ARENA KNOWLEDGE SHARING DEMAND FLEXIBILITY PORTFOLIO RETROSPECTIVE ANALYSIS REPORT

PREPARED FOR ARENA
BY UTS INSTITUTE FOR
SUSTAINABLE FUTURES

JULY 2023

UTS

Australian Government
Australian Renewable Energy Agency

ARENA

RESEARCH TEAM

- Chris Briggs (UTS-ISF)
- Kazi Hasan (RMIT)
- Scott Dwyer (UTS-ISF)
- Usman Bashir Tayab (RMIT)
- Sarah Niklas (UTS-ISF)
- Dani Alexander (UTS-ISF)
- Abhi Chatterjee (UTS-ISF)

CITATION

Briggs, C., Hasan, K., Dwyer, S., Bashir, U. Niklas, S., Alexander, D., Chatterjee, A., (2022) *ARENA Knowledge Sharing Demand Flexibility Portfolio Retrospective Analysis Report.* Institute for Sustainable Futures, UTS. Report prepared for ARENA.

We would like to thank the expert panel,

- Rob Murray-Leech (Energy Efficiency Council)
- Jarrod Leak (A2EP)
- Stephen White (CSIRO)
- Dani Alexander (RACE for 2030 CRC)

UTS DISCLAIMER

Institute for Sustainable Futures
University of Technology Sydney
PO Box 123 Broadway, NSW, 2007
www.isf.uts.edu.au

ARENA DISCLAIMER

TABLE OF CONTENTS

GLOSSARY & ACRONYMS

ACRONYM	NAME
A2EP	Australian Alliance for Energy Productivity
AEMO	Australian Energy Market Operator
API	Application Programming Interface
ARENA	Australian Renewable Energy Agency
AS-4755	This is the Australian Standard *AS-4755 – Demand Response Enabled Devices*
AS-4777	This is the Australian Standard AS-4777 – *Grid Connection of Energy Systems Via Inverters – Part 1: General Requirements*
AUD	Australian dollar
C&I	Commercial and Industrial
CCS2	Combined Charging System
CFO	Chief Financial Officer
CHAdeMO	A DC charging technology
CO2	Carbon dioxide
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DER	Distributed Energy Resource
DMIS	Demand management incentive scheme
DNSP	Distribution Network Service Provider
DR	Demand Response
DRED	Demand Response Enabled Device
EDGE	Energy Demand and Generation Exchange
EEC	Energy Efficiency Council
EV	Electric Vehicle
FCAS	Frequency Control Ancillary Services
FD	Flexible Demand
GW	Gigawatt
HEMS	Home Energy Management
HVAC	Heating ventilation and air conditioning
ICT	Information and communications technology
IEC	Information, Education & communication
ISF	Institute for Sustainable Futures
IT	Information technology
kW	Kilowatt
MASS	Market Ancillary Services Specification
MDP	Metering Data Provider
MECE	Mutually exclusive and collectively exhaustive
MW	Megawatt
MWh	Megawatt hour
NEM	National Electricity Market
NMI	National Meter Identity
OCPP	Open Charge Point Protocol
OEM	Original Equipment Manufacturer

ACRONYM	NAME
PHEV	Plug-in hybrid electric vehicle
PPA	Purchase power agreement
PV	Photovoltaic
RACE for 2030 CRC	Reliable, Affordable, Clean Energy for 2030 Cooperative Research Centre
REALM	Renewable Energy and Load Management
REEP	Residential Energy Efficiency Program
RERT	Reliability and Emergency Reserve Trader
RMIT	Royal Melbourne Institute of Technology
RoCoF	Rate of Change of Frequency
SCADA	Supervisory control and data acquisition
SoW	State of World (scenario)
TES	Thermal energy storage
TOU	Time-of-use
UTS	University of Technology Sydney
V2G	Vehicle-to-grid
VGI	Vehicle Grid Integration
VPPs	Virtual Power Plants
WDR	Wholesale Demand Response Mechanism

EXECUTIVE SUMMARY

ARENA has identified demand flexibility as a strategic focus area and defines it as the capability to vary customer energy demand in response to variable generation, network or market signals. Increasing demand flexibility can support the integration of renewable energy, reduce consumer bills and enhance system security through the energy transition.

ARENA has previously committed $180 million to 55 projects, either to demonstrate demand flexibility enabling technologies or approaches, or broader energy productivity projects that include demand flexibility.

This report provides the findings of these previous ARENA funded projects that contribute to five key knowledge gaps in the Demand Flexibility portfolio:

1. What are the barriers to accessing value-streams for demand flexibility and value-stacking?
2. How are flexible demand technologies being used and what are the priorities for innovation?
3. How can reforms to regulatory frameworks, metering and baseline methodologies support efficient levels of flexible demand?
4. What are the key 'pain points' in the customer journey?
5. What are the barriers to scaling flexible demand and the priority actions?

Demand flexibility delivers widespread net benefits – and the scale of opportunity depends on future energy usage

Modelling commissioned by ARENA (NERA 2022) estimated the potential for demand flexibility and found a range of consumer cost savings under all energy transition scenarios through to 2040 (Table 1). Increased flexibility in energy demand becomes more valuable as higher volumes of variable renewable energy and customer energy resources became part of our energy supply.

The largest opportunities identified by NERA (2022) are in electric vehicle smart charging, matching residential hot water heating with solar generation and greater flexibility in residential air-conditioning and commercial heating, ventilation and air-conditioning (HVAC). However, the contribution of different technologies depends on the future pathway of the energy transition and electrification of various sectors.

TABLE 1: CONSUMER COST SAVINGS UNDER DIFFERENT LOAD FLEXIBILITY SCENARIOS (NERA 2022)

SCENARIO	DESCRIPTION	SAVINGS
State of World 1	Baseline case i.e. greater flexibility with current technologies	$1 - $6 billion
State of World 2	High electric vehicle uptake	$3 - $5 billion
State of World 3	Electrification	$4 - $5 billion
State of World 4	High distributed energy resources	$8 - $18 billion
State of World 5	High hydrogen	$3 billion

This review highlights three key types of challenges to scaling demand flexibility.

Key Challenge #1: Establishing the foundations to scale demand flexibility – technical standards, metering and measurement

Many of the ARENA-funded projects reviewed faced challenges in delivering the expected volume of demand flexibility using the technologies projected to be the best opportunities to date. Whilst there are areas where technology innovation is required, the primary challenge is addressing the barriers to deployment and scaling rather than breakthroughs from technology innovation.

Technical standards were identified as a major barrier to unlocking residential demand flexibility:

- In relation to residential air-conditioning, the coverage and operation of the technical standard for demand response enabled devices (the AS-4755) was identified as a key limitation, as many air-conditioning units did not have the demand response capability due to non-compliance with AS-4755 technical standard; technical issues with the operation of units (e.g. some units turned off completely instead of reducing their output leading to households exiting the program); and the costs of addressing technical issues always exceeded the benefits.

- The technical and procedural requirements governing vehicle-to-grid connection (AS-4777[1]) were considered more onerous than international jurisdictions.
- The absence of a common interoperability standard across behind-the-meter devices and EV chargers was identified as a barrier that needs to be resolved before mass deployment. In the absence of a common interoperability standard across devices, competition for surplus solar between devices could lead to sub-optimal outcomes for the customer and energy system (e.g. is surplus solar best used to heat water, stored in a battery or exported to the grid).

The review of technical standards for DER are the subject of multiple processes through the Distributed Energy Integration Program (DEIP), the AEMC and AER. There is no national framework for harmonising technical standards which are set by a multiplicity of processes and authorities and no requirement for compliance with standards (AEMC 2022). The experiences of many ARENA-funded pilots to date underlines the urgency and importance of establishing modernised, common standards underpinned by effective governance – in particular there is a window of opportunity before widespread adoption of EVs and behind-the-meter storage to avoid a repeat of the issues experienced by other technologies such as air-conditioning units.

Smart meter coverage is low and often doesn't contain the necessary 'smarts' required to maximise the demand flexibility opportunity. Both the penetration and quality of smart meters were regularly observed as major barriers to demand flexibility in the residential sector. The penetration of smart meters (outside Victoria) is low and the cost of upgrading customer infrastructure site-by-site is not financially viable.

Residential demand flexibility can be unlocked by an accelerated roll-out of smart meters alongside other benefits such as enhanced network visibility. The findings of this review are consistent with the recommendations of the AEMC review (2023) to accelerate the roll-out of smart meters towards 100 per cent coverage.

Baseline methodologies used to quantify the volume of demand flexibility operationalised need to balance accuracy with compliance requirements that create excessive transactional costs or exclude load types. The baseline methodologies used by AEMO for commercial and industrial sites are well-understood but exclude load types which are not flat and predictable – 80 to 95 per cent of loads according to Oakley & Greenwood (2021). Multiple demand flexibility providers noted they filter customers based on fit with AEMO baselines and do not attempt to register customers they expect to be incompatible.

Nor is there an effective measurement system for demand flexibility in the residential sector with reports of 'false negatives' and 'false positives'. Residential demand flexibility is not included in the AEMO baselines (or the wholesale demand response mechanism), but it has been observed in ARENA projects that it would be unsuitable for household air-conditioning loads: for example the volume of demand response to reduce air-conditioning loads driven by hot temperatures later in the day is understated by the use of a 10-day electricity consumption average in the AEMO baseline (only partly offset by an adjustment set earlier in the day).

Baselines are difficult to set for residential households and the growth of rooftop solar, battery storage, electric vehicles and other technologies and devices that use, store and discharge energy will make it even more challenging to baseline and forecast residential demand in coming years.

The intersection of restrictive baselines with the high costs of customer acquisition can create a barrier to entry and market growth for the Wholesale Demand Response (WDR) mechanism. With a limited pool of loads that can be registered, investing in the costs required for market entry can present a high risk. Analysts have identified baselines operating in an international context that could be applied in Australia (DNV Kema 2013a & 2013b). New baselines need to be trialed for the expansion of the WDR to other sectors and loads.[2]

1 AS-4777, 'Grid connection of energy systems via inverters – Part 1: General Requirements

2 See DNV KEMA (2013 a & b) for a summary of baselines used in international jurisdictions and how they could apply in Australia

Will automation of demand response be possible at scale?

Automation of demand response at business sites was described as the 'holy grail' and associated with higher volumes of demand response and less impact on sites – but all providers noted that in practice it was often difficult to achieve. Common customers concerns included cyber-security, health & safety, and operational impacts. These concerns were often overcome as customers became more comfortable with demand flexibility in practice, while other providers focused on developing more advanced communication systems with participants. Demand flexibility providers noted residents were more willing to cede control over some devices (e.g. pool pumps) than others (e.g. air-conditioning) – though this may have been related to the operational performance.

Nonetheless, the ARENA portfolio experience highlights that the path to coordinated demand flexibility is not straightforward: building social license for automated demand response is likely to be as important as technical innovation for aggregating and orchestrating customer energy resources.

Key Challenge #2: Improving access to demand flexibility value-streams

Value-stacking – combining multiple energy services and revenues – has been a priority of past ARENA-funded projects as it increases the value of demand flexibility for the energy system and financial returns for participants. For example, as one demand flexibility provider noted, a second value stream has the potential to double financial returns.

Four revenue or value streams can be potentially accessed by demand flexibility providers in exchange for energy services:

- Emergency demand response payments for capacity or events contracted via the Reserve Emergency Reliability Trading (RERT) scheme.
- Network demand flexibility: for example, payments to shift electricity consumption out of peak demand times to avoid or defer network upgrades
- Wholesale demand flexibility: payments for availability of capacity or arbitrate to reduce consumption in high-price times and/or increase in low-price times
- Frequency Control and Ancillary Services (FCAS): payments for fast-response demand response to maintain frequency and voltage.

The provision of demand response via the Reserve Emergency Reliability Trading (RERT) scheme and Frequency Control and Ancillary Services (FCAS) is well established. However, network demand management and wholesale electricity market demand response are less common. Past ARENA-funded projects have navigated the multiple value streams, sometimes successfully (e.g. developing a protocol for combining FCAS and wholesale arbitrage) but less successfully at other times (e.g. network demand contracts preventing participation in RERT). Some customer loads are inherently suited to selective value streams, such as large industrial loads that are better suited to rare emergency demand response events, while cold stores are more suited to automated intra-day load shifting of refrigeration in response to wholesale prices.

Many of the ARENA-funded projects reviewed were found to be 'value-pairing' rather than 'value-stacking' – recruiting customers for a second value stream after they have become comfortable with demand flexibility. Whilst there is a new cohort of ARENA-funded projects aiming to demonstrate 'value-stacking', these pilots are still at an early stage and the eco-system of participants and providers are still being developed.

A 'level playing field' is required for demand flexibility within and across programs

Government schemes have primarily focused on increasing renewable energy supply or energy efficiency rather than the uplift of demand flexibility. Policy and programs need to review the integration of demand flexibility alongside energy efficiency and storage to avoid conflicting incentives and support the development of demand flexibility and value-stacking opportunities where it can be a cost-effective alternative or complement to renewables and energy efficiency.

There's a need to promote financial certainty in the demand flexibility market

One of the strongest themes across the ARENA-funded projects reviewed in this study was the difficulty making the necessary business case when the valuation of demand flexibility across the different energy services remains uncertain: the value of demand flexibility shifts depending on a range of factors and circumstances such as weather, market prices, the application of baselines etc. RERT offers greater financial certainty than most value streams with an availability payment and event payments but as one customer stated 'they did not want to have to depend on a grid emergency' in order to make money from demand flexibility.

Demand flexibility has often grown most successfully in international jurisdictions such as Great Britain and leading US states with longer-term revenue mechanisms or price signals (e.g. capacity mechanisms) that can create greater financial certainty (see Liu 2017). As Brown et. al. (2019: 4) conclude in a review of international demand response mechanisms: 'jurisdictions with capacity markets consistently attract the most demand response participation, and the demand response resources there earn the vast majority of their revenues from capacity'. It is important that demand flexibility can participate effectively in the Capacity Investment Scheme proposed by the Federal Government. Under the Capacity Investment Scheme, contracts-for-difference will be open through competitive tender for dispatchable capacity to support variable renewable energy. Aggregated flexible demand could be a cost-effective alternative to energy storage technology, such as batteries and pumped hydro storage.

White certificate schemes are another option for creating greater revenue certainty and resolving the measurement challenges. Under energy efficiency and small-scale renewable energy certificate schemes, there is less revenue uncertainty for proponents and the energy savings or generation are not required to be quantified at a household level – they are averaged based on industry technology data. The use of these techniques may also be more appropriate for measuring demand response at a household level than to measure to exacting baseline methodologies. Certificate schemes with more stringent measurement and verification could also be a pathway for scaling demand flexibility in C&I sites. The recently commenced NSW Peak Demand Reduction Scheme is the first certificate scheme for demand flexibility in Australia.

Future programs should focus on innovative collaborations between stakeholders that create value-reflective drivers

The results of innovative tariff trials have been encouraging, such as EV users shifting charging out of peak demand periods or a 'solar soaker' tariff in South Australia which creates incentives to heat water in the middle of the day. However, most pilots have been implemented under standard retail tariffs with rates for blocks of time (off-peak, shoulder, peak), which limit the financial returns from demand flexibility (ISF 2018). There is a notable gap in pilots with collaborations between networks and retailers using cost-reflective tariffs or payments either by themselves or in combination with external value-streams.

Capturing the demand flexibility opportunity for EVs is going to require greater cooperation between the energy, building services, and transport fields – with new skills, capacity-building, mapping, improved data and engagement facilitate better two-way flow of information. While the ARENA-funded EV trials reviewed in this study are generating invaluable lessons with regards to operation and standards for vehicle to grid, they are also demonstrating that it may be too early for value-stacking from EVs. For example, EV charger integration within building services and building energy management systems are not well understood for effective vehicle grid integration. There are still many questions relating to vehicle-grid integration and demand flexibility that may need to be resolved first.

There are strategic implications for expanding demand flexibility to new and existing solar PV owners.

- The more likely pathway to impact for residential demand flexibility is to target new solar customers via the solar retailer and installer. Demand flexibility participation could be offered as an additional benefit at the point of installation instead of being the focal point for customer engagement. Metering issues can be addressed via installation of smart meters. Partnerships to bundle demand flexibility offers with rooftop solar via solar retailers/installers could be an avenue for growth.
- For existing solar owners, demand flexibility can increase the value of their solar generation. Frequency and volume of solar curtailment are growing rapidly as the growth in supply outstrips demand. There are a range of solutions emerging including proposals to apply export tariffs to rooftop solar – which is likely to be extremely unpopular and risk unintended consequences (e.g. damaged trust amongst consumers). Demand flexibility on its own may have less appeal for solar owners but agreement by households to orchestration to increase demand flexibility (e.g. remote control of air-conditioning) in exchange for increased scope for solar exports (e.g. dynamic operating envelopes) could be a solution to this problem.

Key Challenge #3: Planning Ahead - solutions for customer acquisition

Lengthy, expensive customer acquisition processes were identified as a recurring theme through almost most C&I, EV and residential projects reviewed in this study. There were common reports of long lead times, multiple site visits and bespoke negotiations. Demand flexibility requires a 'long and technical sales cycle' with 'extensive customer education and lengthy approvals associated with a 'novel' program. Customer acquisition was nominated as the 'major cost' of demand flexibility by a leading provider.

Uncertainty over financial impacts is a major deterrent to household participation. For residential demand flexibility, there was extensive experimentation in the ARENA-funded trials to create more attractive customer offers. Models over time coalesced around several core features: 'opt-in/opt-out' models to reduce concerns about being locked-in, no up-front costs, and sign-up payments sufficiently large to meet the 'get out of bed' test (variously estimated between $10 - $50).

For C&I sites, some of the success factors observed for customer recruitment were identifying an 'internal champion' within organisations, early alignment between procurement and operational staff and iterative recruitment campaigns that are able to quickly reconfigure offerings and targets based on field learnings.

