Project Final Report

Social Science

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CONSORT: "Consumer Energy Systems Providing Cost-Effective Grid Support" is a collaboration between The Australian National University, The University of Sydney, University of Tasmania, Reposit Power and TasNetworks. The Australian Government, through the Australian Renewable Energy Agency, is providing $2.9m towards the $8m trial under its Research and Development Program.

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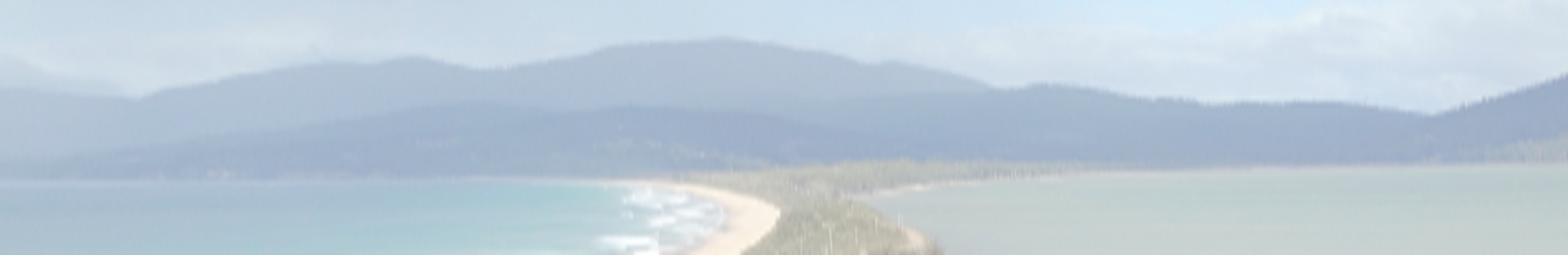
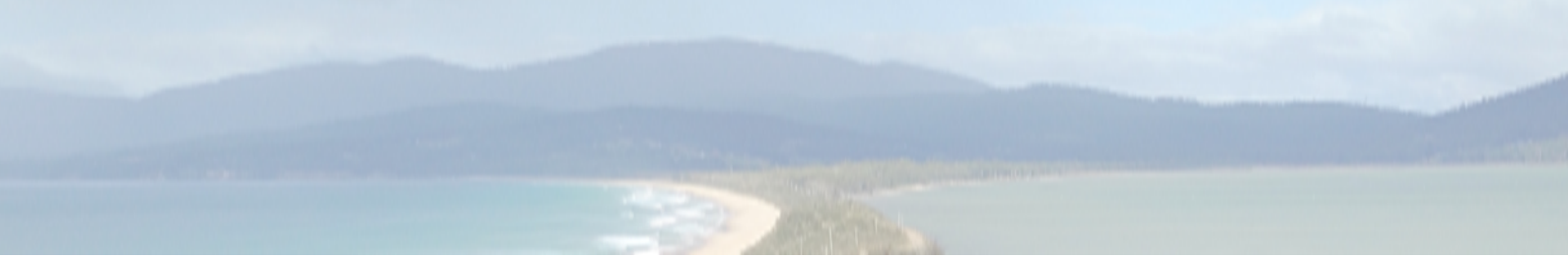
TasNetworks Delivering your power





Executive Summary

This social research report brings together a wealth of rich new qualitative data on how householders respond to Distributed Energy Resources (DER). Through dedicated ARENA funding for the social research on the CONSORT project over a three-year period, we have been able to investigate in-depth 34 households who took part in the Battery Trial on Bruny Island, Australia. Our key findings, discussed here, cover the installation of the new technology, householders' emotional responses to the technology, how household behaviours changed over the course of the trial, and household reactions to new payment systems, tariffs, and rewards.

An overall finding of practical importance to similar trials underway elsewhere is how our social research was able to identify issues with the technology at an early stage - because we were in frequent 'front-line' contact with the households - and thereby communicate to, and work with, the rest of the CONSORT team to resolve issues early on. More fundamentally, it emerged over the course of the Trial that many of the unexpected things the Trial households focused on and raised with us did turn out to be important gaps in the technology or CONSORT team understanding. For instance, several households reported a lack of information at the time of technology installation, and it was found that not all installers were able to pass on information about the new technology. The role of installers was later agreed by the CONSORT team to be vital. As another example, a number of households were unsure about which tariff they were on, and it did later emerge that the process for switching tariffs and checking the tariff was convoluted.

We identified in our original project proposal to ARENA (October 2015) the way in which Bruny Island would operate as 'a rigorous…[and] extreme test case' (p.22) for new DER interventions, because of its rural location, high proportion of holiday house (shack) owners and non-average demographics (a high proportion of retirees). This turned out to be the case.

A common assumption amongst industry and government reports on DER is that householders are likely to be willing and unproblematic participants in DER sharing with networks. Our CONSORT social research challenges this assumption: households are diverse, and greater awareness and appreciation of the context in which households make decisions about their energy is crucial to understanding their receptiveness to DER, and their DER preferences.

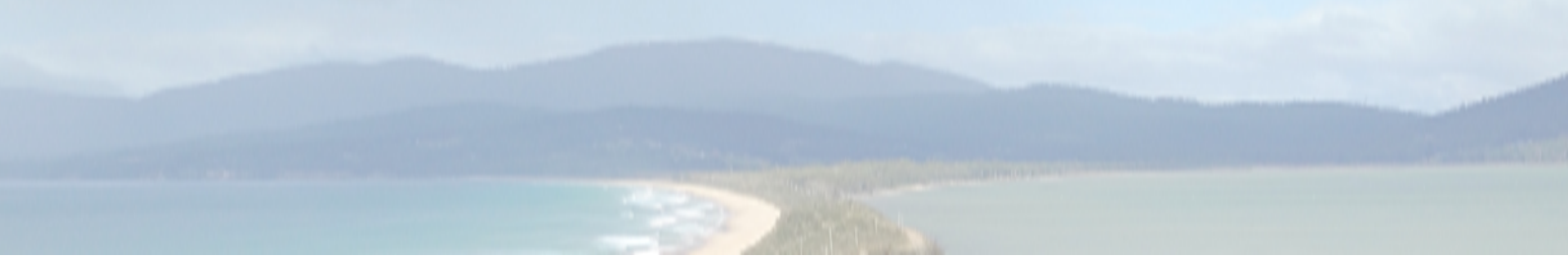


Table of Contents

Executive Summary 3

Table of Contents 4

Key Findings 6

Key Lessons 8

Introduction 9

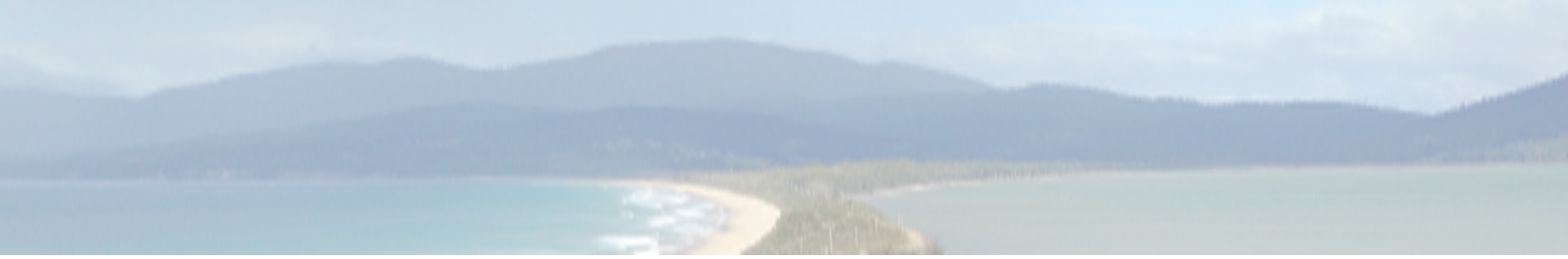
Background and context 10

- The case - a battery trial on Bruny Island 10
- Trial household profiles 11
  - Key attributes 11
  - Physical house traits 13
  - Implications of participant household traits for the Trial 14
- Other DER trials and the research context in Australia 14

