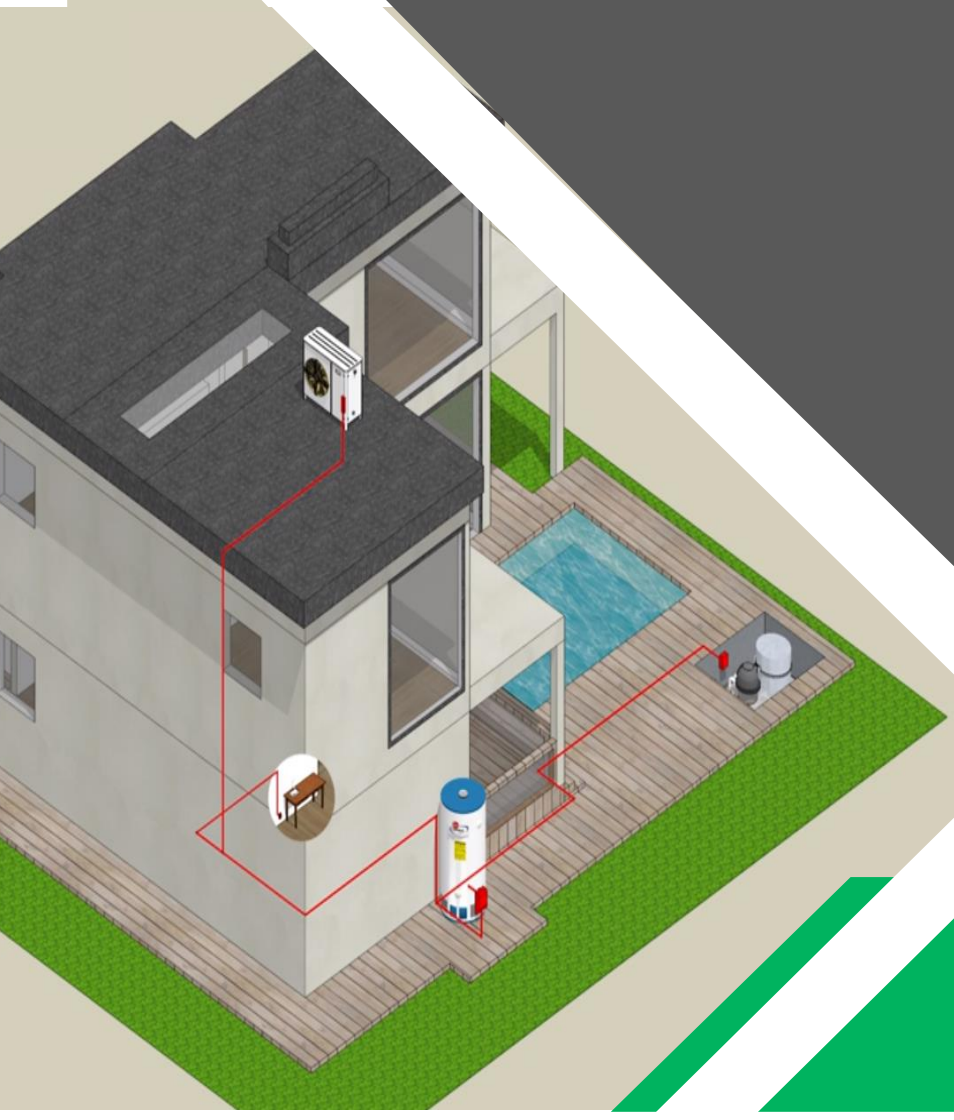
ARENA – ADVANCING RENEWABLES PROGRAM (ARP)

SA SMART NETWORK Project

Lessons Learned Report 2

Bringing SA Hot Water Load Under Active Control

April 2022



Rheem · Combined Energy · Simply energy by ENGIE · SA Power Networks · MARCHMENT HILL CONSULTING

Project Summary	
Project	SA Smart Network Project
Project Numbers	ARENA: 2019ARP023 SA DEM: FA-00181
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Project Control	
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This Project received funding from ARENA as part of ARENA's Advancing Renewables Program and the South Australian Government's Demand Management Trials Program.