More social and behavioural research is needed to better understand customers. Trial participant sizes are small and typically drawn from customer types interested in engaging with technology (e.g. middle-aged men, 'retired engineers') leaving questions about drivers for other groups. How, for example, will EV drivers who are less tech-savvy react to incentives to charge outside peak times? ARENA EV pilots have to date been led by energy utilities; it would be beneficial to see a greater variety of trials with a focus on customers under different use cases, tariff structures, transport actors, and business models.

Integrative business models are key for growth - rooftop solar and demand flexibility

Demand flexibility is rarely a key priority for customers – it's complex, unfamiliar and the financial rewards at the micro-level (especially in the residential sector) rarely align with the macro-value of aggregated demand flexibility. Aggregated demand flexibility can enable higher volumes of renewable energy across the energy system, but households may only earn tens of dollars for participating. Demand flexibility providers observe that the best way to increase uptake is often to incorporate demand flexibility within other services (e.g. installation of air-conditioning) that are valued by customers.

Rooftop solar is currently a household's highest value DER asset – and working out how the value proposition and business model maximises the value of solar can be an important pathway for scaling demand flexibility. Rooftop solar output provides an enormous resource to be stored and shaped to increase value for households and the energy system – but projects observed that it was more difficult to get households with rooftop solar interested in demand flexibility because the financial returns from solar are much larger.

Lessons learned – '*shadow pricing*' could solve customer recruitment challenges:

The Rheem pilot highlights a conundrum for projects using time-of-use tariffs: customer fears about the impacts can prevent pilots attracting sufficient numbers of customers in the first place to demonstrate a tariff. It may be that alternatives such as shadow pricing are required in the initial trial phase to enable customer recruitment; that is, the customer remains on current tariffs but the trial measures results under alternative tariffs to demonstrate financial benefits before switching customers to new tariffs.

1. INTRODUCTION: ARENA & DEMAND FLEXIBILITY

Modelling commissioned by ARENA and undertaken by NERA Economic Consulting estimated the net benefit of increased demand flexibility to range from $8 billion to $18 billion and found the benefits increase as the share of renewable energy grows in the energy system (NERA 2022). There is a large body of research that finds demand flexibility can improve the efficiency, security and resilience of electricity markets and networks with high penetrations of renewable energy.

However, demand flexibility currently plays a modest role across the energy system. Consequently, increased demand-side participation and flexibility has been identified as a strategic priority in ARENA's 2022 Investment Plan. ISF has been commissioned as the Knowledge Sharing Agent for ARENA's Demand Flexibility portfolio, in partnership with RMIT and an expert panel comprising the Australian Alliance for Energy Productivity (A2EP), Energy Efficiency Council (EEC), the RACE for 2030 CRC and Commonwealth Scientific and Industrial Research Organisation (CSIRO).

This report presents the collective insights learnt from ARENA's existing portfolio of projects. The methodology included a combination of desktop review of knowledge sharing reports produced by the projects, stakeholder interviews and expert panel review.[3]

1.1 WHAT IS DEMAND FLEXIBILITY?

ARENA defines 'demand flexibility' as *'the capability to vary customer demand in response to generation, network, or market signals. Demand flexibility can operate in real time and can be incorporated into long-term investment decisions'.* ARENA's demand flexibility portfolio has four objectives:

› Demonstrate the potential value of flexible demand to the electricity system, including through the avoidance of additional network and storage build costs.
› Demonstrate the technical and commercial viability of a range of novel flexible demand options, including managed charging of electric vehicles, flexible operation of hydrogen electrolysers, and other loading shifting technologies in industrial, commercial and residential settings.
› Effectively integrate and orchestrate novel sources of flexible demand and supporting infrastructure and services, such as demand management systems, dynamic operating envelopes and virtual power plants.
› Support projects and knowledge sharing that will inform the regulatory framework on flexible demand, such as how it can best support two-sided markets.

1.2 THE OPPORTUNITY OF DEMAND FLEXIBILITY

Estimating the scale and location of the opportunities for demand flexibility remains a very challenging task. Two major reviews have recently been undertaken on the state of the evidence and modelling on the scale of the opportunity for demand flexibility across different technologies and sectors.

NERA *VALUING LOAD FLEXIBILITY IN THE NEM*[4] (2022)

NERA Economic Consulting was commissioned by ARENA to estimate the potential for demand flexibility under a range of scenarios until 2040. The modelling found that demand flexibility achieves significant cost savings under a range of scenarios (State of Worlds) – with the highest savings occurring in the scenario with the highest penetration of DER.

3 Interviews were conducted with AGL (demand flexibility and electric vehicles), Enel X, Origin (electric vehicles), Rheem,

4 arena.gov.au/knowledge-bank/valuing-load-flexibility-in-the-nem/

TABLE 5 SCALE OF OPPORTUNITY FOR DEMAND FLEXIBILITY, RESIDENTIAL, COMMERCIAL AND INDUSTRY SECTOR

SCENARIO	DESCRIPTION	SAVINGS
State of World 1	Baseline case i.e. greater flexibility with current commercial and residential technologies	$1 - $6 billion
State of World 2	High electric vehicle uptake	$3 - $5 billion
State of World 3	Electrification	$4 - $5 billion
State of World 4	High Distributed Energy Resources:	$8 - $18 billion
State of World 5	High Hydrogen	$3 billion

The modelling highlights the high level of uncertainty and variability in the role that demand flexibility may play depending on the future pathways of the energy transition.

The modelling also highlights there are differences in the key sources of demand flexibility under these different pathways (figures 4 – 7). Notwithstanding these variations, residential sources of demand flexibility dominate the profile in each of the scenarios except High Hydrogen:

› Under the baseline scenario, residential hot water system is the major resource for demand flexibility following by pool pumps and commercial HVAC.
› Under the high DER scenario, the primary sources of demand flexibility are battery storage, residential EV and hot water.
› Under the electrification scenario, flexible EV charging dominates the profile of demand flexibility with smaller contributions from residential and commercial hot water.
› Under the high hydrogen scenario, flexible hydrogen dominates the profile of demand flexibility with contributions from behind-the-meter storage and residential electric vehicle charging.

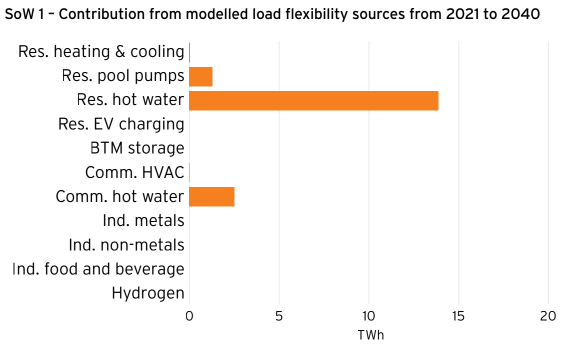


Figure 4 SoW 1 - Baseline scenario

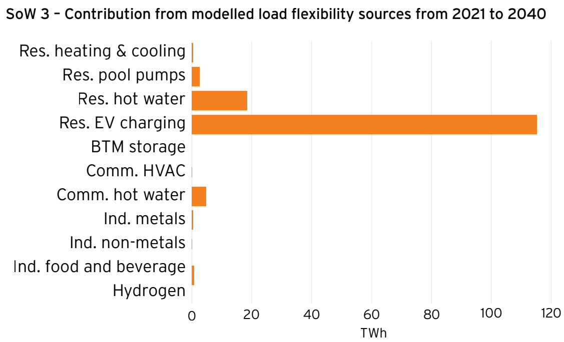


Figure 5 SoW 3 - Electrification scenario

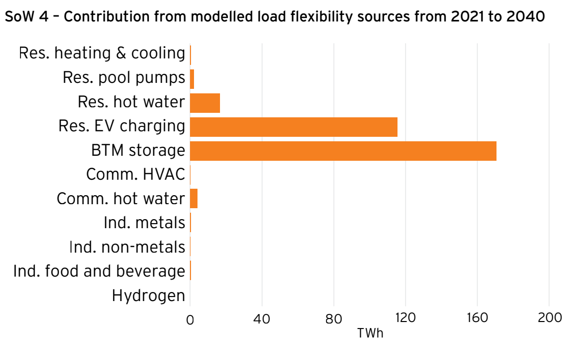


Figure 6 SoW 4 - High DER uptake scenario

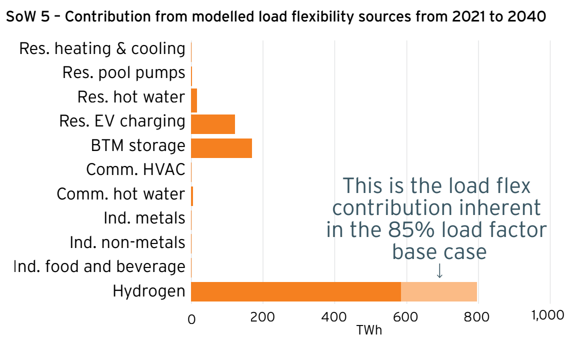


Figure 7 SoW 5 - high hydrogen scenario

RACE FOR 2030 *FLEXIBLE DEMAND AND DEMAND CONTROL OPPORTUNITY ASSESSMENT*[5] (2021)

The RACE for 2030 CRC 'opportunity assessment' found it very difficult to accurately value the demand flexibility opportunity due to major data gaps relating to the size of the opportunity for many sectors and technologies. In particular, there is very limited data on the scope for demand flexibility in the industrial sector. Nonetheless, RACE for 2030 CRC estimated the scale of opportunity across selected technologies within the residential, commercial and industrial sectors (Table 6) for emergency demand response (load shedding), peak demand shifting, and minimum demand shifting.

TABLE 6 SCALE OF OPPORTUNITY FOR DEMAND FLEXIBILITY, RESIDENTIAL, COMMERCIAL AND INDUSTRY SECTOR

SECTOR/LOAD	COINCIDENT WITH PEAK DEMAND		COINCIDENT WITH MINIMUM DEMAND
	EMERGENCY FD RESOURCE	MARKET PARTICIPATION FD RESOURCE	INDICATIVE ESTIMATE ONLY
	(MW SHED)	(MW SHIFT)	(MW)
BUILT ENVIRONMENT			
Residential hot water	450	450	4,900
Residential swimming pool pumps	170	170	450
Residential air-conditioning	6,900	970	970
Commercial HVAC	1,500	190	190
Total	**9,020**	**1,780**	**6,510**
INDUSTRIAL			
Other (non-coal) mining	Unknown	1,044	Unknown
Food, beverage & tobacco manufacturing	Unknown	224	Unknown
Other transport, services & storage	Unknown	22	Unknown
Water, sewerage & draining services	Unknown	83	Unknown
Agriculture, forestry & fishing	Unknown	140	Unknown
Total (32 per cent industry consumption)		**1,511**	

Source: Brinsmead et. al. 2021 (RACE for 2030 CRC)

The largest opportunities that were identified were in agriculture (especially water pumping), manufacturing (food, beverage and tobacco manufacturing), and large industrial energy users (including non-coal mining). Notably, many of the largest opportunities were identified as being in the residential sector:

- **Residential air-conditioning:** top-down disaggregation of the temperature-dependent load highlighted large-scale opportunities across emergency, peak demand and minimum demand services.
- **Residential hot water:** bottom-up stock modelling of appliances identified a large opportunity to shift heating into the middle-of-the-day and a lesser opportunity for emergency and peak demand flexibility.
- **Residential pool pumps:** based on bottom-up stock modelling, the major opportunity is to shift demand into the middle of the day albeit at a lower scale to hot water.
- **Commercial HVAC:** a large-scale resource for switching off air-conditioning (shed) as an emergency measure, but also by nudging thermostat settings up or down (shift) in response to price signals.

One of the key findings shared between the NERA and Race for 2030 studies is that the larger opportunities are likely to be in the residential sector – which is important to keep in mind because of the challenges experienced by ARENA projects to date in the residential sector.

5 racefor2030.com.au/wp-content/uploads/2023/03/RACE-B4-OA-Final-report.pdf

1.3 ARENA'S DEMAND FLEXIBILITY PORTFOLIO

Whilst demand flexibility is a relatively new strategic priority for ARENA, the Agency has previously allocated $180 million across 55 projects across a range of sectors and technologies (see Table 3) that provide valuable lessons applicable to demand flexibility:

- The largest number of projects have been in the **Commercial and Industrial (C&I) sector**, including a partnership with AEMO on pilot projects for emergency demand response under the Reliability and Emergency Reserve Trader (RERT) scheme and on-site energy management and technology demonstration (e.g. process heat, heating and cooling, and thermal energy storage).
- The largest level of investment has been in the **Residential sector**, including RERT, virtual power plants (VPPs), battery storage, and integration with solar photovoltaics.
- A collection of projects have been funded to demonstrate orchestration platforms for integrating DER (including demand flexibility but also solar generation and battery storage). Orchestration platforms and interoperability do not form a major focus for this review, as many of these projects are at an early stage, however, t is expected they will form part of the later stages of the project.
- Four **Electric Vehicle** (EV) projects have been funded – three for residential charging and one for business charging.
- ARENA has funded 11 **hydrogen** projects, but the flexible hydrogen projects are not yet sufficiently advanced to be part of this review.

TABLE 3: ARENA DEMAND FLEXIBILITY PROJECTS, BY SECTOR

SECTOR	NUMBER OF PROJECTS	ARENA INVESTMENT ($M)
Commercial and industrial	20	26.1
Residential	13	77.4
Hydrogen	11	46.6
Electric vehicles	4	8
DER orchestration	7	37.6
Total	**55**	**180**

Note: See Appendix A for a full list of projects

The list of projects funded by ARENA is very diverse with varying levels of relevance for a demand flexibility review; a significant number of projects were not funded directly to demonstrate demand flexibility but a related technology or approach (e.g. energy productivity).

The variety of projects with different aims and metrics create challenges analysing ARENA's impact on demand flexibility. It is not possible to quantify the exact volume of demand flexibility capacity funded by ARENA and its overall cost. The scope of this review is ARENA-funded projects and the depth or number of projects varies significantly by sector, technology and type of demand flexibility. In some cases, there is a cluster of projects (e.g. emergency DR/RERT), but in some other cases there might only be one project (e.g. pool pump). This review is therefore qualitative with insights being drawn from case studies. In each section, the projects are listed to make clear the evidence base.

1.4 SCOPE OF THIS REVIEW

Existing projects were reviewed against a set of knowledge gaps and research questions identified by ARENA. Following input from the expert panel, a sub-set of knowledge gaps identified by ARENA were used to guide the review (see Appendix B for full list).

TABLE 4 KNOWLEDGE GAPS AND RESEARCH QUESTIONS APPLIED TO THIS REVIEW

KNOWLEDGE GAPS	RESEARCH QUESTIONS	
The value and role of demand flexibility	**RQ1:** What value streams are flexible demand currently accessing and how is that value being stacked?	**RQ2:** What are the barriers to accessing value streams from flexible demand?
Use of technologies to enable demand flexibility, level of maturity, and what further technology innovation is required	**RQ3:** How are flexible demand technologies being utilised? Are there key priorities for technology innovation to unlock flexible demand?	
Retail, aggregator and third-party business models and customer journey	**RQ4:** What is the customer experience and what are the key values and pain points in the customer journey? What are the costs for customers and aggregators?	
Regulatory frameworks: barriers and reforms could support efficient levels of flexible demand	**RQ5:** How are current metering arrangements and network and/or retail tariffs contributing to or inhibiting demand flexibility? How can they be reshaped to align with and unlock the value of flexible demand?	**RQ6:** How effective are current methodologies and baselines for flexible loads (e.g. calculations, settlement procedures, verification)? How can they be reshaped to balance accuracy, accessibility and cost?
What are the customer barriers to scaling flexible demand and priority actions	**RQ7:** What are the learnings from successful or unsuccessful models for increasing consumer uptake of flexible demand?'	

2. INSIGHTS FROM ARENA PROJECTS: VALUE-STACKING

BACKGROUND

Demand flexibility can provide a range of energy services and access different value-streams:

- Emergency demand response: demand response contracted for contingency management via the Reserve Emergency Reliability Trading (RERT) scheme.
- Network: shifting electricity consumption out of peak demand periods to avoid or defer network upgrades or into low demand periods to improve grid stability and utilisation.
- Wholesale: demand flexibility in response to wholesale price signals to reduce demand in high-price intervals or increase demand in low-price intervals.
- Frequency Control and Ancillary Services (FCAS): the use of fast-response demand response to maintain frequency and voltage to ensure grid stability.

One of the barriers to increased demand flexibility is creating incentives for consumers by tapping into the different value-streams – either 'implicitly' (e.g. retail tariffs which incorporate price signals) or 'explicitly' (e.g. demand response event payments). Developing systems for 'value-stacking' can increase the value of demand flexibility for the energy system and the revenue and incentives for customers.

RESEARCH QUESTION

RQ 1: What value streams are flexible demand currently accessing and how is that value being stacked?

RQ 2: What are the barriers to accessing value streams from flexible demand?

MAJOR PROJECTS

- AGL *Demand Response (RERT)*, 2017 – 2021
- Enel X *Demand Response (RERT)*, 2017 – 2021
- EnergyAustralia *Demand Response (RERT)*, 2017 – 2021
- Flow Power *Energy Under Control Demand Response (RERT)*, 2017 – 2021
- ISF & A2EP *Renewable Energy and Load Management (REALM)*, 2019 – 2021
- Powershop Australia *Demand Response (RERT)*, 2017 – 2021
- Zen Ecosystems *Demand Response (RERT)*, 2017 – 2020

KEY FINDINGS

- The development of demand flexibility capacity through a funding round for RERT in partnership with AEMO has been one of the great successes of ARENA to date. Whilst demand flexibility remains a fledgling market, the funding round enabled a collection of providers in the Australian market to develop capacity and move demand flexibility from a 'fringe' product.
- Most ARENA projects were 'value-pairing' rather than 'value-stacking' – recruiting customers for a second value-stream. The next generation of projects now emerging are the first to attempt more ambitious value-stacking and combining and optimising three or more value-streams.
- ARENA funding enabled demand flexibility providers to access new value streams, notably RERT and FCAS, but there are few projects targeting network demand management and less wholesale demand management.
- Solutions were sometimes identified to barriers between value stacking, but providers found certain types of customers and loads were inherently suitable for some value-streams and not other streams.
- Electric vehicle projects have been unable to access external value-streams or undertake value-stacking, due to a range of factors including charging technology limitations, response delays related to technical standards and inability to aggregate sufficient volume.