Methods 15

Findings 17

- Subsection 1 – Installed technology, controller and interface 17
  - Installations 18
    - Installation experiences and effects 18
    - Installers as key intermediaries 20
    - Installing DER technology: retrofitting technology into homes 21
    - Technology issues at the installation 22
  - Householder emotions in response to the technology 22
    - Emotions and overall technology acceptance 23
    - Emotions over time 24
    - Coping strategies 25
  - Longitudinal analysis: behaviour change and Reposit app usage 26
    - Behaviour change over time: energy behaviours and practices 26
    - Changes in Reposit app usage over time 28
- Subsection 2 – Finance and pricing-related householder responses 31
  - What motivates? Are financial motives salient? 31
  - Network support payment types 33
  - Household awareness of network operations and NAC 35
  - The impact of tariffs 37



Subsidies and Payback 38

Conclusion **39**

Recommendations 41

References **42**

Appendices **45**

Appendix A: Review of DER trials and studies in Australia 45

Appendix B - Research Methods 47

Participant numbers in social research 47

Recruitment, information provision, and sampling 48

Installations 50

Pre installation focus group 50

Pre-installation interviews 50

Online forum 51

Post-installation (post-install) interviews 51

Energy Diaries 52

Final (‘year one’) interviews 52

Final (post-install, year one) Focus group 53

Appendix C - Technology as installed: example images 54

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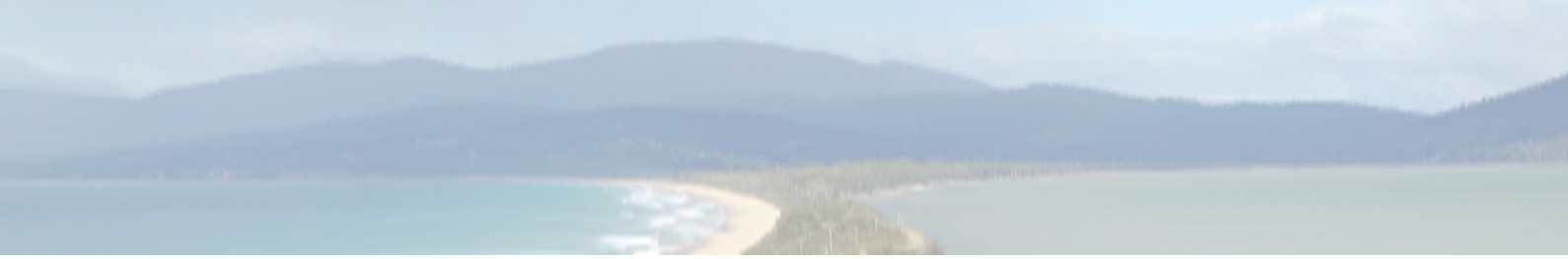
We would like to acknowledge and thank the households who took part in the Bruny Island Battery Trial for participating in the social research - they generously gave their time along with their wonderful insights. Also, we are grateful to the other parts of the CONSORT team for all their valuable input into our analysis.



Key Findings

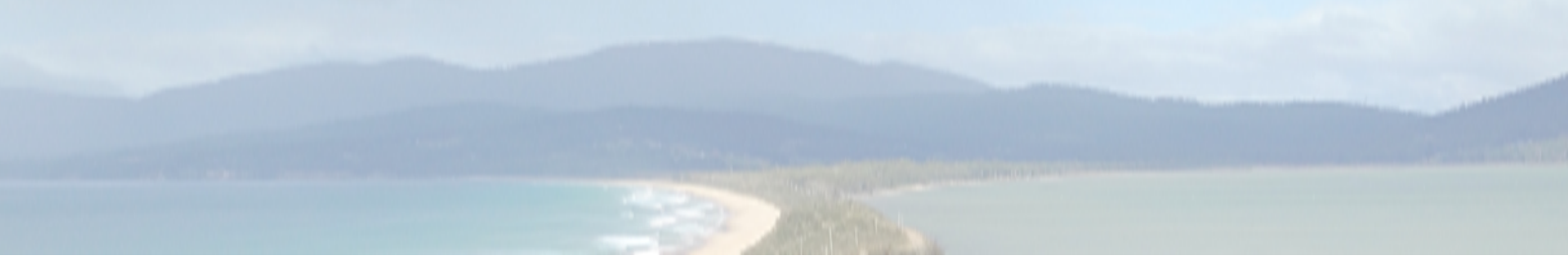
Key findings to have emerged from our social research analysis on installation, emotions, changes over time, and pricing are explored in depth below, and are summarised here as follows:

Technology installations at our Trial households:

- the installation process was not a discrete, one-off event, but rather a diffuse process that for most households took some time and was not straightforward.
- the installation experience was an important moment for households, and one which had a strong impact on their ongoing experiences of the overall Trial, including their satisfaction with the technology and pricing.
- installers varied greatly in terms of the level of education and support they provided for households. In most cases installers did not have the capacity to provide follow up support to households.
- DER systems utilised multiple technologies, which when combined on-site at homes create a rather complex overall system. While each individual technology company involved in the Trial provided information and support for their individual technology component (for example, Reposit provided support related to the Reposit controller and LG provided information support for their batteries), there was a need for householders to combine and synthesize information from different components of the DER system. No stakeholders (other than installers) are currently in a position to provide overall DER knowledge support and problem resolution roles (as no one technology provider has overall responsibility for the DER system). Support for householders in terms of this broader, combined level of understanding required to resolve some technical issues fell primarily to TasNetworks and the installers in this Trial. However, it took considerably more time than anticipated, and this substantial overall advice role is unlikely to be sustainable at scale, either by installers or utilities.

Householder emotions:

- householders' emotions formed a central part of our social research analysis because in situations where people lack critical information, or situations that are complex or uncertain, their evaluations tend to be based on affective (emotional) responses - particularly beliefs about trustworthiness - rather than deliberate cognitive evaluations.
- Trial households expressed both positive and negative emotions: 23 of 32 longitudinally analysed households were overall relaxed and confident in the technology and the Trial, but experienced some level of frustration and confusion, and therefore had criticisms of the installation and the technology; 9 households expressed more negative emotions in regards to the technology and experience of installation such as anxiety, frustration, and even anger.
- for those households experiencing negative emotions, coping strategies were used, such as: reframing the technology from something that needs their active input and



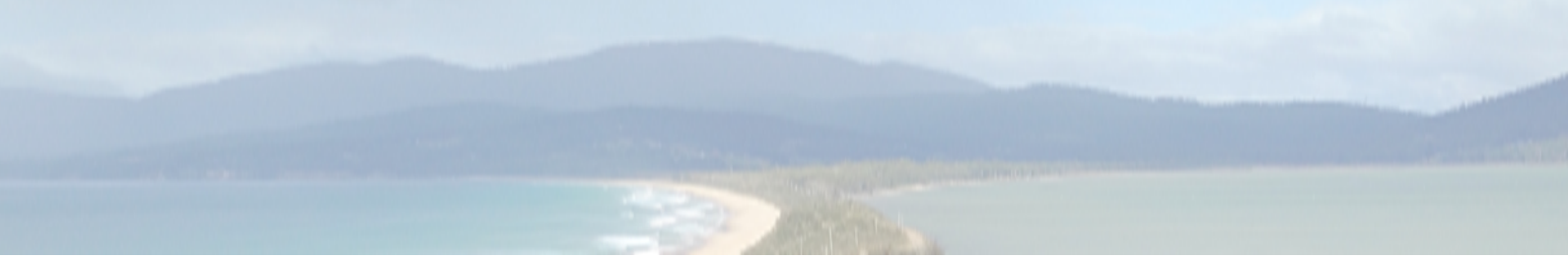
understanding to a technology that can be seen as ‘set and forget’; and taking control and keeping the perceived risk at bay by dismissing the technology (e.g. by opting out of Reposit services).

Changes over time in household energy behaviours and use of the Reposit app:

- Types of energy behaviour change reported to us were mostly to do with changing the timing of energy use activities, rather than stopping behaviours. Typical activities discussed by Trial households include clothes washing, dishwasher, showering, heating (space heating and hot water), and use of the oven.
- The key prompt for household energy behaviour change was the new Time of Use (TOU) tariff.
- We examined the issue of change over time because there is some uncertainty in academic studies about whether household behaviour change is short-lived in response to a new energy technology (or other energy intervention), or whether it persists over the long term.
- Our findings indicate that initial changes in behaviour and use of the Reposit householder app have persisted over the course of the Trial, for the majority of households.