Acronyms

AEMC	Australian Energy Market Commission
AEMO	Australian Energy Market Operator
API	Application Programming Interface
ARENA	Australian Renewable Energy Agency
CET	Combined Energy Technologies
DER	Distributed Energy Resources
DNSP	Distribution Network Service Provider
DRSP	Demand Response Service Provider
FCAS	Frequency Control Ancillary Services
HWS	Hot Water Systems
HEMS	Home Energy Management System
kW	Kilowatt
kWh	Kilowatt Hour
MW	Megawatt
NEM	National Energy Market
PV	Photovoltaic
OPCL	Off Peak Controlled Load
SA	South Australia
SAPN	South Australia Power Networks
VPP	Virtual Power Plant

Contents

1 Executive Summary

Lessons learned	Summary insights	Section
1. Exposure to the global semiconductor shortage has impacted product availability	• Significant increase in essential component lead times. • Significant increase in component cost. • This has resulted in limiting supply of smart electric hot water heater systems and retrofit devices available for customers as part of the project.	*2.1*
2. There are unique challenges to driving customer acquisition	• Requirement to switch retailers. • Requirement to sign multiple Virtual Power Plant (VPP) contracts. • Customer behaviours in the hot water breakdown market versus new upgrade market. • Relatively low market share of the energy retail project partner in SA.	*2.2*
3. The initial rebate structure was not a sufficiently strong incentive for customers	• The original two-phase rebate structure did not create a sufficiently strong customer incentive to sign-up to the VPP program. • Rheem has adjusted the rebate to now be paid as a fully upfront single rebate payment. • This has resulted in additional risk worn by Rheem but required to reach rollout volume objectives.	*2.3*

4. Significant regulatory risks still exist for VPP project economics	• As with most VPPs, Frequency Control Ancillary Services (FCAS) are expected to be key revenue streams for the SA Smart Network project. • AEMO is currently reviewing the Market Ancillary Service Specification (MASS), which could have significant impacts on how FCAS markets operate for behind-the-meter VPPs and reduce the ability of some VPP projects to access FCAS revenues. • Highlights the risk of regulation and emerging technologies.	*2.4*

Table 1: Lessons Learned – Executive Summary.

2 Lessons Learned

This is the second 'Lessons Learned' report for the SA Smart Network project. This report has been slightly delayed as there has been some changes to the project schedule negotiated between the parties (Rheem, ARENA and DEM).

While the project is still at a relatively early stage, the experience gained to date in deploying such a novel product in the real-world has provided insights that are already proving valuable for the rest of the project.

Central to these insights have been customer-related learnings, particularly regarding customer behaviours, key barriers to customer participation and receptiveness to incentives. Considering these learnings, we are adapting our approach to the customer purchasing experience to drive uptake of the combined hot water and VPP solution going forward. We have also sought an additional retail partner in AGL.

The focus of this second Lessons Learned report is on the following four insights:

1. **Exposure to the global semiconductor shortage has impacted product availability.**
2. **There are unique challenges to driving customer acquisition.**
3. **The initial rebate structure was not a sufficiently strong incentive for customers.**
4. **Shifting regulatory environment – MASS consultation.**

Each of these are covered in the sub-sections following.

2.1 Key learning 1: Exposure to the global semiconductor shortage has impacted product availability

The project has been impacted by the global shortage of semiconductors ('chips') needed to manufacture its electric water heaters. The key learning and experience for Rheem is that though delays were expected, the supply shortage has been further exacerbated by the COVID-19 pandemic over the past 12-18 months[1].

For Rheem, the shortage has resulted in significant increases in chip component lead times, 54 weeks in some cases, compared to around 18 weeks typically. These chips are a critical component in Rheem's smart electric water heaters and retrofit devices being rolled-out as part of this project; the delay in delivery has resulted in significant manufacturing constraints. Compounding the effect of increased delivery lead times,

[1] BBC News, "Why is there a chip shortage?" August 27, 2021. Accessed online at: https://www.bbc.com/news/business-58230388

the shortage has also resulted in the cost of chip components increasing by approximately 10%-20%[2].

The constraints on these essential components limited the supply of smart electric water heater systems and retrofit devices available to customers as part of this project and has highlighted the criticality of this essential component in the supply chain of these products.

Rheem's planning and forecasting anticipated some delays. This has now been revised to also account for the effect of COVID-19 on supply-chains.

2.2 Key learning 2: There are unique challenges to driving customer acquisition

Although Rheem anticipated challenges to selling smart electric water heaters due to the product's novelty as well as the trial element of participating in a VPP, the experience to date has been more difficult than expected. The project has identified several specific barriers to customers' willingness to purchase.

The key barriers limiting take-up are:

Requirement to switch retailers

The purchase of a smart electric water heater and participation in the VPP requires customers to change to a participating project retailer. Customers have been slow to switch despite the compelling retail offer for program participants. This is proving to be a significant barrier to customers' willingness to participate.