MANY ARENA PROJECTS DID NOT ACCESS EXTERNAL VALUE STREAMS OR FLEXIBLE TARIFFS

The Smart Energy Demand Coalition (2017) a European industry association usefully distinguishes between 'explicit' and 'implicit' demand flexibility revenue streams and incentives. An explicit demand response scheme involves either capacity/availability and event payments being made to incentivise consumers to engage in demand response. By contrast, an implicit demand response incorporates price signals (e.g. variable tariffs that reflect market value) to shape demand. Both are required in order to fully harness different types of consumers with capacity to engage in demand flexibility.

In general, many C&I ARENA projects were not accessing either external value streams or using retail and network tariffs that reflect external value and create incentives for demand flexibility. Most ARENA projects trialing or demonstrating different types of on-site energy technologies (e.g. process heat, thermal storage, battery storage, solar PV) were aiming to reduce electricity bills through a combination of efficiency, on-site generation and load shaping that reduced network payments (based on monthly peak demand from the site) or peak-shaving retail tariffs.

For some of these projects, demand flexibility was a minor or secondary component. In the Renewable Energy and Load Management project (ISF & A2EP), a collection of sites undertook feasibility evaluations of different combinations of demand flexibility technologies such as cold-water storage tanks and refrigeration with solar PV. One of the key findings was that retail tariffs did not reflect the value of demand flexibility and that it was difficult to develop a successful business case without external revenue streams or tariffs that incorporated the value of external market and network services.

ARENA PROJECTS HAVE BEEN A CATALYST FOR DEMAND FLEXIBILITY IN RERT & FCAS

In May 2017, ARENA partnered with the Australian Energy Market Operator (AEMO) with the aim of funding 200 MW of Demand Response capacity per annum over three years for activation under the RERT mechanism – with at least 143 MW to be available for the summer in 2017. A total of 10 pilot projects in Victoria, South Australia and New South Wales were awarded funding[6].

However, the projects that did proceed had a major impact by demonstrating and enabling demand flexibility portfolios to be constructed for both the C&I and residential sectors which have been a foundation for the expansion into other value streams.

- Enel X: 50 MW (70 per cent industrial, 30 per cent Commercial)
- AGL: 3.9 MW (residential) and 20 MW (C&I).
- Flow Power: 29.8 MW (industrial)
- EnergyAustralia: 50 MW+ (C&I)
- Intercast & Forge: 5 – 12 MWh events (industrial company)
- Powershop: 10,000 – 30,000 residential customers

6 https://arena.gov.au/knowledge-bank/demand-response-short-notice-trial-rert-trial-year-3-report/

In less than four years, demand flexibility remains a fledgling market but has moved from a 'fringe' to a 'mainstream' product with a collection of providers in the Australian market.

- AGL has built a demand response portfolio of 215 MW (1 GW when you include the smelters where demand response existing prior to ARENA funding).
- Enel X has 66 MW registered in the Wholesale Demand Response (WDR) mechanism.
- Flow Power has developed a combined PPA-demand flexibility product that has been influential in the growing Corporate PPA sector.
- The revenue stream from RERT – including a negotiated availability payment and an event participation payment – is relatively stable compared to other demand flexibility revenue streams and proved a good foundation for the development of demand flexibility capacity into other value streams. For example, following the commencement of the Wholesale Demand Response mechanism in late 2021, Enel X have been adding wholesale demand response for customers that participate in RERT and FCAS. The development of demand flexibility capacity through the RERT round has been one of the great successes of ARENA to date.

ARENA funding also enabled the development of demand flexibility for FCAS. Tesla initially made extensive use of and dominated the FCAS market with its large-scale battery (e.g. reporting revenue of $225,000 from 4 events). Other ARENA demand flexibility projects have also successfully accessed FCAS (e.g. Enel X reported 139 FCAS events with an average duration of < 5 minutes).

THE FIRST GENERATION OF C&I PROJECTS ENGAGED IN 'VALUE-PAIRING' RATHER THAN 'VALUE-STACKING'

Notably, ARENA projects have to date engaged in 'value-pairing' rather than 'value-stacking' in which multiple streams are orchestrated and combined. Several projects reported success with recruiting business customers for a second value stream after a positive experience with demand flexibility in another value stream. For example:

- **Flow Power** reported that several customers who started with RERT moved onto wholesale pricing as they become comfortable and confident in their on-site demand flexibility capacity[7]. RERT's combination of relative financial certainty and limited number of demand response events enabled users to gain experience and knowledge that led them to take next step of demand response events for wholesale price events.
- **Enel X** reported that experience with FCAS also created a pool of companies who were 'well-educated' on demand flexibility and therefore able to be recruited for RERT.

For aggregators, there were economies of scale benefits in building off a customer base enrolled in another value stream. As a rule of thumb, one demand flexibility provider noted that adding a second value-stream doubled returns for business participants. Grid-scale batteries and VPPs are also accessing a combination of FCAS and wholesale revenue streams depending on market prices (AEMO 2022).

New ARENA projects are now underway which are aiming to stack multiple value-streams (or provide 'end-to-end solutions'). For example:

- Wholesale/FCAS/Network (GreenSync)
- Wholesale/local network services/emergency DER curtailment/FCAS (Project Symphony)

Electric vehicle charging projects are targeting local peak shaving, intra-day balancing/arbitrage, FCAS and network services.

- **FCAS:** Both ActewAGL and AGL-led trials sought to demonstrate FCAS as a revenue stream for EVs through bi-directional charging. Both trials suffered challenges due to supply chain delays with the chargers, issues with certification, and suitability of the equipment such as metering. AGL decided to abandon the part of their trial that involved FCAS early following initial issues with the chargers.
- **Network:** ActewAGL aims to test frequency response, passive anti-islanding, voltage, rate of change of frequency (RoCoF), phase jumps, and active power management. Reactive power has not been tested due to a lack of firmware support with chargers, while peak shaving and voltage management was not tested as they are not yet able to be implemented by the controller.
- **Wholesale:** there is an alignment between network and wholesale value for electric vehicle charging projects aiming to shift demand from the late afternoon. Peak-shifting through both ToU tariffs and incentives for charging at particular times to assess customer perceptions during and after these events is a feature of multiple electric vehicle trials. However, they are not as of yet explicitly accessing wholesale electricity prices or network payments to address network demand.

7 Flow Power, Project Performance Report – Energy under Control, May 2020, p.10

WHOLESALE & NETWORK VALUE STREAMS HAVE BEEN LESS COMMONLY ACCESSED

If ARENA funding has played an important role enabling demand flexibility providers to access RERT and FCAS as value-streams, there are fewer ARENA projects accessing wholesale market revenues (excluding large batteries) and there is a notable gap in network demand management. There were few projects accessing wholesale pricing (noting these projects mostly pre-date the Wholesale Demand Response (WDR) mechanism). The Demand Management Incentive Scheme (DMIS), designed to create incentives for network demand management, has delivered consumer benefits but the uptake by networks has been very modest.[8]

THERE WAS MIXED PROGRESS ON ADDRESSING CONFLICTS BETWEEN VALUE-STREAMS

ARENA projects observed various conflicts between value-streams when they were attempted to be combined – and mixed results in resolving these conflicts.

› FCAS/Wholesale

There were conflicts between FCAS and wholesale price response. Higher returns from wholesale price events led to under-delivery by customers for FCAS events. A solution emerged from the Tesla project. In collaboration with AEMO, a protocol was developed: whilst the system was operating within the normal frequency band, wholesale price signals would be prioritised by demand response providers and vice-versa to avoid conflicts that could compromise system security.

› RERT/Network

Participants in the RERT funding round reported that customers already on 'critical peak' network tariffs with Ausnet (Victoria) did not participate in RERT because they would face financial penalties even if they missed just 1 or 2 events (Enel X Demand Response). The critical peak network event windows were in the middle of the RERT baseline adjustment period – and therefore reducing demand for the network event lowered the intra-day baseline calculation and removed financial incentives for participating in RERT. There was also uncertainty about AEMO's interpretation of dual participation which led aggregators and businesses to prioritise network demand response participation ahead of RERT.

› RERT/FCAS

There were also conflicts observed between FCAS and RERT. Whilst FCAS was reported as being less interruptive for customers than the longer duration of RERT events, the greater financial certainty of availability payments under RERT generally led customers to 'opt-out' of FCAS to make themselves available in response to AEMO invitations to tender for reserve notices.

There was also uncertainty about eligibility for RERT if customers were providing contingency FCAS – as frequency control is a separate service to 'reserve' capacity. Enel X records that AEMO informed them that any load 'contracted under a reserve contract' is ineligible for FCAS. Invitations to Tender (ITTs) under RERT can last for a week and therefore miss 60-hours of FCAS payments under this interpretation.

High FCAS prices and uncertainty about AEMO interpretation led them to primarily focus on recruiting new sites for RERT and not to dual-register existing FCAS sites.

8 Since the inception of the DMIS (December 2017), $3 million of projects have been funded delivering consumer benefits of $50 million since its establishment in December 2017 (AER 2023). However, this represents a small proportion of the permissible revenue of around $500 million (1 per cent of distribution network revenue) over the 5-year period. Additionally, the most common project type is temporary generation (especially diesel) to reduce peak demand.

BARRIERS TO VALUE-STACKING

Whilst it remains early days for projects that are value-stacking, the following barriers have been observed:

- **Some loads are inherently better suited to particular value streams and not others due to overriding business imperatives:** for example, large industrial loads are suited to emergency demand response events but not intra-day flexing whereas cold stores and refrigeration are better suited automated to intra-day load shifting and wholesale price arbitrage.
- **Valuation of demand flexibility revenue streams is very difficult:** there is high uncertainty about the volume of earnings from different revenue streams making it very difficult to make a compelling business case. The value can vary depending on energy market circumstances, barriers to accessing the opportunity, the pricing model, baselines and resource availability at the time it is required which can also be unpredictable.
- **Pathway to accessing value-streams is sometimes unclear:** Whilst minimum demand has emerged as a major priority in several jurisdictions as rooftop solar erodes demand in the middle of the day, there is limited information on the value of the opportunity, for example, what's the value of the curtailed solar that could be unlocked? What is the value of the network service and how can it be accessed?
- **Electric vehicles have specific barriers:** Determining the availability of vehicles at a given time for V2G was stated repeatedly as a major visibility in the ActewAGL trial. In order to bid into the FCAS market, the retailer needs to understand how much storage capacity is available to bid both ahead of time (days) and in a 5-minute timeframe. As vehicles are unplugged and change location, V2G must resolve this challenge, which is not shared by other technologies in competition with V2G such as stationary batteries and Virtual Power Plants. Determining the value of vehicle-to-grid is contingent on how energy is priced (from fixed fees to dynamic pricing), reconciling revenue with fleet running costs, the emerging costs of public charging by parking operators, impacts on resale value and battery lifetime, as well as many other factors.
- **Non-price barriers:** a range of barriers relating to consumer infrastructure, regulatory standards, IT and data and supply-chain chains were also detailed which are analysed in sections below.

It will be challenging to develop a business case for action until demand flexibility can be more easily, transparently and predictably valued by customers, providers and energy system participants.

3. INSIGHTS FROM ARENA PROJECTS: HOW ARE FLEXIBLE DEMAND TECHNOLOGIES BEING USED?

BACKGROUND

ARENA has funded projects aiming to demonstrate demand flexibility in a range of technologies, including electric vehicles, air-conditioning, pool pumps, residential hot water and thermal energy storage. Snapshots of the experiences and learnings for each of the technologies are outlined in this section.

RESEARCH QUESTION

RQ 3: How are flexible demand technologies being utilised? Are there key priorities for technology innovation to unlock flexible demand?

KEY FINDINGS

The use and experiences with technologies in ARENA projects for demand flexibility has varied significantly. Whilst pilots with some technologies have proceeded relatively smoothly, some of the most prospective opportunities for demand flexibility have encountered major difficulties from technical, supply-chain and regulatory barriers.

- **Air-Conditioning:** residential air-conditioning has been identified as a large-scale opportunity (NERA 2022) and there was some orchestration through ARENA pilots, but overall pilots found the capacity to utilise residential air-conditioning frustrated by technical, operational and supply-chain barriers
- **Electric Vehicles:** It is still early days for electric vehicle smart charging and there have been some encouraging results with the use of flexible tariffs. However, modernising industry standards (e.g. AS-4777) that are not yet fit for purpose before the mass adoption of electric vehicles will be important to avoid the experience of ARENA air-conditioning demand response projects.
- **Pool Pumps:** ARENA has funded one project which successfully orchestrated pool pumps for emergency and wholesale demand response albeit at a small-scale.
- **Thermal Energy Storage:** promising complement to HVAC systems.
- **Residential hot-water:** orchestration has been successful where operational – but supply-chain constraints, regulatory standards and in particular customer recruitment have proven major barriers to scaling the pilot.
- **Commercial HVAC:** there are best-practice cases demonstrating potential but challenges to scale through the building stock.
- **Behavioral demand response:** behavioural demand response projects were generally considered successful and a lever for customer loyalty – albeit inherently limited to motivated customers.

3.1 ELECTRIC VEHICLES

PROJECTS

- ActewAGL *Realising Electric Vehicle-to-Grid Services (REVS)*, 2020 – current
- AGL *EV Orchestration Trial*, 2020 – current
- Jemena *Dynamic EV Charging Trial*, 2020 – current
- Origin Energy *EV Smart Charging Trial*, 2020 – current

KEY FINDINGS

A fully electrified vehicle fleet presents a major opportunity for demand flexibility. With the Australian EV market several years behind other countries of comparable economy and standard of living, there is an opportunity to avoid a repeat of the issues experienced by other technologies – electric water heaters, reversible A/C units, and pool pumps – that hadn't been able to address the regulatory and standards issues before mass deployment.

- With a range of value streams targeted by the projects, the tariff trials yielded some encouraging results in shaping charging behaviour and therefore increasing demand flexibility.
- Other value streams (reactive power, peak shaving, voltage management, FCAS) proved more challenging to capture and monetise due to technical, operational, and supply chain issues.
- Industry standard AS-4777 proved a challenge on multiple levels for enabling bidirectional charging for EVs, showing itself not fit for purpose and in need of major reform if Vehicle-to-Home or Vehicle-to-Grid is to stand a chance to become established in future in Australia.

While a number of flexibility value streams were targeted in the ARENA trials, the real value in the findings were those that were related to those that couldn't be captured due to technical, regulatory, supply chain, or operational issues.

HOME OR WORKPLACE CHARGING HAS BEEN THE PREDOMINANT FOCUS OF EV DEMONSTRATIONS IN AUSTRALIA

To date, most pilots have focused on home and workplace charging due to suitability for longer dwell times and easier market access.

- AGL trialed 200 participants with smart chargers and 100 (increased from 50) with charging controlled via an Application Programming Interface (API) supplied by the vehicle Original Equipment Manufacturer (OEM). 50 customers testing the V2G capabilities didn't proceed due to the issues previously mentioned.
- Jemena's trial of homeowners with smart charging investigated grid integration and customer attitudes to automated load control in households. Jemena's trial also tested EV charging performance for demand response and assessed customer perceptions during and after these events.

- Origin's trial with smart charging found positive results in terms of consumer behavioral change and charger performance. However, it was not able to understand if any further intervention was needed for peak events because charging wasn't occurring (due to active control or incentivised behavior).

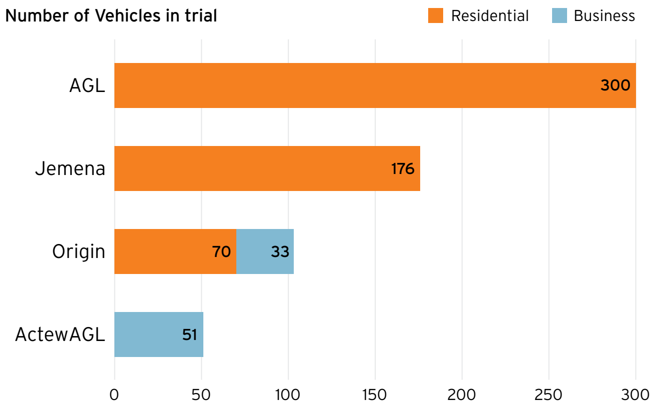


Figure 8 Number of electric vehicle residential and business trials

EARLY DAYS FOR BIDIRECTIONAL CHARGING – BUT BARRIERS TO VALUE-STACKING ARE BEING ENCOUNTERED

Local peak shaving, intra-day balancing, and contingency FCAS are being actively trialed in Australia.

- ActewAGL are in the early days of testing frequency response, passive anti-islanding, voltage, Rate of Change of Frequency (RoCoF), phase jumps, and active power management- reactive power was not tested due to a lack of firmware support, while peak shaving and voltage management was not tested as they are not yet implemented by the JET Charge controls.
- FCAS revenue wasn't generated in either the AGL or ActewAGL trial due to supply chain delays and issues with certification and standards. The knock-on effects were a delay in response times or insufficient aggregation to qualify for FCAS.
- Determining the availability of vehicles at a given time for V2G was stated repeatedly as a major technical challenge. In order to bid into the FCAS market, the retailer needs to understand how much battery capacity is available to bid both ahead of time (days) and in a 5-minute timeframe.

FCAS revenue wasn't generated in either the AGL or ActewAGL trial because of various issues with supply chain delays, certification and standards with the bidirectional chargers. The knock-on effects were a delay in response times or insufficient volume to qualify for FCAS.