Householder perspectives on system value

- Understanding motivations of Trial households with regard to pricing and preferences for using their installed CONSORT technology is important in order to test pre-Trial assumptions underpinning use of the Reposit software. The Reposit controller is designed to optimise against incentive structures that are represented in financial terms. To date, the only incentives exposed to the Reposit controller are to lower the household energy bill as much as possible. In effect this represents a scenario where finances hold critical sway in household decision making around energy. When householders were asked about third-party use of their DER, we found that financial considerations were important, but we also found a range of other issues and motivations to be important, such as battery backup, and community and environmental values.
- A key tension in the Trial was the value householders place on having back-up power available from their battery. It was expected by our industry partners that householders would be happy to share their battery with the network if they were well-paid for its use, but our findings suggest this is not necessarily the case. The rural context of Bruny with above average network outages may be an important influencing factor.
- Most householders did not have a preference between the two types of network support payment that were trialled: Energy Reserve and Energy Use (see Reward Structures Final Report by Chapman et al (2019)). On prompting, those who did express a preference (5 of 30) all chose Energy Reserve due to a perception it would pay them more (as they observed more power would be reserved than would be potentially needed).



- A significant number of households did not change to the Time-Of-Use (TOU) tariff, despite analysis showing they would have been better off financially to do so (see the Reward Structures Final Report (Chapman et al 2019)).
- The process of changing tariffs involved several steps, and was not straightforward, meaning a number of households were not certain what tariff they were on after installation, and even a year later.
- The change in tariff was a really key part of the Trial experience for householders, and was given more consideration by householders than other pricing interventions such as the network support payments.
- Awareness of the NAC was low amongst Trial households - it was generally not differentiated from Reposit.

Key Lessons

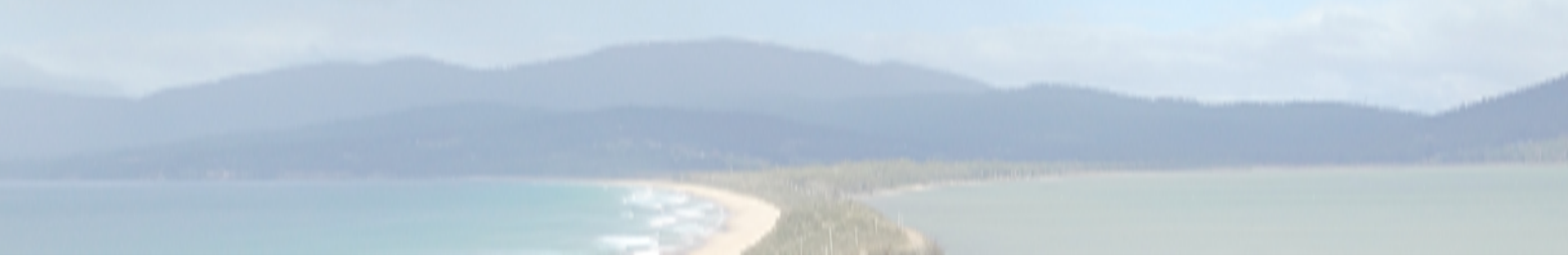
The key general lessons from our social research on the Trial are as follows:

- Householder participation in DER is not certain; it cannot be assumed that householders are willing to participate.
- Householder responses to DER are diverse, and expecting that households will have a uniform and predictable response to any particular DER intervention is unrealistic. For example, some Trial households were responsive to price signals, others much less so; two-thirds of households used the Reposit app regularly, but a few households didn't even download it.
- The households in our Trial on Bruny Island are not typical early-adopters, and our findings therefore give a good insight into issues that might be encountered with DER programs elsewhere that similarly adopt a network area or geographical focus, that necessarily comprise a diverse mix of householders.
- Business models and approaches used by household battery start-up companies and specialist installers are based on their experiences with early adopters, and may not translate well to other types of household.

The key lessons in relation to our specific final report findings on installation, emotions, changes over time, and pricing are as follows:

Installation: the key lesson is to devote resources (people, time, expertise, money) to the installation of household DER technologies. Also, to consider having installers as a core part of the DER project/policy team, including them at the design stage.

Emotions: do not dismiss householder emotional responses to new DER technology (joy, anger, anxiety) as unimportant or irrational as they often alert us to key reactions. Taking into account household emotions is important in DER programs in a variety of ways: for example, communication strategies that only focus on technical information could limit DER uptake, and



some coping strategies used by households (e.g. disengaging) could mean that potentially hazardous technical faults are not noticed and reported.

Changes over time: our findings show that any changes in behaviour (energy practices, use of feedback) reported by households soon after installation (c.2 weeks post-install) do tend to persist over time (12-18 months later).

Pricing: householders value financial rewards, but they do not necessarily trump other values. On Bruny Island, battery back-up at times of grid outages was seen as valuable by Trial households, and this might well be the case in other rural locations where outages are above average. Changes in tariff to TOU, although not strictly part of Trial, were most visible to households, thereby making it harder to explore the specific Trial pricing interventions. A lesson is to carefully map out all household pricing interventions when designing a Trial.

Introduction

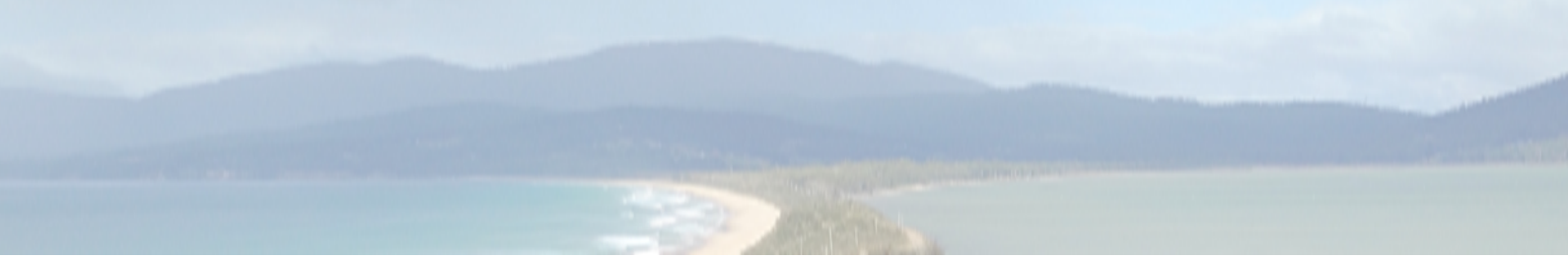
The electricity system in Australia is undergoing significant transformation, and energy networks are learning how to manage peak load events and photovoltaic contributions to their networks. The CONSORT Bruny Island Battery Trial (the Trial) trialled network aware coordination (NAC) as a technical solution to support increased DER. Running from mid-2017 until mid-2019, the Trial worked with householders, Reposit Power, and the local electricity supply utility (TasNetworks) to understand how, with the assistance of NAC, household-owned battery systems could help manage peak loads on the network.

We do not have enough information and understanding of householders in the changing electricity grid. In discussions about the transformation of our energy networks, it is often assumed that householders are willing recipients of new technologies and ways of running the grid, and are responsive to price signals. This social research undertook in-depth qualitative longitudinal research with 34 Trial households on Bruny to better understand these prevalent assumptions. We explored the feasibility of DER from the household (social) perspective using a mix of in-depth qualitative research methods.

Specifically, the social research of the Trial sought to explore the responses to the installed photovoltaics (PV), battery and energy management (Reposit) controller/control system by asking:

How do householders respond to:

- the control system's interface and what actions do they take (in relation to the control system); and,
- the combined PV-battery technology, and the new peak electricity pricing enabled by it?



In this report we therefore examine householder responses and observations regarding the:

- technology installed
- Reposit control system (and its user interface),
- pricing and rewards structures used and tested during the trial.