Requirement to sign multiple contracts

Though there is only one VPP contract, customers need to ensure that they are with a participating retailer who has an eligible retail tariff. The VPP contract signs off participation in the Rheem/CET trial and usage of the home energy management software. We are seeing this as a source of hesitation and confusion for potential customers that is limiting take-up. The addition of AGL as a retail partner should increase the spread of customers who are with a participating retailer, and this should improve the take-up rate.

Customer behaviours in the hot water breakdown market versus new upgrade market

There are two distinct 'moments of truth' for customers in dealing with new hot water systems – those that buy when their current hot water system breaks down (breakdown

[2] The Verge, "TSMC is raising chip prices as supply shortages continue" Accessed online at: https://www.theverge.com/2021/8/26/22642627/tsmc-chip-price-increase-supply-shortages-apple-qualcomm

market) and those who proactively upgrade their hot water system at other times (upgrade market). Customers in these two markets display different purchasing behaviours. The breakdown market is significant in terms of size, and we are observing that the behaviours of these customers is driven by time (to get hot water back ASAP) and price (as it is an unplanned household cost), both of which make it more challenging to offer them a higher priced and more complex product like a smart electric water heater as part of a VPP.

The cost, the perceived complexity of trial participation and the novelty of the technology lead to a longer sales cycle which is seemingly incompatible with the hot water breakdown market where customers are looking for an immediate replacement.

One of the challenges of the trial is to streamline the sales process to tap into the hot water breakdown market. This is currently being advanced by:

- Opening new sales channels, particularly plumbing businesses
- Improving communication and promotional materials surrounding the product and trial
- Introducing additional electricity retailers to the project to reduce the number of perceived barriers to entry of the trial

Low retail energy market share of project partner retailers

The mandatory project retailer's relatively low market share in South Australia (~ 11%) is limiting the project's ability to access a larger number of target customers without the need to switch retailers. To remediate this, Rheem is currently in discussions with additional retailers about joining the project. To date, AGL has been approved by the project as an additional retail partner.

2.3 Key learning 3: The initial rebate structure was not a sufficiently strong incentive for customers

The rebate structure was originally phased into two 'cash back' amounts, one on sign-up and a second paid after remaining in the program beyond August 31, 2022. The experience to date however has shown that separating the rebates in this way did not create a sufficiently strong customer incentive to sign-up to the trial.

With a view to further driving customer uptake, Rheem has elected to switch the rebate structure to a single payment that is fully paid to customers upfront. This is simplifying the acquisition process particularly around the initial contracting of customers, which is recognised as a barrier to participation in the program. This change has resulted in some additional risk being worn by Rheem (namely in the event the customer does not stay in the VPP program long term) however this was considered an essential change to ensure the project achieves its rollout volume objectives.

The project appreciates that it needs to strike a balance between the adequacy of incentives and making the process of participating in the VPP trial less onerous as

highlighted in Learning 2. To this end, it always seeks to first understand if there are any other opportunities to mitigate or manage barriers to participation before looking at other options.

2.4 Key learning 4: Significant regulatory risks still exist for VPP project economics

Unexpected regulatory outcomes can still present a high degree of risk to VPP revenues.

FCAS are an important revenue source for VPPs, estimated to provide up to 75% of total revenue[3]. Rheem's SA Smart Network project is aiming to test the potential FCAS value of aggregated hot water systems and other DER types as part of a VPP, with visibility for SAPN and the Australian Energy Market Operator (AEMO).

However, in a recently released AEMO report on the Market Ancillary Service Specification (MASS)[4], the market operator has proposed relaxing the standards for participation in FCAS markets, finding a middle ground between the existing high speed metering requirements and the slow measurement speeds of battery inverters. Although this change is designed to enable more DER to participate in FCAS markets more easily at scale, it highlights the regulatory risk present in certain areas of the market.

Lowering barriers to entry could represent a material change to the forecast FCAS revenues. With the rise of residential batteries being offered into the FCAS markets by a host of new entrants, there is very likely a dilution in the amount of revenue available to other market participants.

[3] "Did AEMO just kill off the market for battery-based Virtual Power Plants?" RenewEconomy, 2/07/2021. Accessed online at: https://reneweconomy.com.au/did-aemo-just-kill-off-the-market-for-battery-based-virtual-power-plants/

[4] AEMO "Amendment of the Market Ancillary Service Specification (MASS) – DER and General consultation" 27/09/2021. Accessed online at: https://aemo.com.au/consultations/current-and-closed-consultations/mass-consultation?submissions=2

Appendix A: Project Information

Project Background

Water heating is a significant electricity sink, ***comprising 25% of household energy use in Australia*** (the second largest segment of household energy consumption behind space heating and cooling). As a large energy-using appliance that can be 'time-shifted', many DNSP's offer a controlled load tariff that is applied to electric water heaters during off-peak times (referred to as Off-Peak Controlled Load or OPCL), so that they can draw electricity at a predictable time and a cheaper rate. In South Australia, this load is set through static time switches to operate overnight between 11PM and 7AM. Similar timings for OPCL exist across all NEM regions.