INDUSTRY STANDARDS AND REGULATION FOR EVS

Industry standards and regulation are net yet fit for purpose for vehicle grid integration. Legal requirements for a project vary across States and Territories increasing complexity, cost, and confusion among stakeholders. Charging standards are still evolving with short-term fixes being implemented to enable vehicle grid integration. This is resulting in uncertain economic viability and leading to practical difficulties.

CHAdeMO is the only current standard for V2G but the Combined Charging System plug (CCS2) is expected to become the default standard for Australia post-2025. Research questions answered under the CHAdeMO standard will likely need revisited under any new prevailing standard.

For any inverter-based embedded distributed generator to connect to an Australian grid, it must comply with the AS/NZS 4777 standard. The requirements (in both a technical and process sense) have been found to be considerably more onerous for a V2G charger to comply with than in other markets, while slowing the response time beyond what's needed to earn revenue from FCAS events.

Bidirectional chargers are assumed by the standard as a multiple mode inverter connected to a stationary battery, requiring an earthing point, which EVs don't have or need. This required modifications by the charger manufacturer to the hardware to provide an earthing connection to the vehicle through the charger connection. This led to test failure in terms of electromagnetic compatibility and excessive high frequency noise, with further modifications needed which added time, effort, complexity, and reduced visual amenity. Mixing and matching hardware and software across different OCPP (Open Charge Point Protocol) versions will introduce additional maintenance across the ecosystem of charger and software platforms. Closed or proprietary ecosystems can force operators into either using one vendor (leading to lock in) or increase cost and complexity for integration (if technically possible).

3.2 AIR-CONDITIONING

PROJECTS

- AGL *Demand Response (RERT)*, 2017 – 2021
- EnergyAustralia *Demand Response (RERT)*, 2017 – 2021
- Powershop Australia *Demand Response (RERT)*, 2017 - 2021
- Synergy *Alkimos Beach Energy Storage Project*, 2014 – 2021
- Western Power *Project Symphony*, 2021 – current
- Zen Ecosystems *Demand Response (RERT)*, 2017 – 2020

KEY FINDINGS

Residential air-conditioning is a large-scale opportunity for demand flexibility – but in general air-conditioning has proven very difficult for ARENA projects to access to date. Most air-conditioning projects experienced serious technical issues:

- Many air-conditioning units did not have demand response capability (they were not compliant with the AS-4755 technical standard and could not be remotely controlled).
- Installations were too often complex, expensive, slow – and required upgrades multiple visits from skilled installers and inconvenience for customers.
- There were a wide variety of problems in the operation of air-conditioning demand response, including units that did not implement commands and customer complaints when air-conditioning turned down further than intended from 50 per cent to zero.
- technical limitations linked to the AS-4755 standard with compliant units, such as the absence of 2-way communication, a feedback mechanism or a customer over-ride capability.
- The AEMO baseline does not work well for air-conditioning, primarily because the 10-day average discounts the dramatic growth air-conditioning loads that occur on hot days (Oakley Greenwood 2019).

Whilst a portfolio of air-conditioning units was orchestrated within ARENA trials, the level of demand response was less than expected and un-sustainably expensive (leading AGL to conclude it was 'unviable' at present).

Air-conditioning demand response has been an important element of multiple ARENA projects, but the capacity to orchestrate air-conditioning units was limited by a series of technical issues. At the core of many of the technical challenges were the coverage and operation of the Australian Standard for demand-response enabled devices (AS-4755, 'demand response capabilities and supporting technologies for electrical products'):

- Many homes were found to have air-conditioning units that were not compliant with AS-4755 and could not be remote controlled by a DRED. The air-conditioning unit supply-chain is extremely fragmented with a wide diversity of products. AS-4755 is a voluntary standard and therefore many units are not equipped for demand response.
- Retailers don't have the information to target customers with AS-4755 compliant air-conditioning models e.g. AGL reported 40 per cent and the Alkimos Beach pilot reported 54 per cent of homes.
- Consequently, installations were complex, expensive, dependent on the assessment of skilled installers and inconvenient for customers. AS-4755 compliant units still often required an additional adapter to link to the DRED and there are 'many variants' of adapters – often requiring 2 or 3 site visits. Some of the AS-4755 compliant units had not fully implemented all of the demand response modes under the AS-4755 and required modifications. Upgrading units was a 4-hour installation at which the homeowner must be present.

Zen Ecosystems uses a different technology that does not require a DRED (direct control using infrastructure-red signals connected via the internet to the Zen Ecosystems cloud software) and can be self-installed. Whilst this could circumvent these technical issues, they were unable to evaluate the quantum of demand response because they could not get access to participants NMI data.

Once operational, there were also frequent issues with the performance of the air-conditioning units for demand response:

- There was no feedback mechanism to confirm the unit had successfully executed the command.
- Units responded inconsistently to central commands and investigations were unable to determine patterns behind unexpected behaviours (e.g. specific models) – these sites were therefore withdrawn from the trial.
- There's no over-ride capacity for the consumer to opt-out (which would require a phone call) and the AS-4755 does not incorporate room temperature. Customers raised complaints about comfort levels when air-conditioning units reduced their output to zero (instead of the intended 50 per cent or 75 per cent level). Some of these households were also withdrawn from the project.
- Even where compliant and operating as intended, the AS-4755 has technical limitations e.g. it only specifies one-way communication (whereas 2-way communication is standard in domestic appliances and internet control technology) and it is based on half-hourly consumption.

It should be noted there are examples of programs beyond ARENA which have found that relatively short adjustments to air-conditioning units could be aggregated into substantial load reduction with minimal impacts on customer comfort. Energy Queensland (2022:11), for example, has direct control of the air-conditioning units of over 140,000 customers using audio frequency load control.

The uncertainty over operation of air-conditioning units and absence of customer over-ride in AS-4755 is a major issue because customers were observed to be reluctant to cede control over air-conditioning. A survey by Project Symphony found: *'For residential customers, the DER devices they are least comfortable giving complete orchestration is air-conditioning.'*[9]

Overall, portfolios of residential air-conditioning were orchestrated but the results were lower than expected:

- There was less capacity than expected during demand response events (AGL reported only around 20 per cent of units in the trial were turned on at the time of the demand response events, both of which were held on weekday afternoons) and there were post-event spikes in demand as the air-conditioners ramped up to return to temperature set-points.
- For customers whose air conditioner was turned on and able to be controlled, the average load reduction was 1.7kW, but this result was due to many of the units reducing energy consumption to zero rather than the requested 75 per cent. If the air conditioners had correctly executed the 75 per cent consumption mode command, the average load reduction per unit would have been in the order of 0.6kW.

9 Western Power, Project Symphony Work Package 3.2: Aggregator Report, May 2022

Whilst demand response was able to be achieved from a portfolio of air-conditioners, it was a lot more expensive and difficult than expected. AGL went so far as to conclude it was currently 'unviable'.

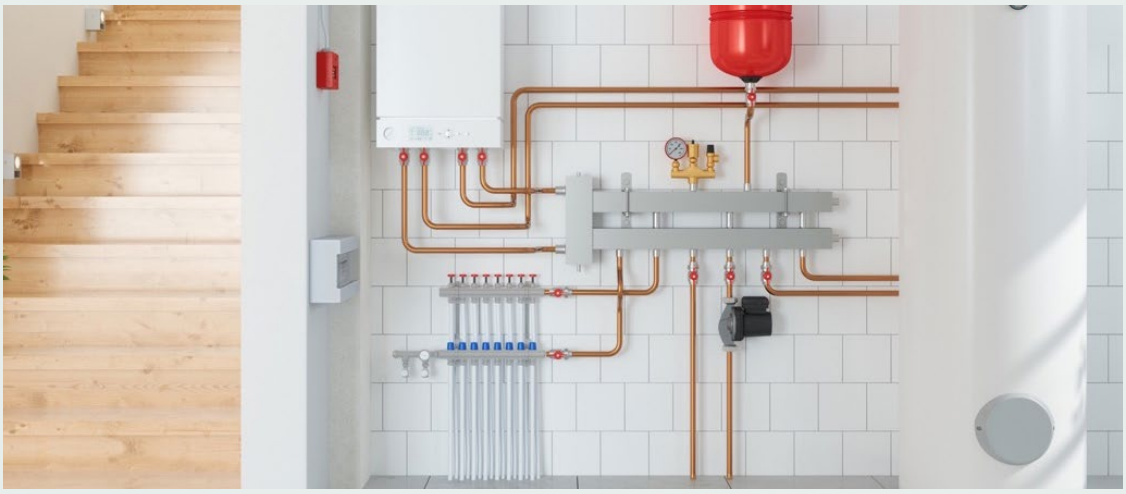
Zen Ecosystems and AGL also observed that if the dynamic baseline approach of AEMO were to be applied it would be unsuitable for household air-conditioning loads.

> *'high demand in the NEM on very hot days is often blamed on air-conditioning, however, counter-intuitively, air-conditioning loads don't work well as a DR resource in the RERT program because they often don't baseline well, especially in Southern Australia where the prevailing weather patterns in summer comprise increasing temperatures over 4 or 5 days, culminating in a very hot day (usually the RERT event day) followed by a cool change. In the case the 10-day average in the RERT baseline tends to discount the air-conditioning load on the very hot day because the average air-conditioning load on the previous 10 days has been much lower. This discount is supposed to be compensated for by the same-day adjustment factor but this doesn't happen because it is calculated too early in the day … before air-conditioners are operating at full load'.*[10]

The key learning from the ARENA pilots is that the coverage and specifications of technical standards need to be reformed to lay the foundations for mass up-take of residential air-conditioning demand response. There are some technology solutions that are claimed to be suitable for self-installation but as soon as any retrofitting or site visits are required, the cost exceeds the benefits. Technical standards need to be enhanced and diffused through the fleet of air-conditioning units to create the mass scale, streamlined implementation and range of functions required to be cost-effective. If the pathway is also through RERT or the WDR (instead of a government program), the operation of the AEMO baseline for air-conditioning also needs to be reviewed.

10 AGL NSW Demand Response: Final ARENA Knowledge Sharing Report, May 2021, p.69

3.3 RESIDENTIAL HOT WATER SYSTEMS



PROJECTS

- Rheem *Smart Network (Hot Water Load Under Active Control)*, 2021 – current
- Roche, D., Dwyer, S, Rispler, J., Chatterjee, A., Fane, S & White, S. (Forthcoming). *Domestic Hot Water and Demand Flexibility.*

KEY FINDINGS

Within a VPP using Home Energy Management Systems (HEMS), Rheem is using orchestration and a 'solar soaker' tariff to demonstrate the use of flexible hot water storage in South Australia, shifting hot water heating into the middle of the day to support grid stabilisation associated with the duck curve and deliver customer savings. The pilot aims to access wholesale and FCAS revenue streams and work with network businesses.

While it is still early in the life of the pilot, there are useful learnings:

- For participating customers, load control of hot water in combination with the solar-soaker tariff has worked well – but they have not been able to acquire sufficient customers to achieve a viable scale as of yet. The key issues with **customer acquisition** have been general inertia (customers typically only think of water heating when the system breaks down), a requirement to switch retailers and in particular to sign-up to a cost-reflective tariff. As the tariff applies to other devices and consumption which unlike hot water are not controlled, customers cannot be sure they will benefit and are very nervous about signing up to a time-of-use tariff.
- The Rheem pilot highlights a conundrum for projects using time-of-use tariffs. Whilst the ultimate objective is to switch consumers to **time-of-use tariffs**, fear about the impacts can prevent pilots attracting sufficient numbers of customers in the first place. It may be that alternatives such as shadow pricing are required in the initial trial phase to enable customer recruitment to occur.
- Another issue of wider significance is conflicts between smart hot water and battery storage for the surplus solar because of the lack of a **common interoperability standard** that enables orchestration across behind-the-meter devices. Competition for surplus solar could undermine the capacity of sites to provide external market services. Rheem has excluded customers with batteries with proprietary controls that cannot be orchestrated with the hot water system to avoid this situation.
- Incentives for energy-efficient heat pump systems that are not available to the less-efficient but more flexible electric resistance heaters with demand response capacity have also undermined their capacity to recruit customers by dramatically altering the relative costs.
- ISF modelling (Roche et. al., 2023) and analysis highlights the future pathway for hot water systems for decarbonisation is likely to include a mix of energy-efficient heat pumps and flexible electric hot water storage systems, as they have different benefits and suit some types of customers better (e.g. some apartments don't have space for heat pumps). ISF modelling finds there is large-scale flexible demand capacity, ranging from 17 GW (scenario with high uptake of heat pumps) through to 24 GW (higher uptake of electric resistance heaters with demand response capacity). Policymakers should review programs to ensure the incentives will enable the growth of both market segments (Roche et al. forthcoming).

ARENA is co-funding Rheem with the South Australian Government to demonstrate the orchestration of residential hot water systems. The project objectives are to:

- demonstrate how a fleet of actively controlled water heaters could participate in the wholesale electricity and FCAS markets.
- demonstrate the effectiveness of a 'solar soak' tariff as an incentive for shifting water heating to the middle of the day.
- Commercialise a remote-control device and integrate with other devices.

The project is at a relatively early stage but there are some interesting learnings of relevance to hot water and other residential demand flexibility applications.

THERE HAVE BEEN MAJOR CHALLENGES WITH CUSTOMER ACQUISITION – ESPECIALLY ASSOCIATED WITH SWITCHING CUSTOMERS TO COST-REFLECTIVE TARIFFS

Customer acquisition – led by Rheem, not the participating retailers – has been very challenging, significantly due to issues with the retailing arrangements and time-of-use tariffs.

- The purchase of a smart electric water heater and participation in the VPP requires customers to change to a participating project retailer with an eligible retail. Notwithstanding attractive retail offers, signing multiple contracts and switching retailers have led to hesitation and confusion for potential new customers.
- The requirement to switch to a time-of-use tariff has been a major problem because consumers are very nervous about whether they will benefit. Participants are on the 'solar soaker' tariff offered by SAPN which is 25 per cent lower in the hours of 11am – 3pm, 50 per cent in traditional off-peak, and 125 per cent in morning and evening shoulder periods.
- As the retail tariff applies to all devices and consumption, it is difficult to provide an iron-clad consumers will benefit as whilst the hot water can be controlled, use of air-conditioning units and other devices is not. Without such a guarantee, consumers are reluctant to sign-up.
- There is an issue of wider relevance to demand flexibility pilots as the ultimate objective is to switch consumers to time-of-use tariffs that create effective incentives to align consumption and generation. It may be that alternatives such as shadow pricing are required in the initial trial phase to enable customer recruitment to occur.
- The rebate structure to encourage consumers to sign-up to the pilot was originally phased into two 'cash back' amounts, one on sign-up and a second amount paid after remaining in the project beyond an agreed date. However, separating the rebates did not create a sufficiently strong customer incentive to sign up to the trial. Rheem elected to switch the rebate structure to a single payment paid to customers upfront. Whilst this has been positive to date, it results in additional risk for Rheem where customers prematurely exit the trial project.
- Customers also generally only think about or replace their hot water system when there is a breakdown.

Flexibility in the design of pilots is required to enable changes to increase customer acquisition.

SUPPLY-CHAIN SHORTAGES HAVE SLOWED THE TRIAL

- The project was impacted by the global shortage of semiconductors chips which resulted in significant increases in lead times (54 weeks in some cases, compared to around 18 weeks typically), an increase in the cost of chip components by 10 per cent-20 per cent – and delays and higher prices reduced customer participation.

HOT WATER LOAD SHIFTING HAS BEEN OPERATING EFFECTIVELY FOR EARLY PARTICIPANTS – BUT COORDINATION BETWEEN DEVICES IS LACKING WITHOUT A COMMON INTER-OPERABILITY STANDARD

- There is a mix of solar and non-solar households participating in the pilot.
- For participants to date, remote control of hot water systems has led to increased self-consumption of solar for water heating (up to an estimated 90 per cent of rooftop solar generation) in the middle-of-the-day with associated savings.
- However, the scale of customers has not been sufficient for implementing wider objectives.
- Another issue observed is the lack of common inter-operability standard for devices behind the meter with different proprietary standards between for example battery storage and the hot water system. This leads to different devices 'fighting each other' for the surplus solar, which can for example lead to the battery using surplus solar for storage which would otherwise participate in an FCAS event. Rheem have had to exclude customers with batteries that cannot be controlled and orchestrated with the hot water system for this pilot. There is no labelling or information for consumers who are unaware of the potential issue when they purchase a battery.

3.4 POOL PUMPS

PROJECTS

- Pooled Energy *Demand Management and Modulation*, 2017 – 2022

KEY FINDINGS

ARENA has funded one project to date utilising pool pump technology.

Pooled Energy combined a range of pool customer services (e.g. water quality) with energy services, including energy efficiency and demand response. The objective of Pooled Energy was to pilot the use of controlling the timing of pool pumps to clean in low-price times and switch-off in high-price times or provide emergency demand response and FCAS services. The object of Pooled Energy was to 'pool' the energy demand of approximately 1 million backyard swimming pools into a single virtual load, leveraging what they estimated was a swimming pool load available in Australia of around 2 GW.

Whilst Pooled Energy did not scale as hoped, the orchestration of pool pumps appears to have been successfully demonstrated. As of May 2021, Pooled Energy had a total of 2062 connected systems (a total household load of approximately 2.5 MW). Some of the outcomes of the pilot:

- energy and emissions savings from upgrades and operating swimming pools more efficiently – around 2.8 MWh per pool per year.
- Pool pumps were orchestrated for wholesale arbitrage (856 load shedding events when the price was >$150/MWh, including 368 events in a single month) and FCAS events.

One of the project lessons is that controlling and 'flexing' is comparatively easier compared to some other residential loads (e.g. air conditioners) because customers do not mind ceding control over their pool pumps (subject to maintenance of water quality) – pool pumps are a discretionary load in the background.

Pooled Energy was established as a retailer and went bankrupt (alongside a series of other small retailers amidst the wholesale market turbulence of 2022). Another lesson may be that this is an opportunity for a larger retailer or a specialised demand response provider via the Wholesale Demand Response mechanism. Remote control of pool pumps appears to be a prospective opportunity for larger retailers and aggregators.