Our empirical research generated findings that most commonly overlapped the discrete research questions and categories listed above. However, for ease of reporting we have organised our findings across two subsections: subsection one relates to householder understanding about the installed technology, including the controller and its interface; and subsection two presents pricing-related findings. Our key findings have been selected on the basis of their relevance to the design of future DER programs for householders with similar technology mixes, trading relationships, or pricing structures.

The remainder of the report is structured as follows: first, we provide background and context to the social research on the Trial; second, we outline the methods used; third, we present our key findings; and fourth, our conclusions and recommendations.

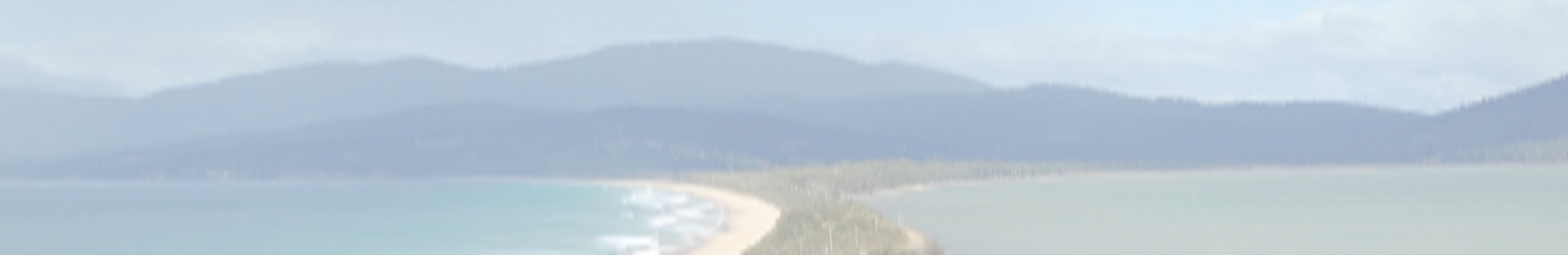
The Appendices provide further detailed information on: a review of DER trials and research in Australia (Appendix A); research methods (Appendix B); images of the installed technology (Appendix C).

Background and context

The case - a battery trial on Bruny Island

The Bruny Battery Trial is testing a DER coordination solution. Bruny Island was chosen as a location to install batteries as there was already an existing constrained electricity network, in the form of a constrained undersea cable. When the undersea cable reaches maximum current during times of peak electricity use, a diesel generator is used to support the network. Bruny Island is a well-loved island and a known tourist attraction. It is a rural space, with both farming properties and smaller suburban-style areas of housing at townships. Most of the island has access to mains electricity, so the network is relatively long or ‘stringy’ compared to the households it supports, as is the case with much of Australia’s electricity network. Relative to other DER trials (see information later in this section of the report), Bruny Island is more rural and has a fluctuating population, with a high proportion of holiday home (‘shack’) owners. The local context of Bruny Island is described in more detail in Lovell et al 2018.

In 2016, householders on Bruny were offered the opportunity to take part in the Trial. Participants were selected from submitted expressions of interest (the ballots identified some basic requirements for the Trial) which were then put into a random ballot (see Trial Deployment Final Report by Jones et al (2019) for more detail, as well as Appendix B in this



report). Participants selected through the ballot were offered a place on the Trial and were asked to choose an installer from a pre-selected list of installers, provided by TasNetworks. Offering a choice of installers to households was intentional, so that the Trial represented as closely as possible a ‘real world’ situation. Householders received a substantial subsidy to support the installation of batteries and also contributed a minimum of $2,000 themselves. Many householders contributed more money for larger systems, or if they needed to do additional work (outside the trial scope) for their installations. Most households received a $16,000 subsidy, based on the battery size they had specified and installed. The maximum possible subsidy was $17,200.

Households participating in the Trial had installed: batteries, a ‘smart’ battery controller (the Reposit box) and photovoltaic panels (some used their existing panels, some installed new ones). Novelty in the Trial was due to: the combination of these technologies being installed; the sharing of power with the network; the use of automated control platforms at the houses and on the network; and the Consort team’s in-depth examination of the whole Trial, including the social research evaluation.

Trial household profiles

Key attributes

Here we outline some key attributes of participating households. This information helps contextualise the social research, and is also relevant in considering how this Trial might be scaled-up.

At pre-installation interviews, 36 households took part, but after two households withdrew before installation, our final number of households involved in the Trial was 34 (see Table 2: Participant numbers, Appendix B). Figure 1 below shows employment, occupancy and age data that was collected during pre-installation interviews with households.

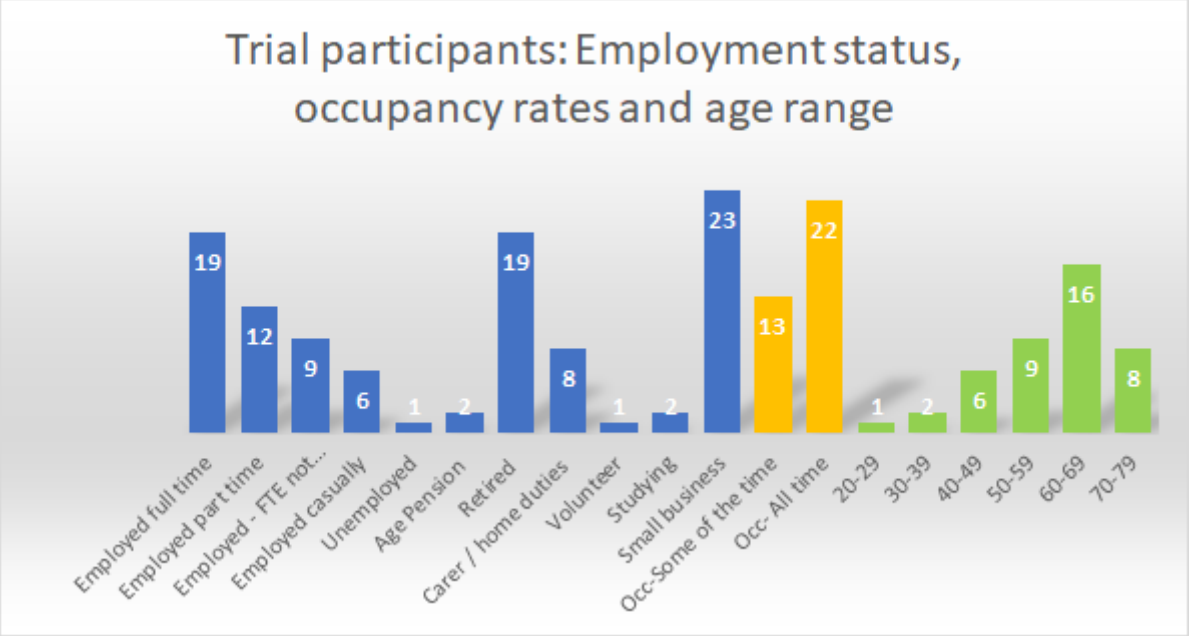
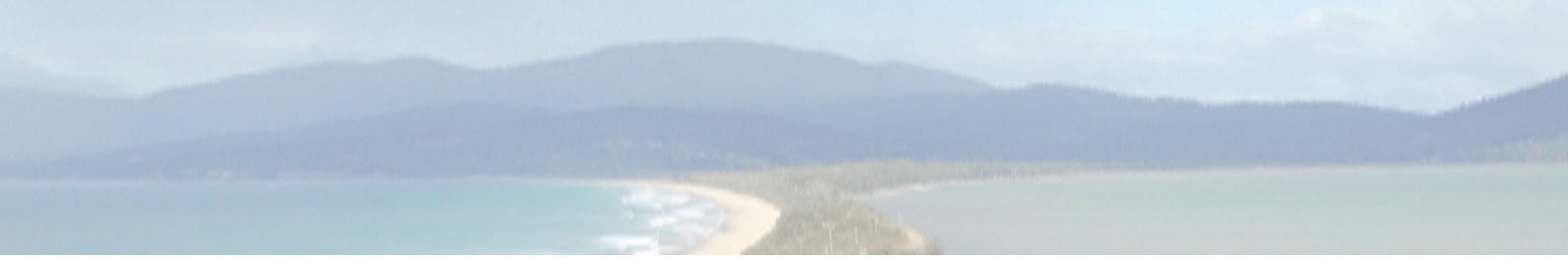


Figure 1: Trial participants: employment (in blue), occupancy (in yellow), age of householder (in green).