This off-peak timing is based on historic centralised generation, and transmission network loads which have become out-dated due to high penetrations of residential solar in the network. With growing rooftop PV penetration, significant volumes of electricity are being generated such that grid demand during the middle of the day is being reduced to record low levels, creating the "duck curve" (see Figure 1 below). In addition, PV uptake has increased variability in the range of power flows that the network must be able to support (e.g. demand transience due to cloud cover, fluctuations in demand between the middle of the day and in the late afternoon) and can cause power quality issues such as high voltages when PV systems are at peak output. This can limit the renewable energy hosting capacity of networks unless costly network solutions are employed (e.g. transformer taps, voltage regulators, load compensators) or customers are incentivised to shift load through energy storage or demand management incentives.

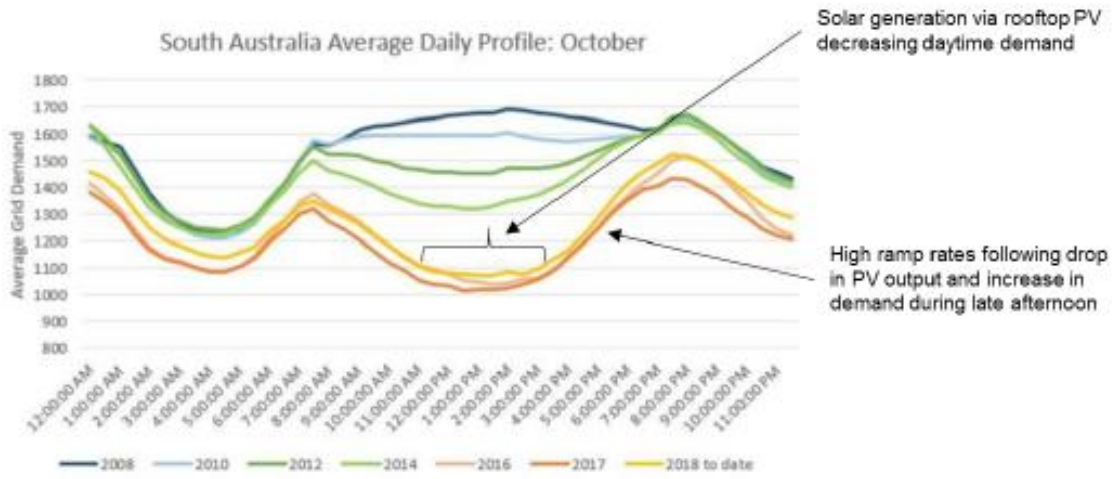

Figure 1: Impact of solar PV on daily demand profiles in South Australia.

SA Power Networks (SAPN) has over 300,000 off peak hot water storage loads throughout its distribution network. Assuming an average water heater power draw of 3.6 kW, this equates to 1,080 MW of untapped DER load, with a total average daily

energy consumption of between 3 – 4.5 GWh (based on 10 - 15 kWh of water heating per tank per day - weather and seasonally dependent). This represents a significant energy storage capacity in South Australia, and more widely across the NEM, yet to be harnessed.

In South Australia, currently, electric hot water systems on controlled load are switched on at a fixed time via mechanical time switches at the customer's premises, or in switches that have been incorporated through electronic meters. SAPN's control over electric water heaters is limited to these time switches, which cannot be controlled dynamically or remotely. Timing can only be varied by manual adjustment for each customer. Furthermore, all hot water systems are currently run at their full load rating when heating, at a significant ramp rate which has previously driven spikes in electricity prices in SA.

Rheem's Smart Network project aims to demonstrate how this significant energy resource could potentially be brought under control using novel technology developed through 5 years of innovation in variable power water heating and home energy management systems. The project aims to test different strategies to shift the timing of water heating to consume excess solar PV generation during the day.

Project Overview

The SA Smart Network project aims to explore alternative approaches for shifting the timing of and demonstrating active control over hot water systems within South Australia.

The project will explore the potential for 2,400 residential hot water systems along with (at a minimum) 200 air conditioning systems and 200 pool pumps to provide aggregated demand response within a VPP to deliver wholesale market value to participating customers. The project will test the potential to derive further wholesale value and deliver FCAS, in addition to bill optimisation for trial participants.