3.5 THERMAL ENERGY STORAGE

PROJECTS

- A2EP & Climate-KIC *Renewable Energy for Process Heat Opportunity Study (Phase 2)*, 2020 – 2022
- Brimbank City Council *Aquatic and Wellness Centre Integrated Energy System*, 2020 – 2024
- Glaciem *Advancing Renewables with PCM Thermal Energy Storage*, 2019 – 2023
- ISF & A2EP *Renewable Energy and Load Management (REALM)*, 2019 – 2021
- Shell Energy *Advancing Renewables in the Manufacturing Sector*, 2019 – 2022
- Zen Ecosystems *Demand Response (RERT)*, 2017 – 2020

KEY FINDINGS

Thermal energy storage (TES) is an effective complementary technology to centralised heat pump-based heating and cooling systems which can deliver bill savings.

- **Advancing Renewables with PCM Thermal Energy Storage:** Glaciem Cooling Technologies project installed a Thermocold DYN 900 thermal energy storage (TES) unit, integrating it into one of Rowland Flat's existing refrigeration plants. With the integration of the advanced control and forecasting algorithm (ACFA), PV and TES, the site can save $2,300 in energy costs over 6 hours of peak price event. The ACFA control signals to charge the TES when the import prices are low or negative and discharge the TES during the peak demands from the grid. Peak events that have electricity prices over $0.5/kWh provides savings of $6,331 whilst arbitrage savings (when electricity prices are below $0.5/kWh) contribute $6,164. When the ACFA fully utilised PV and TES system with price signal than the demand reduction charges can be significant and had higher savings from demand reduction. Based on the NEM retail prices (RRP) provides a 26 per cent cost savings while doubling the size of TES results in another 33 per cent cost savings. However, a significant cost saving can be achieved by reducing the peak demand.
- **Renewable Energy and Load Management:** Undertaking feasibility assessments across a range of sites (big-box retail, cold store, food manufacturing), the REALM project found cold water storage could be an effective source of on-site storage for intra-day arbitrage and peak shaving. The 1250 kWh thermal cold tank would be approximately equal to 125 kWh battery energy storage (BES). The on-site TES option could be more cost-effective than BES but the costs for non-BES applications were sometimes not easily available and in general less transparent than for BES.
- **Renewable Energy for Process Heat Opportunity Study (Phase 2):** A2EP project found that the optimum sizing of heat pump, thermal storage, and heat recovery equipment can reduce capital costs by 20 per cent. Thermal storage and heating pump flexibility could reduce gas consumption by 75 per cent. A2EP project also proposed to use single cycle flexible CO_2 refrigerant machine as an alternative source of heating and cooling. In trans-critical (TC) mode, chiller heat pumps can simultaneously produce the three thermal streams and in subcritical (SC) mode it can do cold and medium temperatures. If there is no demand for medium heat in either TC or SC modes, the heat automatically diverts to a gas cooler. The gas cooler and/or the medium heat service is required to cool the CO_2 again to enable the cycle to run. Note that if either of the heating energy services are required cooling cannot be turned off, as the equipment is essentially a chiller, albeit with advanced heat recovery systems. The lack of industry awareness of renewably powered alternatives to fossil-fuelled process heating technologies is limiting the adoption of heat pumps.
- **Remote control of refrigeration:** Zen Ecosystems reported they were able to reduce cooling loads of refrigeration by 11 per cent. Barriers identified were access to data (refrigeration contractors own the customer relationship but don't have access to NMI data and as a non-retailer Zen Ecosystems does not have access to the MSATS) and the relatively small benefits for an individual participant.

3.6 COMMERCIAL HVAC

PROJECTS

- AIRAH *Affordable Heating and Cooling Innovation Hub (i-Hub)*, 2019 – 2023
- Zen Ecosystems *Demand Response (RERT),* 2017 – 2020

KEY FINDINGS

The Australian heating, ventilation, air-conditioning, and refrigeration (HVAC&R) sector has 22 per cent electricity consumption of total electricity generation in Australia, and it is responsible for around 50 per cent of peak demand on the electricity grid. The ARENA has co-funded the Affordable Heating and Cooling Innovation Hub (i-Hub) project to enable renewable energy technologies for HVAC&R equipment in commercial buildings. The i-Hub project focuses on renewable energy technologies as well as emerging and enabling technologies that reduce heating and cooling loads, improve building and system efficiency, control and shift loads, store thermal energy, and a range of technologies which can improve utilisation of renewable energy within the commercial building and the grid.

Some of the key findings to emerge from i-Hub project were:

- **Significant reduction in peak demand and energy bills could be achieved:** The i-Hub project highlighted that though each building would be different, there are examples of 25 per cent reduction in peak demand using thermal load shifting. In Newcastle, building energy bills has been reduced by 6 per cent by employing a model predictive control to facilitate demand flexibility. Though COVID affected the baseline estimation, a machine learning-based algorithm has been developed to forecast baseline under uncertainty.
- **Digitalisation, IT infrastructure and interoperability:** Digitalisation in buildings, particularly IT, connectivity, and interoperability requirements for flexibility is rare in mid-tier buildings. Education and training related to digitalisation will be required. There are opportunities around using a data platform as a common infrastructure for standardising data exchange and supporting market signals to drive demand flexibility.
- **Energy bills are not necessarily the main consideration for building owners:** Commercial building energy cost is a relatively minor operating cost. If energy bill is 3 units, the rent is 30 units, then the staff cost is 300. Hence, energy bills are not an important consideration in the business operation. So, appropriate market design and value stacking issue need to be solved. Also, there are challenges around demand uncertainty, identifying value proposition and value stacking potential. Often customers are wanting the flattest possible tariff structure, and if there's a flat tariff, then there's not much incentive to provide any flexible demand.
- **Scalability and supply chain is a barrier:** An individual building is a small entity and does not participate directly in the electricity market. They participate with their electricity retailer. Additionally, one key barrier is the supply chain issue. Though the building owner support the participation, there are involvements of facility manager, building management contractor, and technology vendor. Hence, seamless coordination between stakeholders is a challenge.

On a small sample of buildings, Zen Ecosystems successfully demonstrated pre-cooling of small and medium-sized commercial buildings using internet-connected thermostats.

3.7 BEHAVIOURAL DEMAND RESPONSE

PROJECTS

- AGL *Demand Response (RERT)*, 2017 – 2021
- EnergyAustralia *Demand Response (RERT)*, 2017 – 2021
- Zen Ecosystems *Demand Response (RERT)*, 2017 – 2020

KEY FINDINGS

A number of projects in the RERT round focused on residential behavioural demand response in which customers were paid for reducing load in response to text alerts.

- **Behavioural demand response projects were broadly successful:** Powershop estimated a load reduction of 0.45 kWh per household during events across a base of 10,000 – 30,000 customers. AGL estimated load reduction of 0.1 to 0.3 kWh under 30 degrees, 0.6 kWh over 31 degrees and 0.9 kWh at 39 degrees. Zen Ecosystems reported the 'appeal' of the behavioural project was strong with over 50 per cent of participants responding to text messages.
- **Financial incentives may wane as a motivator:** financial incentives were observed as being important in signing up participants but there were differing views on the impact on financial incentives for participation in events. AGL observed most households participate if they can, changing the level of financial incentives did not yield major differences and there was some 'participation fatigue' over time. Powershop trialed the use of a 'prize draw' to summarised greater participation in peak demand reduction events but the difference was not 'statistically significant'.
- **Demand response programs can be an effective source of customer loyalty.** AGL observed they came to see demand response as a 'loyalty program' that also delivered demand response – rather than a program that focussed purely on the MWs of demand response. Amongst customers motivated by environmental and social values, the behavioural response program was extremely popular and has therefore continued to operate.
- **High concentration of demand response amongst customers:** reflecting the underlying motivators for participants in behavioural demand response, AGL found 80 per cent of the demand reduction was delivered by around 20 per cent of customers and 30 per cent of participants delivered zero. Powershop also concluded behavioural programs should be targeted at 'more engaged' customers. Both retailers also observed that the customers who were more likely to participate are already relatively energy efficient and therefore there was less to save. Consequently, whilst behavioural programs can deliver demand response there is also a limitation to scaling.

4. INSIGHTS FROM ARENA PROJECTS: BUSINESS MODELS & CUSTOMER JOURNEY

RESEARCH QUESTION

RQ5: What is the customer experience and what are the key values and pain points in the customer journey? What are the costs for customers and aggregators?

KEY FINDINGS

- Few C&I or residential projects explicitly identified **customer segments** in the knowledge sharing reports. Notably, where segmentation analysis did occur (e.g. Tesla, Zen Ecosystems, electric vehicle pilots), an over-representation of particular demographics (e.g. older men with a strong interest in new technology) was observed which limits learnings for mass consumer adoption. In electric vehicle pilots, social research components are present in all trials with useful insights for customer preferences but there is a lack of exploration of business models.
- The lengthy, expensive **customer acquisition** process is a recurring theme through many of the C&I, electric vehicle and residential projects. Demand flexibility is not core business for any organisation, it requires a 'long and technical sales cycle' with extensive customer education and is a 'novel' program with lengthy approvals. Customer acquisition was referred to as the major cost of demand flexibility programs – which needs to be central to the design of programs, pilots and policy.
- Some factors for improving customer recruitment were identified including identifying internal champions, working on early alignment between procurement and operations staff, digitising and resourcing sales and iterative recruitment campaigns that can quickly absorb learnings and recalibrate.
- Through the **installation** phase, automation was described as the 'holy grail', but all providers noted it was difficult to achieve in practice.

In 2019, ISF developed a customer journey framework (Figure 8) for mapping customer experience and business models for DER projects which is also useful framework for demand flexibility projects.

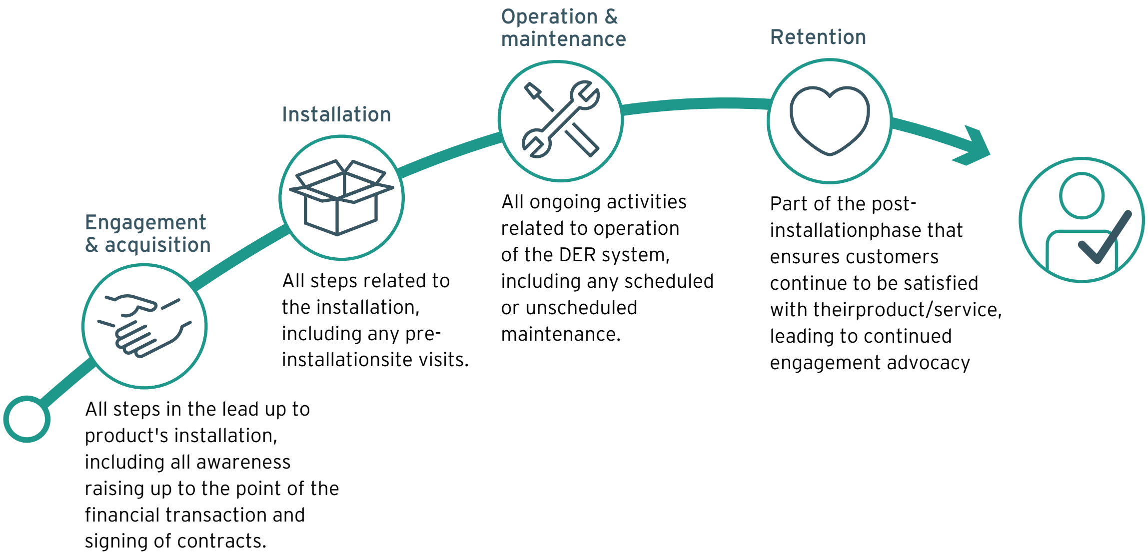


Figure 10 DER Customer Journey
Source: Dwyer (et al 2020), ARENA DER Customer Insights: Customer Journey

4.1 STAGE 1 – CUSTOMER ACQUISITION

The time and expense of customer acquisition is a recurring theme through many of the projects funded by ARENA. Demand flexibility is not core business for any organisation, it can be difficult to get the necessary internal focus, it requires a 'long and technical sales cycle' and as a 'novel' program approvals take longer than usual. Across all sectors, there were extensive reports of the time, costs and challenges with consumer acquisition:

- There are significant costs and time-commitment required even before going through the engagement and acquisition of individual customers, including preparatory work for building a portfolio of demand response includes market research, lead generation, contract development, and staff recruitment.
- There were frequent reports of long lead times, multiple site visits and bespoke negotiations required to enroll C&I customers with case-by-case payments.
- Business customers were reportedly sometimes very keen initially but ultimately decided against signing-up due to concerns about impacts on business operations.
- Many projects observed that customer awareness of DER, demand flexibility and VPPs is in general low. Complex concepts are required to be explained to customers with a low knowledge base 'requiring multiple touch points and time to achieve consumer participation'.

> *'It can be difficult to motivate a customer to join a program that helps solve a problem they don't know about; and has the perception of little to no impact on their day-to-day life. A significant amount of education is needed before beginning recruitment' (Flow Power).*[11]

Customer acquisition was sometimes referred to as the major cost of demand response for providers.

FACTORS INFLUENCING CUSTOMER ACQUISITION IN THE C&I SECTOR

There were some factors observed to support customer recruitment:

- **Business recruitment requires alignment between procurement and operational staff**. Several projects noted differences between procurement and operations – and focusing on procurement managers was problematic if there wasn't alignment with operations managers. Early engagement with operations and facilities managers is essential for successful recruitment.
- **Identifying an 'internal champion'** was crucial: *'without the in-house champion driving the idea of implementing DR the proposition* **always** *falls over'* (Flow Power).[12] AGL also noted the importance of 'central coordination' within businesses.
- **Iterative customer recruitment campaigns:** Project Symphony ran into early problems with customer recruitment but reconfigured their offering and focused recruitment through a portfolio of aggregators with their own customer bases and channels. Digitising the sales interaction was another key recommendation.

Financial uncertainty is a fundamental challenge for C&I recruitment. During contract signing – which often requires approval from senior management, e.g. the Chief Financial Officer (CFO) – an offering including steady, reliable stream of revenue (i.e. availability payments) is more likely to be successful. In the case of RERT, availability payments provide revenue certainty – but potential earnings from Dispatch Payments during emergency events aren't considered "bankable" revenue. One particular customer stated 'they did not want to have to depend on a grid emergency' in order to make money from demand flexibility. There is an even higher level of uncertainty over wholesale revenue which makes it hard to build a compelling business case.

FINANCIAL INCENTIVES AND HOUSEHOLDS

One notable area of difference between the C&I and residential sector was experimentation with the value proposition. Whereas the broad structure of the model for C&I customers appear to have been relatively stable (availability payment + event payments) – albeit requiring bespoke negotiations – there was a lot of experimentation in the residential sector as providers tried to fine-tune payment models to find an enticing value proposition for consumer recruitment. Whilst there is significant variation, some of the common elements programs developed over time included:

- Choice to avoid consumers feeling 'locked-in': the use of 'opt-in' and 'opt-out' options.
- No up-front costs for participation.
- a sign-up payment sufficient to meet the 'get out bed' test – which was variously estimated to be between $10 – $50. Up-front payments were sometimes considered insufficient by customers and the structure of payments needed to be adjusted throughout pilots to bring forward payments.

11 Flow Power, Project Performance Report – Energy under Control, May 2020, p.10

12 Flow Power, Project Performance Report – Energy under Control, May 2020, p.10

- Certainty of events: in order to attract participants, there needed to be a commitment to a minimum number of events to make it worthwhile for households.

Notably, financial incentives were important for residential customer acquisition but less so for on-going participation (see below).

CUSTOMER ACQUISITION FOR EVS

In the EV sector, long lead times were also observed as needing to be factored in to take account of need for education, business decision making and process, and identifying and selecting suitable customers.

- Fleet managers view the V2G/smart charging proposition through the lens of their specific organisation's climate change goals and strategies. They were also interested to understand how it can improve asset utilisation, and lower peak demand charges (i.e. by blocking charging during peak demand periods).
- At work/fleet charging was found to require long lead times due to corporate processes, the need for sign offs, and multiple stakeholders that needed to be involved in the decision making.
- Educating businesses oIVs and charging requirements was found to be important to participation in trials.
- For those businesses who chose not to patriciate in the Origin trial, they cited the economic value in procuring Ian EV over a Plug-in hybrid electric vehicle (PHEV) was not justified, despite the reduced emissions and lower maintenance and operating costs.
- For the business participants who did chose to participate in the trial, the uptake of EVs was not driven by economics, but rather linked to a sustainability commitment or a business offering intrinsically linked to sustainability. Transitioning to EVs was seen as "the right thing to do".
- For business and private EV owners, assurance is required that sufficient charge in vehicles will be available when they are needed, and trust in any level of control being assigned to service providers.
- Jemena concluded that a thorough, well tested screening process would have addressed some of the challenges it experienced when seeking to enrol private EV owners in its trial.
- Jemena's trial also found that direct email marketing via JET Charge's existing EV customer was the most effective channel for participant recruitment, followed by Facebook and friend referral. These early adopter EV owners were found to be already highly engaged, knowledgeable, and willing to participate.
- Customer registration experience must be kept simple and intuitive, while questions are designed to be succinct and easy to answer without the need to seek supporting information.

4.2 STAGE 2 – INSTALLATION

In the installation phase, automation was often the key issue highlighted in the C&I and residential sector. Automation and remote control delivered higher levels of flexible demand capacity. Sites without automation were more likely to experience lower performance due to issues such as technicians being away, busy, personnel turnover etc. Consequently, automation and remote control was described by some providers as the 'holy grail'.

Whilst there were some reports of success, all projects found high levels of automation unable to be achieved in practice. Flow Power observed that there are three 'fundamental' steps required – a compatible electricity meter (often not there), access to the site (not always granted) and integration with the on-site control system.[13] A common theme of RERT projects was the opposition or reluctance of customers to remote control of loads. AGL reported that 'none' of their C&I customers accepted remote control whilst others observed a range of responses from opposition through to acceptance (Enel X, EnergyAustralia, Flow Power). One provider noted they have moved past the issue by refining their communications systems over time and were now satisfied they could achieve a comparable level of DR.