The older age distribution of the trial participants is partly a reflection of the demographics of Bruny Island (the median age of Bruny Islanders is 45.3, which is higher than the national average of 37.4), and partly related to the requirement for Trial participants to be home owners. This has meant that very few Trial householders were in the 25-44 year old age bracket (which on the island is 21% of the population). The implications in terms of our findings are discussed in more detail in the Methods section.

While the Trial participants tended to be older, a high number of participants were working full time (19 people from 12 different households). Notably, 23 participants (from 16 different households) had a small business as either their main form of employment, or as an additional employment role (this included retirees). Small businesses included providing accommodation for tourists on the island (e.g. AirBnB), consultancies, and self-employed artists.

Occupancy at the Trial homes varied with 22 houses occupied all the time, and 13 occupied some of the time. There is a holiday house/shack culture on the island, plus some participants travelled off-island for work. Details of Trial requirements for household occupancy can be found in the Trial Deployment Final Report (Jones et al 2019). Of our Trial households: 5 were single occupant, 19 were couples; 9 were families (couples with dependents); 2 were intergenerational families, and 1 was a household shared by multiple families.



Physical house traits

Participant houses were built in various eras: there were new builds from 2017-18 through to historic Federation-era homes. Many houses have been renovated and a number were owner-built. Insulation, a key influence on heating energy loads in homes and a key predictor for overall energy loads, was installed in most cases, in some form.

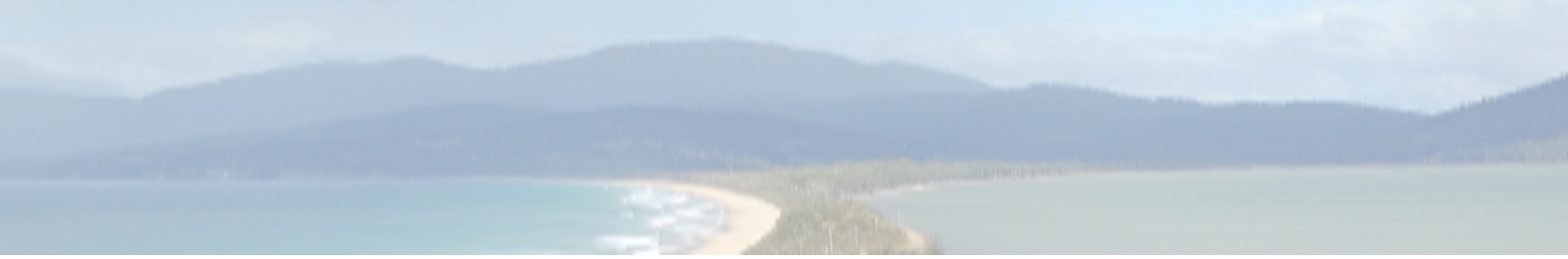
In summary, of the 36 households interviewed and surveyed at the pre-install stage:

- 9 houses were built post 2003, which means they will be to standard or near to standard in relation to Australian Building Code insulation levels (these standards require effective levels of insulation);
- 9 further houses have insulation renovated into most or all of the external building elements;
- 14 houses have some insulation that will in some way help comfort, but is likely too little to support efficiencies in heating and cooling; and
- 4 houses have negligible or no insulation (2 with no insulation, and 2 with minimal to no insulation).

This physical house data suggests that 18 of the 36 Trial houses require higher energy use from heaters and coolers to maintain a similar level thermal comfort, when compared to better insulated homes. This is important context because the need for higher energy use is known to affect stress levels and decisions made regarding energy use (Rooney et al 2016). Higher energy use is also likely to affect attitudes to trading energy during times of thermal discomfort in the home.

Trial households used a range of heating, but with a prominence of wood heaters: 28/36 households had wood heaters at pre-installation. Twenty four of the 28 reported wood fire as a main form of heating (noting that some reported a couple of main forms of heating). Of these 24, 10 only used their wood heater for space heating (and had no electric heating). Twenty six houses of the overall 36 had electric forms of heating (18 of these had both wood and electric), and 13 houses reported electric heaters as a main form of heating. Additionally 2 households used gas for heating, but did so in combination with wood and electric heaters.

Related to heating, only 7 houses source 100% (or very close to 100%) of their energy needs from electricity. Having alternative energy sources may be due to the rural and island location, including household experience of reliability issues with network supply of electricity. Less reliance on electricity as an energy source - mostly with regard to heating - affects decisions and perceptions of electricity use by householders. Households with wood or gas heating combined with electric heating did report changing their use of heating sources depending on the day, their needs, and the weather. Householders reported in both post-install and final interviews that they believed their switching between wood, electric and gas heaters made it hard for Reposit controllers to predict household energy use.



Implications of participant household traits for the Trial

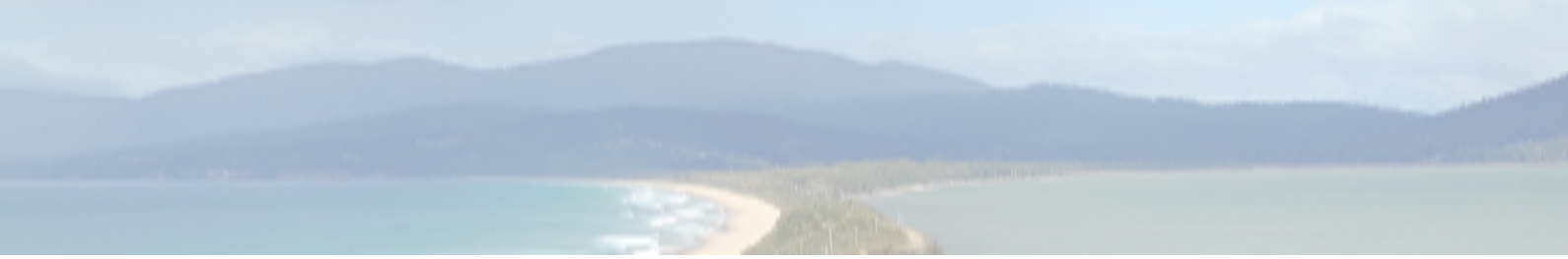
Household lifestyles and physical house characteristics can affect DER energy trading and indicate potential opportunities and constraints for DER trading with networks. In relation to the traits reported above:

- Energy loads in homes occupied 'some of the time' (13/36, 36%) that are used as shacks (holiday homes) will likely have significant changes in energy loads from one day to another and from week to week. This unpatternable dynamic very likely negatively affected the predictive algorithms used in Reposit controllers.
- Where households mix their use of wood, gas and electric based heating sources (18/36; 50%), electric loads will also change substantially day-to-day, and be potentially unpredictable, again affecting the operation of Reposit controllers.
- Where electricity is one of a number of fuel sources, households have less overall reliance on their DER installations, which could lead to less monitoring and less engagement overall.
- Under-insulated homes (16 houses in this trial) require larger draws of energy for space heating and cooling, especially where electric heating is used.
- More dynamic and larger energy loads are likely when: people are home during the day because they, for example, work from home, are retirees or are a young family (22 households in this trial); and, households have a large number of occupants (12 households in this trial). Dynamic and larger energy loads may mean, over time, that households perceive it is best to utilise their stored energy, rather than trade it.
- Higher household occupancy during the day means the Trial population was likely to be more responsive to Reposit notifications encouraging household use of energy when their batteries were full and the sun was shining (typically this situation arose around lunchtime in most Trial households).

Other DER trials and the research context in Australia

A review of Australian academic and industry research that has investigated social aspects of DER was conducted early in the Trial, and was reported in Lovell et al 2018. At the time of writing these reviews, there were few published papers or reports that examined social factors related to battery storage or DER. Reports mainly focused on DER technical feasibility (for example, Marchment Hill 2012, Galanis 2016), and on how to encourage customers to 'behave' in keeping with technical ideas about smart grids.

