019	Consultants	United States
Future Today Institute 2020 Trend Report for Entertainment, Media, and Technology	Future Today Institute	2020	Consultants	United States
Gartner 2019 Top 10 Strategic Technology Trends for 2019	Gartner	2019	Consultants	United States
Hawaiian Electric 2017 Modernizing Hawai'i's Grid For Our Customers	Hawaiian Electric	2017	Energy Organisation/ Agency	United States
IEA 2017 Digitalization and Energy	IEA	2017	Energy Organisation/ Agency	International
IEA 2018 The Future of Cooling	IEA	2018	Energy Organisation/ Agency	International
IIT 2010 ICT Enabled Independent Living for the Elderly	Institute for Innovation and Technology	2010	Research Agency	European Union
KPMG 2017 The Home of the Future	KPMG	2017	Consultants	International
KPMG 2018a Electric Vehicles is the Energy Sector Ready	KPMG	2018	Consultants Energy	Australia
KPMG 2018b Rethinking the impact of autonomous and zero emission vehicles	KPMG	2018	Consultants	Australia
McKinsey & Co 2018 Reserve a Seat-The Future of Mobility is Arriving Early	McKinsey and Company	2018	Consultants	International
McKinsey & Co 2019 There's No Place Like [A Connected] Home	McKinsey and Company	2019	Consultants	United States
Microsoft 2018 The Future Computed	Microsoft	2018	Tech Industry Group or Company	United States
Navigant 2018 Energy Cloud 4.0	Navigant	2019	Consultants Energy	International
OECD 2019 Blockchain Technologies as a Digital Enabler for Sustainable Infrastructure	OECD	2019	Government	International

Report	Organisation	Year	Source Type	Country/Region of Focus
Parliament of Victoria 2018. Inquiry into community energy projects.	Parliament of Victoria	2018	Government	Australia
Pew 2014 Digital Life in 2025	Pew Research	2014	Research Agency	United States
Pew 2016 Gig Work, Online Selling, and Home Sharing	Research Agencies	2016	Research Agency	United States
PWC 2020 Connected Home 2.0	PWC	2020	Consultants	United Kingdom
Queensland Government 2018 Digital and Technology Trends	Queensland Government	2018	Government	Australia
Starcom Futures 2019 Future of Connected Living	Starcom	2019	Consultants	Australia
Tech UK 2018 State of the Connected Home	TechUK	2018	Tech Industry Group or Company	United Kingdom
TechSci Research 2019 Australia Air Purifier Market By Filter Type	TechSci Research	2019	Research Agency	Australia
Telstra 2019 Our predictions for 2019's Biggest Tech Trends	Telstra	2019	Tech Industry Group or Company	Australia
UK National Grid ESO 2019 Future Energy Scenarios	UK National Grid Electricity System Operator	2019	Energy Organisation/ Agency	United Kingdom
Westpac 2018 Smart Industry Report: Emerging Industries	Westpac	2018	Bank	Australia
World Economic Forum 2018 Our Shared Digital Future	World Economic Forum	2018	NGO	International
World Economic Forum 2019 Risk Snapshot: Smart Grids	World Economic Forum	2019	NGO	International

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Published by

Emerging Technologies
Research Lab
Monash University
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Layout and editing: Hayley McKee

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Acknowledgements

The research was funded by the Australian Government through the Australian Research Council's Linkage Projects funding Scheme ('Digital Energy Futures' project number LP180100203) in partnership with Monash University, Ausgrid, AusNet Services and Energy Consumers Australia.

A partnership between:

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