The reasons for opposition or reluctance of C&I customers cited were:

- Cyber-security
- Health & Safety
- Potential operational/financial impacts
- Operational complexity (e.g. no single-point control which required a series of manual tasks by site technicians)

13 Flow Power Project Performance Report – Energy under Control, May 2020, p.10

AGL concluded: *'Whilst there is often a utopian vision of DR portfolios operating instantly at the push of a button in a darkened control room, AGL's experience during this project was that this vision is some distance from reality.'*[14]

The project reports focus more on the factors behind consumer reluctance than success factors in achieving automation. However, Flow Power states that where it occurred it was the commercial benefits became clearer over time. For example, a cold store implemented a fixed daily load-shifting regime that changed the timing of refrigeration. A smelter automated for load reductions at $300/MWh with warnings at $100/MWh. It's notable that these appear to be cases where customers were able to be certain there will always be financial benefits without operational impacts.

In the residential sector, there were notable differences across devices or technologies. A survey by Synergy found commercial customers were more supportive of orchestration of their solar and battery systems than their air-conditioning system and issues were not observed with automation of pool pumps. Tesla observed it was important to deliver tangible results early as otherwise residents started to question why they were allowing an external party to control their battery, solar or device.

In the electric vehicle trials, knowledgeable installers, quality of finish, opportunity for feedback, and refined processes are important for a positive experience.

- Refined planning, communications, and handover processes can help ensure that EV trial participants feel fully informed of what they should expect before, during and after the installation.
- Quality of the finish on installation job is important to EV owners (keeping cabling and conduit near, out of sight, leaving site clean and tidy after).
- Providing customers with the opportunity for input and feedback into the process creates a positive experience and ensures that the charger is installed in the location that best suits their home and parking/charging arrangements.
- Installers that are highly knowledgeable, consultative, and provide attention to detail give confidence to customers.
- Businesses can be worried about continuity of operations through the installation process, seeking assurances that vehicles would be available to drivers without interruption.
- Origin found that private EV owners offered free chargers were more likely to become unresponsive during the installation process or withdraw from the trial if additional unexpected costs were quoted (even if minor compared with charger value).

4.3 STAGE 3 – OPERATION AND MAINTENANCE

Real-world experience through ARENA's projects has illustrated there are many uncertainties in the delivery of demand flexibility – which means a portfolio approach was required to meet contractual commitments. None of the participants in the ARENA projects analysed considered full automation feasible and noted significant numbers of their customers were unable to participate in demand response events for a variety of reasons.

All RERT participants noted 'below-target' results were an early feature due to a combination of factors unexpected site issues (e.g. fire), staffing issues (e.g. turnover of trained personnel, absences), regulatory requirements (e.g. water treatment facilities), timing (e.g. holiday periods and pre-end of year business activity) and conflicting commercial and operational requirements (the rewards from demand flexibility are not always sufficient or there are other more important factors such as meeting contracts, reputation).

One of the learnings observed by almost all RERT participants was that they needed to be significantly 'over-contracted' to meet demand flexibility targets. Buffers of 20-30 per cent were observed as necessary to meet contractual requirements. Consequently, diversity in demand portfolios beyond large customers and across sectors is essential for delivery of demand flexibility contractual requirements.

For residential and C&I sites, IT infrastructure was commonly identified as a barrier. Multiple residential projects reported limitations related to the internet connectivity and public infrastructure. Weak internet connections, 3G network shutdowns, temporarily disconnected modems led to delays in data sending or non-participation in demand response events. For example, Tesla reported that 72 per cent of sites did not have the appropriate hardware and amongst those sites with the hardware 5-8 per cent of households consistently failed to send any data and Pooled Energy reported 236 controllers failed in a demand response event due to network connectivity.

14 AGL NSW Demand Response: Final ARENA Knowledge Sharing Report, May 2021, p.69

Similar barriers have been reported in the **electric vehicle** projects. The communication between the charger and electric vehicle delayed the FCAS response time – and the provider was unable to capture this value unless an active charge session is maintained which isn't always possible with fleets. A stable network connection between the charger, control box, and cloud is needed to ensure the vehicle is available for grid support services which needs running the charger for a long time. Data flow between the end device and the distribution network back-end system caused issues related to firmware design and customer behaviour. For a cloud-based VGI solution, a reliable connection is needed to ensure secure data transfer data. 4G instabilities within certain network areas resulted in a lack of connectivity and delayed data transfer. Wi-Fi as an alternative introduces other complexities such as internet connection reliability. A hardwired ethernet connection was found in the AGL trial to overcome these challenges but it came with additional cost.

Post-installation handover is a critical step with continued communication throughout the operation phase needed to ensure peace of mind for customers.

- For EV trials, post-installation handover and communications was cited as an area that needed most improvement, with lack of clarity and information on handover of the charger hardware, the charging software, and what would be happening next in terms of the trial itself.
- Fleet managers in one trial were anxious that smart charging would require changes to their procedures and parking arrangements would negatively impact drivers. They emphasised that drivers should not have to change their routines to accommodate the trial and called for transparency in sharing the trial's activities and outcomes,
- Some users wanted to know if a V2G session was occurring with their fleet vehicles.
- Confusion emerged within one of the trials amid unclear processes for what to do when a charger has a fault.

5. INSIGHTS FROM ARENA PROJECTS: REGULATORY FRAMEWORKS

BACKGROUND

Australian regulatory frameworks are in transition as the penetration of distributed energy resources grows rapidly. ARENA is the organiser of the Renewable Energy Integration Project (REIP) initiative which facilitates dialogue between stakeholders on regulatory reforms to facilitate and integrate DER. The Australian Energy Market Commission and Australian Energy Regulator are also leading processes to investigate and develop regulatory reforms for DER.

For this project, ARENA identified research questions relating to metering, tariffs and baseline methodologies/ measurement and verification for demand flexibility as the primary focus in the review of funded projects.

RESEARCH QUESTION

RQ 5: How are current metering arrangements and network and/or retail tariffs contributing to or inhibiting demand flexibility? How can they be reshaped to align with and unlock the value of flexible demand?

RQ 6: How effective are current methodologies and baselines for flexible loads (e.g. calculations, settlement procedures, verification)? How can they be reshaped to balance accuracy, accessibility and cost?

KEY FINDINGS

- One of the largest barriers in the experience of ARENA projects was the quality of customer infrastructure. Low penetration of smart meters, the prevalence of smart meters which ‘aren’t that smart’ (and poor quality IT infrastructure) which were often identified as the source of operational failures, additional costs or a barrier to accessing value streams.
- Electricity tariffs remain a barrier to C&I demand flexibility – and there have been very few pilots and trials of alternative models to date. Only one ARENA C&I project has trialled an alternative model (Rheem, a ‘solar soaker’ tariff). EV projects are trialling alternative tariff to shift charging out of peak demand periods with encouraging results, but it is very early in the life of these pilots.
- In the residential sector, there were a lot of ‘false positives’ and ‘false negatives’ with demand flexibility measurement, which is become more complex with the growth of DER assets. ‘Big data’ was not considered likely to provide a solution for measurement of residential demand flexibility.
- In the C&I sector, the operation of AEMO baseline methodologies have become increasingly standard and understood by industry but effectively exclude a range of load types which is a barrier to scaling the wholesale demand flexibility market.

5.1 METERING

Both the penetration and quality of smart meters were regularly observed as major barriers to demand flexibility in the residential sector.

- The penetration of smart meters is low outside Victoria. Consequently, there were extensive reports from projects identifying issues with upgrading, replacing or integrating customer meters (e.g. Flow Power, AGL, EnergyAustralia, Pooled Energy). For example, AGL was only able to install 1500/2300 smart meters and there was an 'uncomfortably high' number of replacements due to access problems (e.g. multi-unit dwellings).
- The upgrading of customer infrastructure is costly and time-intensive – undermining the financial viability of demand flexibility. EnergyAustralia made the same observation regarding load control devices. The installations are also complex e.g. installers make a 'best guess' about the circuit for monitoring (many different types of switchboards, often old), multiple site visits could be required etc.
- There can also be unintended consequences and equity issues. In a residential development, project developers were reluctant to provide updated devices to customers due to high costs which created a polarised participant group of 'haves' and 'have nots' (Horizon Power).
- Projects aiming to access FCAS encountered additional implementation issues. According to the Market Ancillary Services Specification (MASS), the regulation requires the installation of equipment for FCAS by a licenced electrician which led Pooled Energy to concluded FCAS was not viable for pool pump where-ever installation was required.
- Whilst the primary focus of reports on metering was on residential sites, demand flexibility providers also noted similar problems with C&I sites. Flow Power for example observed challenges with the interface between their controller device and old meters and the absence of real-time data as a 'continued impediment to the efficient management of demand response'. For C&I sites, there is a large range of electrical configurations which can add significant complexity and cost. For larger sites, upgrading infrastructure is still financially viable but less so for smaller sites which is a barrier to market growth.
- Several providers noted issues with the Metering Data Providers. **Flow Power** observed that the cooperation of metering providers in upgrading meters – which is the 'exclusive domain' of the Metering Data Provider (MDP) – was a 'surprising barrier'. Different customers have different MDPs and therefore a multiplicity of relationships. Enel X also noted some installations were 'slower' than others and it could be hard finding the right person in the MDP adding weeks to installations.

Even where smart meters were installed providers noted their limitations – AGL summarised by observed the smart meters 'aren't that smart': *'it could be argued that these meters are anything but smart by 2021 standards, in an era where the real-time collection of data from all sorts of internet-connected devices is performed routinely and presented instantly to smartphone apps at our fingertips. The collection of metering data once per day (the 'day after' data used in the NEM) is an outdated model developed at the time of dial-up modems and has been rendered obsolete by technological developments since that time.'*[15]

ELECTRIC VEHICLE METERING BARRIERS

Satisfying FCAS requires recording frequency response at 50 milliseconds. For an EV trial, only one commercially available 3-phase power meter for metering at the main switchboard was found that could respond that fast, with most only catering for 1-second interval data. Charger integration within a building's services and its energy management system are not well understood for vehicle grid integration.

There are differences in metering standards across state jurisdictions. In Queensland, EV chargers must be connected to a Distribution Network Service Provider (DNSP) controlled switched circuit to control load, in the same way electric water heaters are to avoid strain on the electricity network. However, important messages sent at time of peak could be missed resulting in EVs being at the wrong state of charge when the vehicles are needed. In Victoria, DNSPs now mandated to request that dedicated EV chargers (3.6kW or greater) be on time-of-use network tariff. Otherwise, they are limited to a maximum charge rate of 3kW. For EV's, retrofitting chargers to existing fleet depot sites can be challenging and expensive due to limited space and electrical connectivity.

15 AGL NSW Demand Response: Final ARENA Knowledge Sharing Report, May 2021 p.29

5.2 BASELINES AND METHODOLOGIES

Baselines and associated methodologies are a key issue for demand flexibility. Baselines need to be set to measure the counterfactual and the volume of demand flexibility (i.e. how much electricity was consumed relative to what would otherwise have occurred). There is a challenging balance between a measurement and verification regime that ensures the demand management is additional and enacting compliance regulations and requirements that create excessive transactional costs or exclude load types. In the C&I sector, the demand flexibility providers reported growing familiarity and understanding with the AEMO baseline methodologies but also that it represents a fundamental barrier to market growth, scaling and competition by excluding load types that are not consistent and predictable. Within the residential sector, there are fundamental challenges with measurement accuracy and cost that need to be addressed for the growth of demand flexibility.

AEMO BASELINES EFFECTIVELY EXCLUDE SIGNIFICANT CATEGORIES OF C&I CUSTOMERS AND LOADS

Multiple participants observed that rules such as the 4-hour maximum curtailment, 10-minute response and dynamic, intra-day baseline adjustments were identified as excluding participants (AGL, Enel X, Flow Power). AEMO baselines were observed to work well for customers with flat, predictable loads but performed poorly at recognising demand flexibility from temperature-sensitive or variable loads Some of the examples provided included:

- A metal recycling plant (4MW) with fluctuating load as material is fed into plant but could provide 4MW of demand response is effectively ineligible as the baseline is adjusted based on early fluctuations (AGL).
- A plant with an outage was effectively ineligible as its baseline adjusted downwards (Enel X).
- Inter-Cast Forge smelter found cases where there was no incentive to participate in demand response events because the baseline was adjusted downwards due to a period of non-production between shifts.
- Zen Ecosystems analysis of demand response for commercial buildings found ‘the AEMO baseline seldom produced accurate results’ and compared results using the AEMO baseline with an alternative ‘line of best fit’ methodology based on daily usage.
- Customers with spot exposure that responded to high prices before RERT events also experienced baselines adjusted downwards that removed the incentive for load reduction that could have been delivered.

AGL summarises the experience observed by multiple projects: *‘AGL’s experience in the RERT program demonstrated that the AEMO baseline works well for flat and/or highly predictable loads, but discounts DR from temperature sensitive loads and intermittent or fluctuating loads, despite these loads being potentially valuable contributors in DR events’*.[16]

Enel X observed further that the level of monitoring required on 5/30-minute intervals is not realistic outside large customers:

> *‘Based on our RERT experience across three summers, C&I customers and their aggregators should be able to bid in ‘negawatt’s (i.e. we can provide x MW’s of demand response over a certain number of intervals across a day. Requiring customers and aggregators to actively monitor load on a 30-minute or 5-minute interval basis, and then to bid in how much their load can drop to for every interval where they can provide DR, will be difficult for those customers who do not have a flat load profile.’*[17]

Multiple demand flexibility providers noted they filter customers based on fit with AEMO baselines and turn away and do not attempt to register potential customers they expect to be incompatible. These cases are supported by analysis by Oakley Greenwood (2021) that estimated that up to 80 per cent of loads are excluded under the AEMO baselines.

16 AGL NSW Demand Response: Final ARENA Knowledge Sharing Report, May 2021 p.68

17 Enel, ARENA Demand Response Knowledge Sharing Trial: Report 7, December 2020, p.22

‘FALSE POSITIVES’ AND ‘FALSE NEGATIVES’: MEASUREMENT ACCURACY WAS A MAJOR ISSUE IN THE RESIDENTIAL SECTOR

There were many reports of difficulties with accurately measuring the volume of demand flexibility by households. AGL found in follow-up surveys that 25 per cent of household results were ‘false negatives’ (i.e. the household had taken action but no change was recorded) and 41 per cent of household results were ‘false positives’ (i.e., the household did nothing, but change was recorded – in some cases the occupants had left the house). AGL reported that other natural variations created differences in outcomes that were hard to explain to households. Temperature, for example, had a major impact on the volume of measured demand flexibility even if the behaviour was identical.

AGL observed that if the dynamic baseline approach of AEMO were to be applied it would be unsuitable for household air-conditioning loads. The baseline effectively discounts the volume of demand flexibility on the hot day of a RERT event because it uses a 10-day average, and the same-day adjustment is too early in the day to reflect the hot temperatures that drive air-conditioning load later in the day (see air-conditioning technology summary for more detail).

GROWTH OF DER ASSETS MAKE ACCURATE MEASUREMENT MORE CHALLENGING

These measurement issues are exacerbated by the growth of DER assets such as solar PV, batteries and electric vehicles. DER assets impact on the establishment of an accurate baseline for behavioural demand response – and make it very difficult to disentangle demand flexibility from other factors creating variations e.g. cloud cover reducing solar PV generation, disconnection to maintain network stability, remote controlled dispatch of batteries. As AGL conclude: *‘The operation of these devices presents a further challenge to the accurate forecasting and baselining of residential loads for behavioural demand response and will almost certainly lead to errors and double counting in demand response payments with resultant consumer dis-satisfaction.’*[18]

18 AGL NSW Demand Response: Final ARENA Knowledge Sharing Report, May 2021 p.30

5.3 TARIFFS

RACE for 2030 CRC (Brinsmead et. al. 2021) highlighted that the United States Federal Energy Regulatory Commission list six different time varying tariffs for demand flexibility and eight incentive-based demand flexibility programs.

TIME VARYING TARIFF-BASED OPTIONS

- **Time-of-use pricing:** Time-of-use pricing is a pricing method used by electricity providers, where **electricity rates vary over the course of the day.** Usually time-of-use pricing for commercial and industrial users is divided into two time slots i.e., peak hours and off-peak hours.
- **Peak time rebate:** Peak time rebate is a program in which the utility or energy supplier selects days when the program is active during peak hours, but instead of charging the customer more for usage during peak periods, customers are given a rebate for less consumption during times selected as critical periods.
- **Critical peak pricing with control:** Critical peak pricing with control is a price mechanism that combines direct load control with a pre-specified high price for use during designated critical peak periods, triggered by system contingencies or high wholesale market prices.
- **Critical peak pricing:** Critical peak pricing is a pricing mechanism proposed for the critical peak load, and it can guide users to reduce or transfer their critical peak loads.
- **System peak response transmission tariff:** System peak response transmission tariff is a pricing method in which interval metered customers reduce load during coincident peaks as a way of reducing transmission charges.
- **Real-time pricing:** Real-time pricing is a pricing method where the electricity price is determined by the amount of time spent utilizing of electricity.

INCENTIVE BASED OPTIONS

- **Demand bidding and buyback:** The demand bidding and buyback is an incentive-based program that encourages large consumers to change their energy consumption pattern and decline their peak load in return for financial rewards.
- **Direct load control:** The demand response service provider (DRSP) installed load control devices that directly control the load during peak event.
- **Interruptible load:** A bilateral contract between DRSP and participants which determines all demand response actions and characteristics such as action triggers, contract duration and maximum number of hours per activation.
- **Load as capacity resource:** Load as capacity resource is an amount of load that is always reserve for participating in demand response.
- **Regulation service:** Regulation service provides for the continuous balancing of generation, load, and interchange at a very granular level.
- **Non-spinning reserves:** The non-spinning reserve is a *capacity that can be synchronized and ramping to a specified load within 10 minutes*.
- **Spinning reserves:** Spinning reserves are *an electricity grid operator's first strategy for maintaining system reliability following a major disturbance*.
- **Emergency demand response:** Emergency demand response is used when there's not enough electricity supply to meet consumers' needs. This is usually called on if a major generator breaks down, or during summer when demand is very high.