In line with our findings at the time, the international smart grid action network (ISGAN), when talking broadly about smart grids (not DER energy trading with households) argued that, despite smart grid pilots trying to support householder change, 'a consistent and integrated view on how to incentivize end users to change their behavior is still lacking' (2017:1). Further, Geelen et al (2013:160) argued that the 'social context for residential end-users as



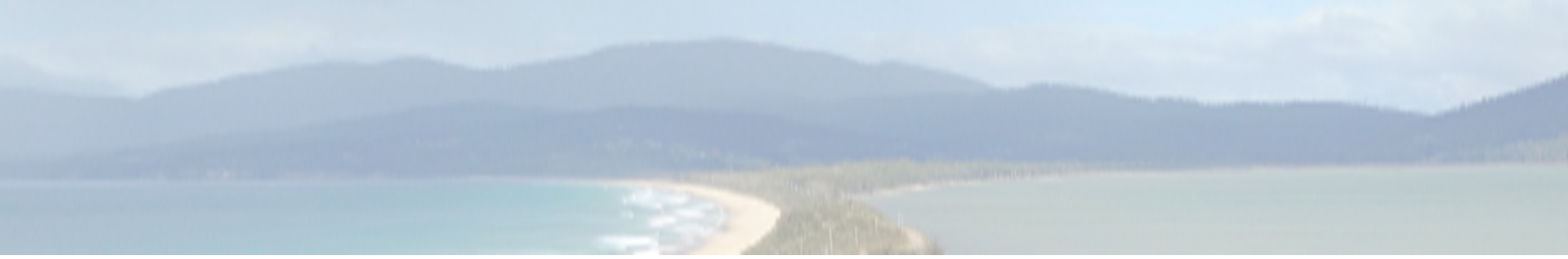
co-providers has to be taken into account more in product and service development to ensure... adoption'. There are significant bodies of social research on energy efficiency, photovoltaics, household demand, energy side management and feedback more broadly (see for example Bulkeley 2016, Isaksson et al 2015, Strengers 2011, Swinson et al 2015), and there is some work on off-grid batteries (for example, Lovell & Watson 2019, Vannini and Taggart 2015). However, all these areas of scholarship are quite distinct from the qualitative longitudinal explorations of householder understanding of DER and new household-DER relationships that we researched for CONSORT.

Internationally, there are still few other academic studies similar to the social research undertaken for CONSORT. However, in the past few years a number of Australian industry, government and non-government organisation prosumer studies have emerged. We provide brief descriptions of significant (published) trials and studies in Appendix A. The majority take an anticipatory approach - identifying trajectories and issues based on stakeholder and user perspectives - often using existing PV data and anticipating inclusion of batteries with PV (CSIRO 2017, Fleming et al 2016, Ginninderry, 2017, KPMG 2017, Moreland project). All of the studies anticipate increased future uptake and use of DER, based on analysis of householder perspectives and expert stakeholder understanding. Both the Clean Energy Council / Energy Consumers Australia (2019) study and the CSIRO / Energy Networks Australia (2017) study engaged on a notable scale with stakeholders from industry and governance organisations. However, to date there is only one published study, by Energex (2017), that researched and engaged with householders using new battery technology and trading their home-based DER technology with the network.

In summary, there are significant gaps in our understanding of household involvement with DER and energy trading with networks. More social research understanding will therefore greatly assist DER transitions, in Australia and internationally. By engaging with households in CONSORT, we have provided a voice to, and understanding of, some of their experiences and important constraints. Our analysis thus provides a basis for informed, evidence-based household DER initiatives, whereas previously many DER projections and decisions have had to be based solely on assumptions about likely household responses. As noted in our Introduction, in many cases current assumptions suggest that households will simply be passive players with regard to DER and network sharing: our CONSORT social research findings indicate this will not be so.

Methods

Social research methods have been used to understand Trial householders' responses to their installed technologies (battery, battery controller, and solar photovoltaics). Our research used a range of qualitative methods: focus groups, interviews, energy diaries and physical observations of the homes. The use of a range of methods and the longitudinal approach - over the two years from just before installation, to the final interview and focus group at the



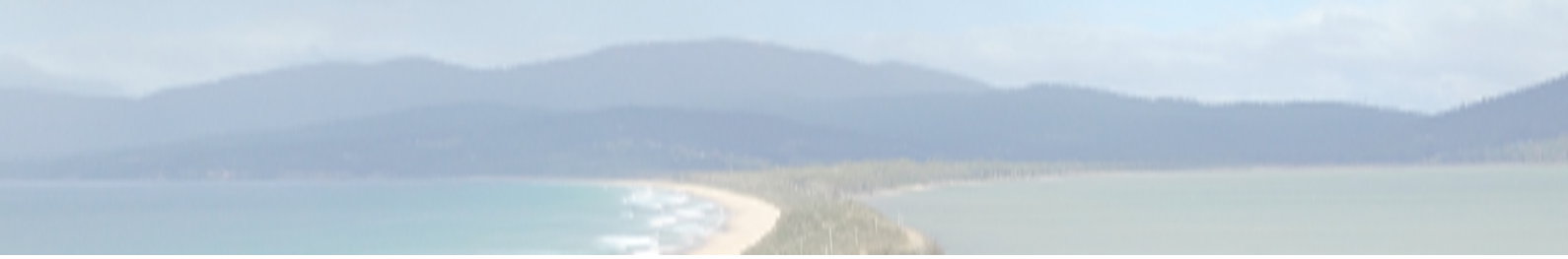
end of the Trial - allowed in-depth exploration of what is a relatively unknown issue: household solar-battery and trading energy responses. Taking an inductive, exploratory approach allowed the dynamics and variations of responses householders had to the technology and the Trial to be explored. This rich, open exploration of householder responses helped to identify key issues relevant to future, possible more widespread application of the CONSORT technologies.

The social research used the following qualitative research techniques:

- semi-structured longitudinal interviews (x3 with each household) over a two-year period: one pre-installation (c.2 weeks prior), one post-installation (c.2 weeks after) and one final interview;
- focus groups (one near the start of the Trial (Sept 2016) and one near the end (Feb 2019));
- home observations related to energy loads and the technology;
- energy diaries (to capture detailed daily information from households on behaviours and pricing, over a 2 week period in July 2018);
- observation of online forum discussions;
- literature reviews; and,
- observation of organisation processes and policy context.

The social research team worked with an 100% sample, i.e. we researched all 36 households initially enrolled in the Trial. Note that, depending on the topic of analysis, in this report we cite different numbers of households, because the household numbers involved in the Trial changed slightly over time (see Appendix B). Of the 36 original households interviewed (at the pre-installation stage), 2 households withdrew, leaving 34 overall. Of the remaining 34, 1 of these did not have a post-installation (‘post-install’) interview because their installation was very late. Additionally, 3 further households did not have a final (year 1) interview completed, because they moved house (1), or their installation was too delayed to take part in the final interviews (2). Therefore, longitudinal (before/after install) research findings report on either the 33 households for whom we have with post-install interview data; or 30 households for whom we have final interview data (see Table 2, Participant count, Appendix B).

Exploratory and iterative learning approaches were used by the social research team in order to examine this relatively new socio-technical phenomenon, which used a mix of technologies only recently combined and applied in domestic settings, required shifts in understanding and practices from householders, and created a relationship between the network and householder that required re-conceptualisation of traditional roles as consumer and producer. Iterative learning allowed for interim findings to be shared the rest of the CONSORT team, and to ensure that we took the most appropriate next steps in the social research. In practice, this allowed the detail of each stage of the social research to be developed with up to date understanding of the phenomenon, and with input from the wider CONSORT team.