Furthermore, the project will investigate hot water control through testing a range of technologies and product offerings, developed to maximise participation from customers, assess customer preferences for participating in hot water demand management, and demonstrate a low-cost and scalable solution to providing active control. This will include the development and commercialisation of a retrofit device that can be added to existing hot water heaters.

The project also involves collaboration with Combined Energy Technologies (CET), a leading provider of home energy management systems (HEMS) in providing active control over the hot water systems, SA Power Networks in developing a network tariff to incentivise hot water load shifting and a number of Project Retailers to develop a range of product offerings to achieve customer participation in the aggregation/orchestration of hot water systems within the VPP, and pass back value derived in the wholesale market to participating customers.

The project will involve the development, deployment, and demonstration of three solar-smart electric water heater solutions (PowerStore, PowerStore Lite and a Retrofit

device) and two load control adapters, one for air conditioning systems and one for pool pumps. These devices will all be integrated with CET's HEMS. These products are described in the table below.

Technology	Quantity	Description
PowerStore	200 PowerStores in solar homes 200 PowerStores in non-solar homes	The PowerStore is a solar-smart electric water heater that was released by Rheem to the market in Q3 2018. The PowerStore product can provide 15kWh of thermal energy storage and offers dynamic adjustments to its power demand on the network. The PowerStore will be available to customers who are replacing their hot water systems or to customers with new installations looking for a sophisticated and state-of-the-art HWS (with the benefits mentioned earlier).
PowerStore Lite	500 PowerStore Lites in solar homes 500 PowerStores Lites in non-solar homes	Rheem is developing the PowerStore Lite that is designed to be a lower cost deployment solution to the PowerStore. It will not offer all the functionality of the PowerStore, however it will still offer active control. The PowerStore Lite will be available to customers who are replacing their hot water systems and customers with new installations.

Technology	Quantity	Description
Retrofit device	500 Retrofit devices in solar homes 500 Retrofit devices in non-solar homes	The Retrofit device will be developed to be retrofitted to existing hot water systems, targeting households that are not replacing their hot water systems. The devices will be low cost, allow for rapid deployment and will be available to solar and non-solar homes. The device will enable active control of existing hot water systems, targeting customers with suitable water heater systems that are willing to upgrade to the new technologies to take advantage of savings and to assist with grid stabilisation.
Air Conditioning System Adapter	200	The air conditioning adapter will be developed to interface with existing air conditioning systems. These devices will be targeted at existing customers within the program to further increase the value of their solar smart electric water heater and Home Energy Management Systems.
Pool Pump Adapter	200	The pool pump adapter will be developed to function with pool pump systems. These devices will be targeted at existing customers within the program to further increase the value of their solar smart electric water heater and Home Energy Management Systems.

Technology	Quantity	Description
HEMS	The HEMS will be integrated with the PowerStore, PowerStore Lite, Retrofit and load control adapter devices	CET's Home Energy Management System (HEMS) is the interface that enables active control of the hot water systems and other DER using Power Line Telecommunications (PLT) and to allow the CET/Rheem cloud-based application VPP to monitor and control household loads to shift the load into the solar period, to lower energy costs for consumers and to participate in stabilising the grid.

Table 2: Project technologies

Project Objectives

The project seeks to demonstrate that hot water systems can provide aggregated demand response within a VPP and deliver potential wholesale and FCAS value to participating customers.

The objectives for the Project will be achieved through the following outcomes:

- Improved understanding of the feasibility of different approaches for shifting hot water load to provide network value in South Australia, including the development of new tariff structures that reward electricity consumption aligned with variable renewable energy (VRE) generation.
- Improved understanding of the incorporation of hot water load within a broader demand management package (through inclusion of other household controllable loads or DER types), as well as assessing customer preferences to different incentives.
- Understanding the potential savings that solar and non-solar customers could receive on electricity bills because of active control of hot water systems or load shifting and proposed new tariff structures (Time of Use tariffs).
- Test the potential wholesale energy and potential FCAS value of aggregated hot water systems and other DER types as part of a VPP, with visibility for SAPN and the Australian Energy Market Operator (AEMO).
- Advance the commercialisation of a locally retrofit device to control hot water load in SA.

Project Stakeholders & Participants

The Project partners with Rheem Australia are:

- Combined Energy Technologies (CET) - will develop the Home Energy Management System (HEMS) interface that will enable active control and aggregation/orchestration over the hot water systems.
- South Australia Power Networks (SAPN) - will develop a network tariff structure to incentivise hot water load shifting and promote the use of active control for such devices.
- Project Retailers – will develop a range of product offerings to achieve customer participation within the VPP and to pass on value derived from the wholesale market to participating consumers.
- Marchment Hill Consulting – will be responsible for the Knowledge Sharing deliverables for the duration of the Project.