C&I AND RESIDENTIAL

There have been limited use of time-based tariffs in ARENA projects:

- **Advancing Renewables in the Manufacturing Sector:** Shell energy used time-of-use tariffs and wholesale market price to perform energy management with management of solar PV, battery energy storage system (BESS) and thermal energy storage. Shell energy project estimated the project participants could reduce annual energy costs by an average of 27 per cent with a capital investment of $29m.
- **Phase change material thermal energy storage:** Glaciem Cooling Technologies project combined thermal energy storage with spot pricing and peak demand reduction. Several experiments were undertaken for different peak events with significant savings from each peak event.
- **Rheem/South Australian Power Network:** Rheem are currently acquiring customers to orchestrate hot water systems on a 'solar soaker' tariff (25 per cent of the tariff 11am – 3pm, 50 per cent in tradition off-peak, 125 per cent in morning and evening shoulder periods). This is the only project including a network tariff.

- There have been trials with time-of-use pricing and real-time pricing but only one project includes both a retailer and network. Other sites were developing business cases for using solar, storage and any other technologies within standard tariff structures, generally aiming to peak-shave network demand charges and reduce usage charges on relatively flat tariff structures. The Renewable Energy and Load Management project highlighted there was significant existing on-site storage (primarily cold-water tank storage and refrigeration) across supermarket, agri-business, retail, manufacturing and cold-store sites. However, retail tariffs did not provide effective incentives. Without tariffs that reflected the value of load-shifting, financial returns were generally estimated to be beyond standard commercial benchmarks.

ELECTRIC VEHICLES

The testing of time-based tariffs in EV trials to date have been limited but have yielded encouraging results so far (although it's important to note these results may be skewed by the disproportionate participation of 'early adopters').

- Origin tested several different financial incentives for charging at specific times. They found that when offered a 10c per kWh reward for charging outside peak hours (with the credit applied to their energy bill), charging consumption at peak times was reduced by 20 per cent, while also habituating this charging behavior after the trial had ended. Another test found that, when a 25c per day reward plus 10c per kWh outside peak hours was offered to allow Origin to control the charger, consumption at peak times was reduced by 24 per cent through this more automated process.
- The Jemena led trials saw smart chargers installed in homes to investigate consumer responses to having their charging managed, as well as testing real time network conditions. While testing tariffs were not a key part of the trial, tariff insights were obtained due to a release on the 16th June 2021 of a new Tariff Order by the Victorian Government. This Order mandated that any Electricity Distributor who becomes aware of a residential household having a Dedicated EV Charger installed (defined as 3.6kW or greater) must be on a Time of Use (ToU) network tariff.
- Of the 23 Jemena participants, 16 of them (70 per cent) were found to be on a Single-Rate network tariff. Therefore, the participants had to be informed immediately that if they installed the charger with a rate of charge exceeding 3.6kW, they would need move to a ToU network tariff. 10 out of the 16 (63 per cent) participants chose to be moved to the ToU network tariff, 5 (30 per cent) were happy to have the maximum rate of the charger reduced to 3kW (so they could remain on the Single-Rate network tariff) and 1 participant (6 per cent) opted out of the trial.
- AGL is currently testing a control group of 100 customers with EVs on a time-of-use (TOU) tariff but no results are available at the time of writing.

Continued dissemination of the results of these trials with regards to the implications of tariffs for flexibility will be needed to better understand the benefits and opportunity. Future EV trials could look to better design tariff structures to incentivise consumers to participate in demand flexibility programs with their EVs (whether private, or business fleets), while providing greater insight into their effectiveness for providing demand flexibility.

6. INSIGHTS FROM ARENA PROJECTS: CUSTOMER BARRIERS TO SCALING UP DEMAND FLEXIBILITY

BACKGROUND

The fundamental question is how to scale up for demand flexibility by addressing a range of customer barriers. In this section, the key findings on barriers and the learnings on how demand flexibility might be scaled from across ARENA funded projects are synthesised and analysed.

RESEARCH QUESTION

RQ 7: What are the learnings from successful or unsuccessful models for increasing consumer uptake of flexible demand?'

KEY FINDINGS

There are three key categories of learnings and priorities for scaling up demand flexibility identified.

1. Laying the foundations for growth

- Technical standards: common technical standards which are fit-for-purpose with high coverage are a key foundation for growth. There is an opportunity for electric vehicles to 'get it right' before the diffusion of the technology unlike air-conditioning units.
- Smart meters: modernisation of the technical standard and accelerated roll-out of smart meters are another pre-condition for scaling residential demand flexibility.
- Baselines: the exclusion of variable C&I loads needs to be addressed if other providers are to enter the market for greater scale and competition.
- Measurement of residential demand flexibility: precision measurement does not appear cost-effective – can deeming methodologies comparable to residential energy efficiency and renewable energy be developed?

2. Program design to facilitate growth

- ARENA and government programs will continue to have a critical role in the development of demand flexibility. There are several important learnings to emerge for future program and pilot design:
- Supply-chains: government programs need to focus on driving change through supply-chains as well as more traditional priorities such as demonstrating technologies and changing energy rules.
- Customer acquisition is a threshold challenge: customer acquisition needs to be incorporated into pilot design with a flexible approach that reflects the common challenges experienced by pilots. Better understanding of customer segments beyond early adopters is also required.
- Flexible tariffs: there is a major gap in pilots with flexible tariffs and network demand management – which are required as well as orchestration to access external value streams for scaling demand flexibility.

3. Pathways to impact and scale

- Demand flexibility is rarely a key priority for customers – it's complex, unfamiliar and the rewards at the micro-level rarely align with the macro-value for the energy system (especially in the residential sector). The roll-out of demand flexibility needs to identify the pathways through which it can complement other services that are valued by customers.
- In particular, programs & business models could be better designed to complement rooftop solar. Integrating demand flexibility with PV installation via solar retailers. New solar installations appear a more promising route as projects report lower interest amongst existing solar owners used to higher financial returns. For existing owners, maximising the value of rooftop solar is more valuable to households than demand response participation; the path to impact is likely to be via linkages with dynamic operating envelopes which are being trialled by multiple projects.
- Scaling demand flexibility in electric vehicles will require merging the energy and transport fields – with new skills, capacity-building, data and engagement.

6.1 LAYING THE FOUNDATIONS FOR GROWTH

Studies of demand flexibility often focus on detailing the numerous barriers. Reflecting on the project reports, this study has also highlighted a myriad of barriers experienced by ARENA pilots. There are foundational barriers for which there are solutions that need to be addressed to enable growth in demand flexibility services.

TECHNICAL STANDARDS

The major focus of project reports was on the AS-4755 – the standard for demand-response enabled devices encompassing air-conditioning units, electric storage water heaters and pool pumps. The experience of the pilots underlines issues highlighted in other reviews:

- The low coverage of the AS-4755 air-conditioning units made implementation of a mass-scale program unviable because of the costs for recruiting and upgrading units to provide demand response.
- The AS-4755 does not appear currently fit-for-purpose with a range of technical limitations highlighted including the absence of two-way communication, the absence of data verification or a customer over-ride function. Upgrades were often required to units that were compliant with AS-4755.
- Manufacturers of pool pumps, hot water systems and electric vehicle chargers do not currently offer products compliant with the AS-4755. There are air-conditioning units compliant with the 2012 AS-4755 but not the later 2014 version.

Other limitations with AS-4755 have been detailed by Gill & Kuiper (2021) such as the absence of autonomous device registration and management, a common inter-operability standard for operation between devices, support for provision of tariff prices, recognition of multiple party control of devices or a method for interaction with dynamic operating envelopes. The absence of verification functions means it cannot be used to calculate financial rewards for customers participating in demand response programs.

AGL determined that mass control of residential air-conditioning is 'unviable' under the AS-4755:

'AGL's conclusion from this trial is that the remote control of existing (already installed) air conditioners for demand response is not currently viable using the technology specified in AS4755. While this may be improved if the air conditioners were fitted with the appropriate control technology at the factory and/or during installation, concerns remain around the approach used in AS4755, its impact on comfort levels, its effectiveness if comfort levels are not impacted and the lack of a local override capability. Innovations in internet-connected domestic appliances and internet control technology in recent years have already left AS4755 behind … If air conditioner control is to be used for DR purposes in the future, it is far more likely to be achieved using this type of technology that that specified in AS4755'.[19]

There is a wider debate occurring on the implementation of technical standards.[20] The Australian energy ministers mandated the adoption of AS-4755 by air-conditioning, hot water systems (July 2023), pool pumps (July 2024) and electric vehicle chargers (July 2026) following review (Department of Environment and EnergyAustralia 2019) but implementation has not yet occurred. There is an international standard ('Standard for Smart Energy Profile Application Protocol', IEEE 2030.5) with compliant products and projects operating in Australia and one of the activities of the Distributed Energy Integration Program (a collaboration between a range of stakeholders organised by ARENA) is considering an IEEE2030.5 Australian Implementation Guide. There is no national framework for harmonising technical standards which are set by a multiplicity of processes and authorities and no requirement for compliance with standards (AEMC 2022).

Technical standards are the focus of other reviews and processes[21] and it is beyond the scope of this paper to undertake a comprehensive review. Nonetheless, this review of ARENA projects underlines the urgency of reform on technical standards. It is vital that common, modernised technical standards operating across technologies, sectors and supply-chains are in place to avoid the fragmentation, costs and technical limitations that have been observed as inhibiting residential air-conditioning demand response and emerging for behind-the-meter devices interacting with battery storage.

19 AGL NSW Demand Response: Final ARENA Knowledge Sharing Report, p.38

20 The Clean Energy Council is advocating for the AEMC to establish a review to consider roles and responsibilities for DER technical standards, developing a technical standards workplan or roadmap, interpretation of standards and economic evaluation of standards.

21 For example, see the rule change determination by the AEMC (2022) on governance for DER technical standards which includes a list of processes and authorities. As the consultation paper notes, 'there is no national framework for harmonising' minimum DER technical standards (AEMC 2022: 6) with technical standards being set through a multiplicity of processes and organisations including Standards Australia and state-based incentive schemes. 'Any delay implementing new DER technical standards as the market and technology evolves may lead to significant amounts of new DER capacity in the NEM that is not fully capable of supporting security and reliability objectives.'

For the two EV trials where bidirectional charging was pursued, AS4777.2:2022 Inverter Requirements Standard proved a major impediment on multiple levels for enabling bidirectional charging for EVs. This standard specifies the performance and behaviour of inverters and is relevant for any DER connected to the grid. The technical standard classes bidirectional EV chargers as a multiple model inverter as if it was connected to a stationary battery energy storage system. The standard requires that a battery is connected to an earthing point but with EVs, there is no need for one due to the insulating rubber tyres that are in contact with the ground. Modifications to rectify the situation led to further issues with high frequency noise which meant it failed the Electromagnetic Compatibility (EMC) test. As a result of seeking to comply with the AS4777 standard, there were multiple issues that led to increased cost, complexity, delays, and reduced installation aesthetics. It was noted in the ActewAGL project that the issue is specific to Australian technical standards and is not present in those that exist in other countries (e.g. UK's G99 for connecting generators to the grid). While the ActewAGL project pursued V2G despite the challenges, the AGL project decided to terminate the V2G aspect of its trial following the initial delays and challenges. Analysis of the ActewAGL trial by the ANU's Battery Storage and Grid Integration Program recommend an extension of the AS4777.2:2020 to directly apply for bidirectional chargers in terms of classification and testing procedures.

SMART METERS

Whilst there were issues identified with metering amongst C&I sectors, the view of providers interviewed was that upgrades were cost-effective for many sites (albeit less so as the size reduces) – and the issue was negotiating organisational commitment to the disruption. However, for residential demand flexibility the penetration and quality of smart metering in particular is fundamental. AGL noted: *'the penetration of smart meters in NSW is still relatively small; the widespread adoption of demand response at the residential level is likely to be problematic until it is much higher'*.[22] Outside of Victoria the coverage of smart meters is only around 30 per cent.

In its review of smart meters, the AEMC (2022) has concluded there is a net benefit from 100 per cent coverage of smart meters (including greater consumer participation in energy market services including 'solar-soaker' tariffs). The review of ARENA projects and the limitations observed by pilots due to low coverage of smart meters is qualitative, but the experience reported by ARENA pilots is consistent with the recommendations of the AEMC.

EXPANDING ELIGIBLE BASELINE METHODOLOGIES FOR THE C&I SECTOR…

For the C&I sector, the baseline methodologies are a limiting factor on the expansion of the wholesale demand response market. The AEMO baselines have grown to become an industry standard – but the AEMO baselines are not well-equipped for variable or temperature-sensitive loads (and therefore also sites actively shaping and optimising on-site DER). A study by Oakley Greenwood (2022: 12) found the baseline methodology excluded from 80 per cent – 95 per cent of C&I loads.

Multiple providers noted that they trial businesses for compliance – and don't proceed with sites that aren't going to meet the requirements. Whilst there doesn't appear to be a problem as sites registering all comply with the standard, it represents a major barrier to scaling and new market entrants. Customer acquisition is the greatest cost and the pool of customers to recover costs is limited by eligibility. It's notable that only one service provider (Enel X) has registered capacity in the WDR mechanism to date. Exclusion of up to 80 per cent of sites is a barrier to new entrants as the market scale to justify the risks and costs of consumer acquisition is lacking.

Consequently, trials of new baselines are required to expand eligibility to new loads and grow the WDR.

… AND A MEASUREMENT AND VERIFICATION APPROACH FOR THE RESIDENTIAL SECTOR

For the residential sector, the same level of measurement precision as the C&I is neither cost-effective nor practical. Some projects have tried to measure the level of demand flexibility more precisely. AGL, for example, trialed a 'deep learning' model to set individual customer targets – which was an 'interesting experiment' but 'deemed unsuccessful' due to being data-hungry, the unavailability of local temperature data and measurement issues for rooftop solar owners. Precise measurement of household demand response is difficult, expensive and variation in results creates customer dissatisfaction and complaints where targets are not achieved due to baseline adjustments despite active participation. A simpler 'percentile range' target setting approach was used as an alternative. The conclusion drawn was that a 'big data' approach was not practical, and the costs appear to exceed the benefits.

22 AGL NSW Demand Response: Final ARENA Knowledge Sharing Report, May 2021, p.21

It may be that comparable approaches to energy efficiency and renewable energy certificate schemes need to be developed for residential demand flexibility. In certificate schemes, the energy savings or generation are not required to be precisely measured at a household level – they are averaged and deemed based on industry technology data. The use of techniques such as deeming may also be more appropriate for measuring demand response at a household level. The NSW Peak Demand Reduction scheme (a certificate scheme for peak demand reductions) has only just commenced operations but could prove to be a more fruitful model for expanding demand flexibility.

6.2 PROGRAM DESIGN

CUSTOMER RECRUITMENT

One of the strongest themes across projects is the costs and challenges with customer recruitment for new demand flexibility pilots and products. There are several implications:

› better social research and customer understanding is needed: customer understanding is hampered by the often unrepresentative sample of participants in the pilots. For example, most participants in the Tesla VPP were 50-plus men without children that owned their own home. Another project referred to the disproportionate number of 'retired engineers' in their trials and others noted a concentration of demand response amongst a small number of highly motivated customers. Tesla was the only demand flexibility project that explicitly included a customer/social research analysis in the projects reviewed.

› EV trials have focused on EV owner end-user innovators and early adopters, and predominately been industry-led. Unrepresented groups include disabled drivers, regional drivers, apartment dwellers, fleets, and renters, or geographically contained groups such as EV user communities/community groups and councils. This means research being done today on different vehicle usage patterns and driver expectations (critical for understanding VGI) will have to be repeated for insights on the mass market. ActewAGL project research revealed a lack of literature on the attitudes of EV owners and the wider public attitudes on V2G.

› Program and pilot design needs to be sensitive to the challenge of customer recruitment. Simplified processes which make it as easy as possible for customers to sign-up, front-loaded incentives, avoiding offers with financial uncertainty that dissuade customers and flexibility to change approaches as learning on customer evolves are some of the features required.

SUPPLY-CHAINS MATTER: IMPROVING THE OPERATION AND RESILIENCE OF SUPPLY-CHAINS

Supply-chains were not an explicit focus of the research questions for this project, but various supply-chain issues were commonly referred as obstacles across multiple projects and technologies. Examples include:

› shortages, cost increases and delays in the supply of imported components (e.g. semi-conductor chips for electric hot waters, smart electric vehicle chargers);

› skill gaps (e.g. the emerging field of electric vehicle grid integration, maintenance and servicing for vehicles, chargers, data science, and fleet management, which requires the integration of a diverse array of data and technical skills relating to transport, energy, IT and data science);

› the influence of particular actors within supply-chains for the uptake of demand flexibility technologies (e.g. hot water installers on consumer choice when the system breaks down).

Supply-chain dynamics can be overlooked by the energy sector that tends to focus on energy rules, markets, business models and technologies. Supply chains are more than just mechanistic distribution chains – there are multiple actors interacting and shaped by different incentives and capabilities to connect with consumers in often highly fragmented markets. Intermediaries such as manufacturers, product wholesalers and retailers, traders and installers operate according to their own interests and perspectives. The operation of supply-chains can make-or-break initiatives to scale up consumer adoption of demand flexibility technologies.

Consequently, programs and projects need to consider supply chains in their design. Programs and projects need to be strategic in thinking about which actors can be a 'blocker' or 'enabler' of change and how to change supply-chains as well as energy market regulations etc. For electric vehicles, for example, actors along the supply-chain needs to understand vehicle usage patterns, charging preferences, fleet operational requirements, building energy systems, grid requirements, demand flexibility requirements, and how to integrate hardware and software to deliver a seamless charging experience for the user.