To inform future projects and programs, we note here key limitations to the social research, as well as alterations to methods, that may be useful to consider:

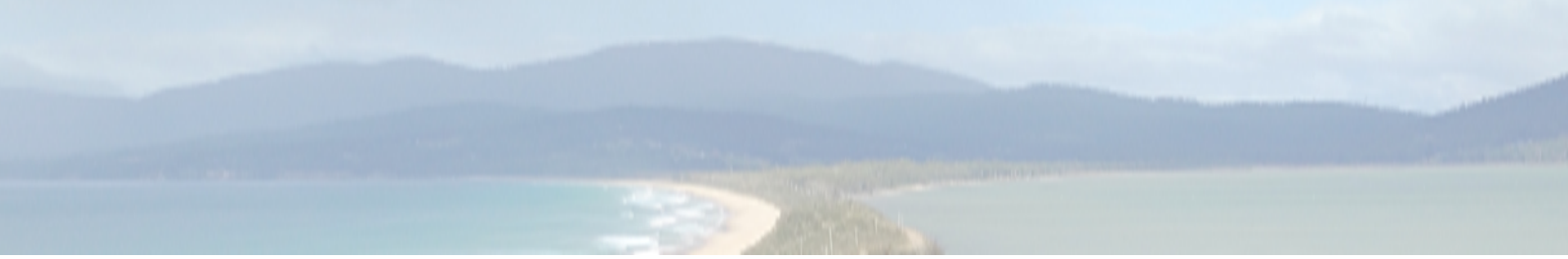
1. As the network constraint and available network opportunities defined this Trial, and the households involved volunteered, our social research necessarily engaged with the available sample. However, the sample was skewed and included a large group of older householders (some as retirees, some still working - see above). While there was limited opportunity in this Trial, further social research in the area may find it useful to ensure that a broader range of household types are involved.
2. While our mix of empirical collection methods (interviews - 100, c.1 hour duration; house observations - 33; focus groups - 2; energy diaries - 33) collated useful data, more empirical research was undertaken than there was time and the capacity of the social research team to fully analyse.
3. Besides early customer engagement early in the project, social researcher contact was the only regular planned contact the CONSORT team had with householders. TasNetworks had a lot of contact during installation and householders did also call Reposit, but when social researchers went to houses, there were often unresolved issues that householders had held onto. Social researchers were often told about these unresolved issues, and we thus became the ‘front line’ for the Trial. After research visits or contacts, social researchers spent significant lengths of time relaying issues to the rest of the team and ensuring that householders were in contact with the key organisations they needed to talk to. In future projects this feedback role needs to be formally incorporated as a customer engagement activity, or within another similar defined role. The feedback from householders also required the wider CONSORT team to allocate substantial time to responding to issues.

Further detail and explanation of our methods can be found in Appendix B.

Findings

Subsection 1 – Installed technology, controller and interface

Here we focus on three key cross-cutting themes that stood out for us in our social analysis as important findings related to the technology, the controller and the interface. These findings are judged as likely to be useful to other trials, and to the energy community more broadly, and include: the pivotal role of installations, the role of emotions, and longitudinal trends (household changes over the course of the Trial). We discuss each of these in turn below, before turning to our research findings about the finances and pricing in Subsection 2.



Installations

The Trial installation processes and householder responses provide useful learnings for future DER projects. In relation to installations, we outline key themes that emerged from our social research, including:

1) householder experiences of installation and related effects;
2) the role of installers as key intermediaries and installer risks
3) issues related to retrofitting technology; and
4) technology issues at the time of installation.

Conversations about installations mainly occurred at our household post-install interviews (c.2 weeks after installation). Sources of understanding about installation also came from Veryan Hann's PhD interviews with installers on the Trial, and Trial team members. Further analysis of installation is being included in Veryan Hann's social research PhD thesis, which is currently being written.

Installation experiences and effects

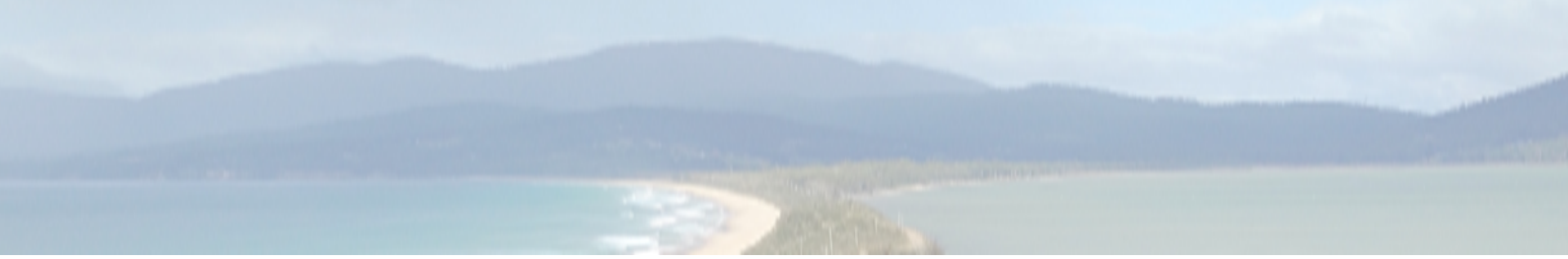
Installation experiences and their effects have emerged as important moments in householder relationships with DER. Installation processes, including the initial installation quoting processes, were reported by householders in depth, and often with negative emotion (frustration, confusion).

Installation experience

As noted, the DER technology installed for CONSORT consisted of four key elements – PV panels[1], inverter, battery, Reposit 'smart' battery controller – and their functional integration. These components and their successful integration often necessitated additional components, such as an internet connection, a TOU tariff, a new switchboard and wiring, meter connection, the digging of a trench, and inspections.

As such the process of installation included a wide array of components, works, regulations and expertise. Installations had been described in early Trial discussions and documents as though they would be relatively straightforward (single) events, but in reality the need for various components, on-site design and learning and financial negotiations required many interactions (TN innovation engineer, interview, Feb 2018; Installer interviews by Veryan Hann - 2017). As such, the householder experience of installation was often diffuse and complex, rather than discrete, extending over multiple months rather than a one-off moment, and involving multiple actors and organisations.

[1] A few households had existing PV panels.



Experience as complex

Householders reported that choosing installers, deciding on equipment and the installation was all fairly complex, and that it was difficult to develop understanding fast enough to engage in the choice of technology for their home. The majority of householders at this stage relied on the installer's advice to choose the technology for their systems.

The complexity of the installed CONSORT technology was a source of interest and also frustration and confusion for participants. Engagement with the complexity varied. Some participants became disengaged over time due to the complexity of the system, which was seen as overwhelming, while others developed a thorough and nuanced understanding of the technology and its performance (and were able to troubleshoot in quite a sophisticated way with regard to their installed CONSORT technology, for example Households BT104, BT122, and BT130). In general, those that either had little knowledge of the technology but trusted it, or those with more knowledge and confidence, were more likely to accept the technology.

Installs took longer than expected

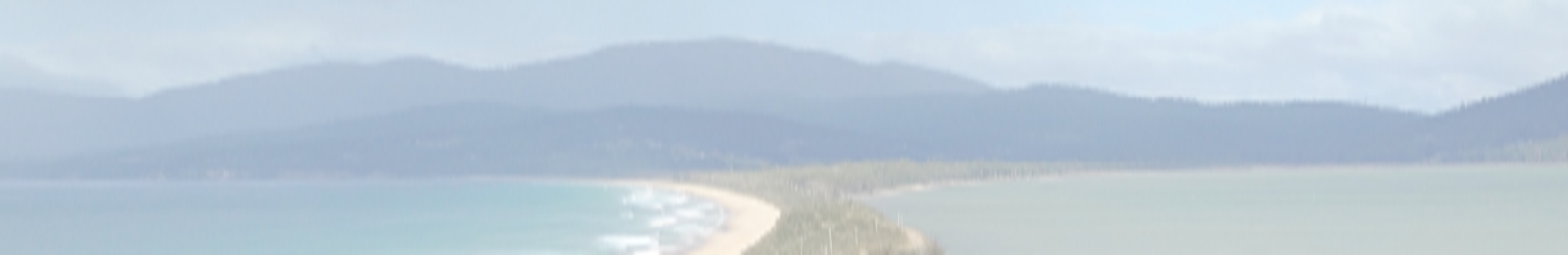
For the majority of households, the process of installation was slower than expected. We identified that installation duration was affected by:

- installers' learning about this technology;
- the rural and island location (travel time, ferries and short working days);
- battery deliveries being significantly delayed for many households;
- recall and replacement of Reposit hardware;
- inspections and rectification of various technical and safety issues requiring repeat visits (and interactions) between installers, safety authorities and householders;
- installers being slow at submitting paperwork;
- one installer had significant delays in completing installs, and had the largest number of Trial households.