TARIFF INNOVATION AND COLLABORATIONS BETWEEN NETWORKS AND RETAILERS

The Smart Energy Demand Coalition (2017) usefully distinguishes between two types of demand response – 'explicit' (responses to incentive payments) and 'implicit' (responses to price signals). Both types are needed to reach a broad range of customers.

ARENA funding has enabled the successful demonstration of demand flexibility for emergency demand response and FCAS and the development of technical and personnel capacity amongst leading providers that has also supported the growth of wholesale demand response. The next wave of projects are trialing various approaches to value-stacking.

However, there are some notable gaps in the development of demand flexibility value-streams and what ARENA has funded to date. There are few cases of flexible or cost-reflective tariffs, or network demand management pilots in collaboration with retailers. Where networks do trial new tariffs, they are not always implemented by retailers. This reflects a wider issue as illustrated by the very modest take-up of the Demand Management Incentive Schemes (DMIS) by networks. The DMIS was introduced to create an incentive for distribution networks to implement demand management with savings to be shared between networks and consumers. Whilst distribution networks have spent just over $3 million with benefits for consumers of $50 million, this is a very small portion of the permissible expenditure under the DMIS of 1 per cent of network revenue (or approximately $500 million). Consequently, there is major scope for increasing network demand management and value-stacking trials between networks and retailers which is an area ARENA could focus on funding pilots.

ELIGIBILITY OF DEMAND FLEXIBILITY WITHIN GOVERNMENT SCHEMES

As government schemes have primarily focused on increasing renewable energy supply or energy efficiency, the integration of demand flexibility within government schemes is variable. The issue was highlighted by Rheem which observed a major impact on customer recruitment due to increasing subsidies for electric heat pump systems. Electric heat pump systems are more efficient than resistance electric hot water systems with smart controls, but they are not suitable for all households – both have a role to play in the pathway to a low-carbon domestic hot water sector. ISF modelling commissioned by ARENA estimates a potential of 15 –24 GW of flexible demand capacity from domestic hot water under different scenarios. Whilst there is sometimes debate about efficiency versus demand flexibility in relation to hot water storage technologies, integrated policy to increase the uptake of both technologies.

The hot water system example highlights a wider issue in relation to a 'level-playing field' for demand flexibility within government schemes. For example:

› There are a range of schemes which provide incentives for energy efficiency but not demand flexibility technologies, including energy efficiency incentives and ratings and white certificate schemes. Certificate schemes have been a pathway for scaling in renewable energy and energy efficiency. The NSW peak demand reduction scheme is the first equivalent scheme for demand flexibility.

› It is unclear whether demand response will be eligible for the Capacity Investment Scheme in addition to battery and pumped hydro storage. Under the Capacity Investment Scheme, contracts-for-difference will be open through competitive tender for dispatchable capacity to support variable renewable energy. Aggregated flexible demand can play an equivalent role and could be a cost-effective complement and alternative to battery and pumped hydro storage. In view of the challenges developing a business case amidst high financial uncertainty, capacity mechanisms have often been the catalyst for the growth of demand response in other jurisdictions where it has come to play a significant role.

The wider point is that government schemes should be reviewed to test if eligibility should be extended for demand flexibility alongside energy efficiency, renewable generation and storage to support the development of demand flexibility where it can be a cost-effective alternative.

6.3 PATHWAY TO IMPACT

COMPLEMENTING ROOFTOP SOLAR

One of the barriers to the uptake of demand flexibility by households is that the direct financial returns from participation are often modest. There were different views on the level of financial incentive required to motivate consumers. For example, AGL paid a $10 sign-up bonus and 3 x $5 for event performance up to $15 per event, whereas EnergyAustralia found $20 was considered 'negligible' and $50 for use of a battery on top of feed-in tariffs 'piqued interest'. Consequently, it was observed by several demand flexibility providers or industry experts that uptake of demand flexibility can be increased when combined with other services or products that consumers value. For example, it was observed that wi-fi enabled air-conditioning with demand response capability was proving popular with customers because of the control it provides.

Rooftop solar output provides an enormous resource to be stored and shaped to increase value for households and the energy system – but it was observed by some providers that it was more difficult to get households with rooftop solar interested in demand flexibility because the financial returns from solar are much larger. Expectations on financial returns were raised by ownership of solar. Rooftop solar is a household's highest value DER asset – and working out how the value proposition and business model maximises the value of solar is an important consideration for the scaling of demand flexibility.

There are strategic implications for expanding demand flexibility to new and existing solar PV owners:

1. The more likely pathway to impact is to target new solar customers via the solar retailer and installer. Demand flexibility participation could be offered as an additional benefit at the point of installation. Aside from the impact solar ownership has on financial expectations, there are other issues that could be side-stepped by focusing on new installations. Existing systems with net metering create measurement issues and smart meters are typically installed at the same time as the solar panels. For larger solar retailers, expanding their offerings into other technologies (e.g. heat pumps for hot water) and demand flexibility is an incremental change that could increase the value of their business. Partnerships to bundle demand flexibility offers with rooftop solar via solar retailers/installers could be an important avenue for growth.
2. For existing solar owners, the greater source of value will be the role of demand flexibility in unlocking solar generation. The frequency and volume of solar curtailment are growing rapidly, especially on weekends at times when solar output is high and when demand is relatively low. There are a range of solutions emerging including proposals to apply export tariffs to rooftop solar – which are likely to extremely unpopular and risk unintended consequences and worsen consumer trust in energy institutions. Demand flexibility on its own may have less appeal for solar owners but bundled with orchestration and increased scope for solar exports (e.g. dynamic operating envelopes) could be a solution to this problem – with households adopting controlled loads and demand flexibility rewarded with greater envelopes. Project Symphony is an example of how demand flexibility could be integrated with solar PV to combine energy system and household value. This appears to be a more promising avenue for demand flexibility at household level than recruiting customers on the basis of the financial rewards from participation in demand response events.

ELECTRIC VEHICLES – GREATER COOPERATION BETWEEN FIELDS, GETTING THE STANDARDS AND POLICY SETTING RIGHT EARLY, AND SUPPORTING THE NEED FOR THE NEXT WAVE OF EV FLEXIBILITY TRIALS

Capturing the demand flexibility opportunity for EVs is going to require greater cooperation between the energy, building services, and transport fields – with new skills, capacity-building, mapping, improved data and engagement. If experts from those groups are to work together more closely, it will take time and require an integration of their networks and building new relationships to facilitate better two-way flow of information. Research platforms that encourage this type of cooperation can accelerate this, such as the RACE for 2030 and iMove. ARENA support can also help encourage this through providing support for collaborative projects that span these fields.

While lessons from ARENA EV trials generated invaluable lessons with regards to operation and standards for V2G, it also demonstrated that it was too early for this form of demand flexibility from EVs. There are still many research questions relating to vehicle grid integration and the opportunities for demand flexibility using managed charging combined with other forms of DER.

ARENA's funded trials on EVs and demand flexibility have been strongly energy utility led and so it would be beneficial to see a greater variety of these trials with a greater focus on the needs of customers, different use cases, tariff structures, and propositions, transport actors, and business models.

With another major trial on EV grid integration announced and others likely to follow as new standards are adopted and EV adoption increases, ensuring knowledge sharing and exchange between trials is essential to ensure lessons previously learned are built upon.

With the EV market still at the early stages in Australia compared with other comparable economies, and the experience of demand flexibility, there is window of opportunity where the policy settings and standards can be set now that can ensure the full potential of demand flexibility to be realised. There is a critical role for ARENA in supporting the significant amount of work that is needed to build an evidence base for EV demand flexibility, which can support this level of informed decision making.

APPENDIX A: LIST OF ASSESSED ARENA PROJECTS (STAGE ONE)

PROJECT TITLE	PROPONENT NAME	SECTOR	PROJECT STATUS
Renewable Energy for Process Heat Opportunity Study (Phase 2)	A2EP	C&I	Active
Affordable Heating and Cooling Innovation Hub (i-Hub)	AIRAH	C&I	Active
Brimbank Aquatic and Wellness Centre Integrated Energy System	Brimbank City Council	C&I	Active
Demand Response (RERT)	Enel X	C&I	Finalised
Advancing Renewables in the Manufacturing Sector Project	ERM Power	C&I	Active
Demand Response (RERT)	Flow Power	C&I	Finalised
Advancing Renewables with PCM Thermal Energy Storage Project	Glaciem	C&I	Active
Demand Response (RERT)	Intercast & Forge	C&I	Finalised
Project EDGE	AEMO	Enabling	Active
DER Integration and Automation Project (DERMS)	Evoenergy	Enabling	Finalised
Project SHIELD	Redback Technologies	Enabling	Active
Advanced VPP Grid Integration	SA Power Networks	Enabling	Finalised
Flexible Exports for Solar PV	SA Power Networks	Enabling	Active
Optimal DER Scheduling for Frequency Stability Study	University of Tasmania	Enabling	Finalised
Project evolve	Zepben	Enabling	Finalised
Realising Electric Vehicle-to-grid Services (REVS)	ActewAGL	EV smart charging	Active
Electric Vehicle Orchestration Trial	AGL	EV smart charging	Active
Dynamic Electric Vehicle Charging Trial Project	Jemena	EV smart charging	Active
Electric Vehicle Smart Charging Trial	Origin	EV smart charging	Active
Virtual Power Plant (VPP) Demonstration	AEMO	Residential	Finalised
Virtual Power Plant (VPP) Demonstration	AGL	Residential	Finalised
CONSORT: Consumer Energy Systems Providing Cost-Effective Grid Support	Australian National University	Residential	Finalised
White Gum Valley	Curtin University	Residential	Finalised
Alice Springs Future Grid Project	DKRI (Intyalheme)	Residential	Active
Project Converge	Evoenergy	Residential	Active
Decentralised Energy Exchange (deX) Program	GreenSync	Residential	Finalised
Project Highgarden	Horizon Power	Residential	Finalised
Indra Monash Smart Microgrid Project	Indra Australia & Monash University	Residential	Finalised
Narara Ecovillage Smart Grid	NEV Power	Residential	Active
Pooled Energy Demand Management and Modulation	Pooled Energy	Residential	Finalised
Smart Network (Hot Water Load Under Active Control)	Rheem Australia	Residential	Active
VPPx Project	Simply Energy	Residential	Finalised
Alkimos Beach Energy Storage Project	Synergy	Residential	Finalised
Virtual Power Plant (VPP) Demonstration	Tesla	Residential	Active

PROJECT TITLE	PROPONENT NAME	SECTOR	PROJECT STATUS
Networks Renewed	University of Technology Sydney	Residential	Finalised
Renewable Energy and Load Management (REALM) Study	University of Technology Sydney	Residential	Finalised
Project Symphony	Western Power	Residential	Active
Demand Response (RERT)	AGL	Residential / C&I	Finalised
Demand Response (RERT)	EnergyAustralia	Residential / C&I	Finalised
Demand Response (RERT)	Powershop	Residential / C&I	Finalised
Renewable Hydrogen Demonstration for Heavy Transport	Ark Energy	Active	Flexible hydrogen
Denham Hydrogen Demonstration	Horizon Power	Active	Flexible hydrogen
Power to Gas Demonstration	Jemena	Active	Flexible hydrogen
Feasibility Study – Hydrogen Hub	Port of Newcastle	Active	Flexible hydrogen
Hydrogen process R&D Project	Queensland University of Technology	Active	Flexible hydrogen
Feasibility Study – Central Queensland Hydrogen Project	Stanwell	Active	Flexible hydrogen
Toyota Ecopark Hydrogen Demonstration	Toyota	Active	Flexible hydrogen
New Energies Service Station Geelong Demonstration Project	Viva Energy	Active	Flexible hydrogen

APPENDIX B: KNOWLEDGE GAPS AND RESEARCH QUESTIONS

KNOWLEDGE GAPS	RESEARCH QUESTIONS
What is the value of demand flexibility (for customers) and what role can it play in energy and related markets?	What value streams are flexible demand currently accessing and how is that value being stacked?
	What are the barriers to accessing value streams from flexible demand?
	What is the emerging role of flexible demand in balancing supply-side variability in practice?
What technologies are being used to enable demand flexibility, what is their level of maturity, and what further technology innovation is required?	How is thermal storage, battery storage, material storage (e.g. stockpiling) and onsite generation being utilised?
	What are the opportunities and/or issues regarding behind-the-meter device interoperability and multi-device orchestration?
How are retail, aggregator and third-party business models incorporating flexible demand and what are the value and pain points associated with emerging models?	How are product marketing models emerging and what learning has occurred with regard to customer acquisition and retention?
	What is the customer experience and what are the key values and pain points in the customer journey?
How do regulatory frameworks enable and shape commercial and technology approaches and what specific reforms could support the achievement of efficient levels of flexible demand?	What capability is emerging for the demand-side to forecast demand and meet demand targets, such as in the context of 'Scheduled Lite'?
	What role does the new wholesale demand response mechanism play and what are its limitations?
	What alignment is there between market-based responses and minimum demand mitigation?
	How are current metering and network and/or retail tariff arrangements contributing to or inhibiting the use of demand flexibility?
	What methodologies and benchmarks are needed to baseline flexible loads (e.g. calculations, settlement procedures, verification)?
	What is the optimal balance between accuracy, precision and cost?
What are the customer barriers to scaling flexible demand and what are the priority actions to progress this?	What are the costs for customers and aggregators associated with implementing greater demand flexibility?
	What discount rates are used or are implied in customer decision making and how do these relate to contract or lease duration?
	How are models successful or unsuccessful in different contexts?

REFERENCES

Australian Energy Market Commission (2021) *National Electricity Amendment (Governance of Distributed Energy Resources Technical Standards) Rule 2022,* Consultation Paper. www.aemc.gov.au/rule-changes/governance-distributed-energy-resources-technical-standards.

Australian Energy Market Commission (2022) *Review of the Regulatory Framework for Metering Services, Draft Report,* November.

Australian Energy Market Operator (2022) *Wholesale Demand Response: Annual Report.*

Australian Energy Market Operator (2023) *Quarterly Energy Dynamics Q4 2022.*

Brinsmead, T.S., White, S., Bransden, C., Stanley, C. Hasan, K., Alexander, D., Sprague, M., Northey, J., Walgenwitz, G., Nagrath, K., Briggs, C., Leak, J., Harkins-Small, L., Murray-Leach, R. and Jennings, K. (2021). *Flexible demand and demand control. Final report of opportunity assessment for research theme B4,* RACE for 2030 CRC.

Brown, T., Newell, S., Spees, K & Wang, C. (2019) *International Review of Demand Response Mechanisms in Wholesale Markets*, Prepared for the Australian Energy Market Commission.

Clean Energy Council (2022) *Submission to the Australian Energy Market Commission Draft Determination: Governance of Distributed Energy Resources Technical Standards*. www.aemc.gov.au/rule-changes/governance-distributed-energy-resources-technical-standards.

Department of Environment and EnergyAustralia (2019) *Consultation Paper: 'Smart' Demand Response Capabilities for Selected Appliances*, August.

DNV KEMA (2013a) Development of Demand Response Mechanism: Baseline Consumption Methodology – Phase 2, report prepared for AEMO. www.aemo.com.au/-/media/files/initiatives/wdr/baseline_consumption_methodology_phase_2_report_oct13.pdf.

DNV KEMA (2013b) Development of Demand Response Mechanism: Baseline Consumption Methodology – Phase 2, report prepared for AEMO. www.aemo.com.au/-/media/files/initiatives/wdr/baseline_consumption_methodology_phase_2_report_oct13.pdf.

Energy Queensland (2022) *Demand Management Plan*, April.

Energy Synapse (2022) *Load Flexibility Study: Technical Summary,* https://arena.gov.au/assets/2022/02/load-flexibility-study-technical-summary.pdf

Hoch, L., Rick, A., Cruickshank, A., Darlington, M & Lilford, D. (2020) *Phase 1 – Baseline Methodology and Participant Testing. Wholesale Demand Response Mechanism – Baseline Methodology Testing and Metrics*, Report prepared for AEMO.

Hoch, L., Rick, A., Cruickshank, A., Darlington, M & Lilford, D. (2021) *Phase 2 – Baseline Methodology and Participant Testing. Wholesale Demand Response Mechanism – Baseline Methodology Testing and Metrics*, Report prepared for AEMO.

Kuiper, G. & Gill, M (2021) 'Mandating A4755 Ignores Households and Widely Supported International Solutions', ieefa.org/wp-content/uploads/2021/08/Mandating-AS4755-Ignores-Households-and-Widely-Supported-International-Solutions_August-2021.pdf, https://ieefa.org/wp-content/uploads/2021/08/Mandating-AS4755-Ignores-Households-and-Widely-Supported-International-Solutions_August-2021.pdf

Liu, Y. (2017) 'Demand Response and Energy Efficiency in the Capacity Resource Procurement: Case studies of forward capacity markets in ISO New England, PJM and Great Britain, *Energy Policy*, 100.

Oakley Greenwood (2019) *Baselining the ARENA-AEMO Demand Response RERT Trial*, arena.gov.au/assets/2019/09/baselining-arena-aemo-demand-response-rert-trial.pdf.

Oakley Greenwood (2021) *Phase 2 – Baseline Methodology and Participant Testing: Wholesale Demand Response Mechanism – Baseline Methodology Testing and Metrics*, Report prepared for AEMO.

Roche, D., Dwyer, S., Rispler, J., Chatterjee, A., Fane, S. & White, S. (2023). *Domestic Hot Water and Flexibility.* Report prepared for ARENA by UTS Institute for Sustainable Futures (in publication).

Smart Energy Demand Coalition (2017) *Explicit Demand Response in Europe: Mapping the Markets 2017*, Brussels.

Further information is available at
arena.gov.au

Australian Renewable Energy Agency

To explore potential for funding visit:
arena.gov.au/funding

Postal Address
GPO Box 643
Canberra ACT 2601

Location
2 Phillip Law Street
New Acton ACT 2601

Engage with us

ARENAWIRE

Australian Government
Australian Renewable Energy Agency

ARENA