Effects of the installation experience

In addition to delays and unanticipated complexity, householders reported diversity in installation experiences. For some, the experience had been relatively straightforward; for others, the experience was frustrating or distressing, with difficulty choosing an installer due to varied approaches and quotes; poor communication from installers, and inconsistent follow up.

Householders reported that installation processes affected them in numerous ways. As researchers we noted that a number of these effects were lasting and determined how positively households viewed the Trial and the technology. The effect of complexity on understanding is related here. Further discussion of emotional effects on installations is discussed in the section below - 'Emotions about installations'.



Effect of complexity on understanding

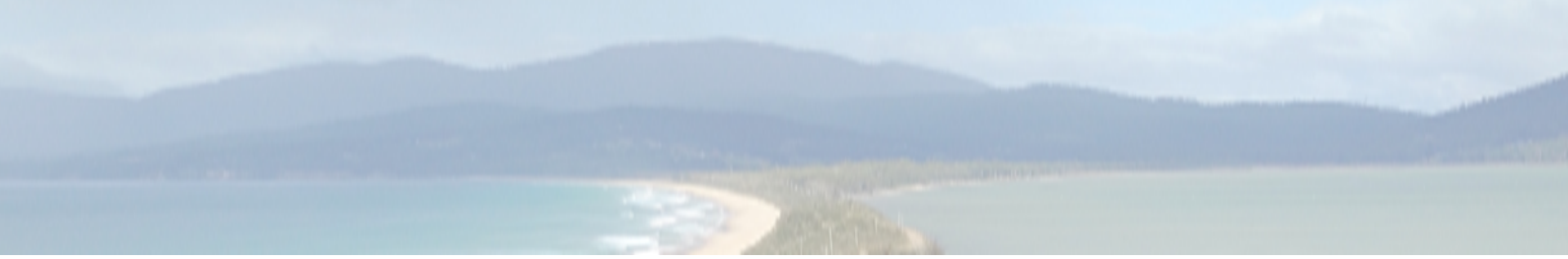
It was assumed that installers would provide technical design support, sales, supply, install and follow up support for householders. However, we observed that installers in the most part do not have the capacity to fulfil all these roles. Most installation quotes did not include extra time for educating householders at length about their systems. Some installers spent extra time with householders to explain the CONSORT technology, and others did not. If an installation was done in a hurry, then householders were left with very little explanation and often did not develop understanding. Householder reported that the lack of understanding did lead to them becoming disengaged (for example, Households BT113 and BT136). When householders were disengaged or lacked important understanding, we observed that technical issues were often left unresolved. The health of the installed CONSORT technology partly relies on householders identifying problems as they arise, and yet householders were not in some cases provided with enough information to undertake this system health check role. For example:

- Household BT109 had a problem with their battery not charging. It was only picked up because there was a social research interview scheduled and the interviewer and householders checked the app, which showed the battery charge was at 2%;
- Household BT135 (a husband and wife couple) used the opportunity of thinking through the installed CONSORT technology during the year one interview time to work out how to understand the Reposit app; and
- Household BT137 had nothing explained by their installer and did not even know they had a back-up system for periods of network outage.

No other stakeholders (other than installers) are currently available in the marketplace to fill knowledge support and problem resolution roles. Installers' likely lack of capacity for these extensive roles leaves a fairly large gap in support for householders. Within CONSORT missing support for householders in terms of understanding or resolving technical issues fell to TasNetworks, as well as Reposit and the CONSORT social researchers. This was possible as part of a Trial, but the additional workload would likely not be compatible with a real-world commercial situation.

Installers as key intermediaries

Overall, we observed installers to be key intermediaries in the Trial and their efforts were pivotal to successful installations and use of technology. Intermediaries are '...actors that facilitate relationships between key actors and enable sharing and pooling of knowledge' (Bush et al 2017: 139).There were significant expectations on installers to play a number of roles in the process that they couldn't necessarily be paid for, including their education role, as outlined above. Additional communication and assistance provided in this Trial to participants would not be feasible in the 'real world' marketplace: "we cannot continue to offer a Bruny-level-service when we have 10,000 batteries" (TasNetworks Engineer, CONSORT team, Feb 2018). Installer roles are likely to evolve as they learn and establish DER install practices, and the market becomes more familiar with DER products.



Overall, it was observed that a) installers are a form of knowledge broker, b) they can enhance or thwart the installation process, thereby creating either frustration for participants or providing solutions, and c) the installer's role is one of increasing complexity in a changing work landscape and that they face business risks. We agree with Gliedt et al (2019:1255) who suggest that 'communication, education, training, advice, support, and learning-by-doing' are important for scaling up innovative technologies.

Installing DER technology: retrofitting technology into homes

Through observations of installations and installed technology in homes and through interviews with householders, we were made aware that retrofitting (designing) technology into existing homes can be challenging. Successful retrofits of technology required active design and retrofit planning before installation. Safety concerns, integrating into existing strict electricity network standards, and adjusting to fit each individual differently designed, built and positioned home were typical issues that needed consideration during installations. Images of installs are included in Appendix C to indicate variations in Trial homes and install resolutions, the types of technology used, and the meter board safety communications that were required.

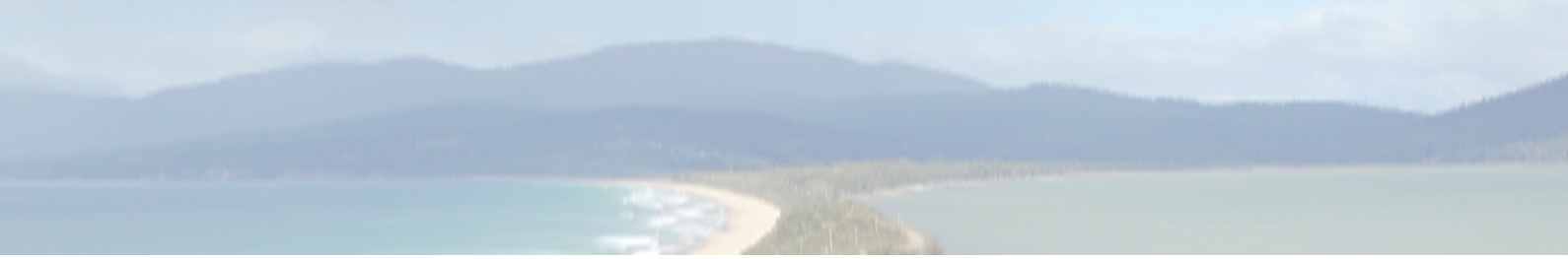
Of note with regard to retrofitting DER technologies into existing homes are:

- Positions available to use for DER installs were different in each house, with different materials to fix the installations to, and different positions around the houses available to be used. Installations were usually done in shaded positions and were on south-facing walls (although note that one battery was positioned on a northern wall, but with shade cloth covering it). Some households had their technology installed in sheds or storage areas, others had the technology installed on verandahs.
- Aesthetics resolution of installations varied greatly, with some very compact in (vented) cupboards (for example, Households BT123 and BT128), and others were quite spread out and more visually intrusive (for example, Households BT106 and BT126).
- Positioning of the technology on external walls of bedrooms or living areas meant that some households reported an annoying noise being heard inside, most likely related to the battery or inverter cooling fan.
- Safety signs were installed in meter boxes and around the technology. Multiple safety signs were required for each installation, including shut down procedures, but the sheer number of signs could be confusing in an emergency.

Further, through discussions with planning professionals, it became apparent that there may be planning requirements in relation to DER installations on this scale in homes. This was not something we were able to investigate further as part of our CONSORT social research.

In relation to issues of retrofitting technology into homes we recommend:

- Design and planning is needed for each site to ensure technology installations go smoothly and produce positive, aesthetically pleasing outcomes. This design work



needs to occur before the day of installation. While there was some design and planning in most cases, it was not always very well done.

- Aesthetics need to be considered when retrofitting DER technology: households care about the aesthetics of their homes. Many have a deliberate style associated with their home, and heritage guidelines may apply. The installed CONSORT technology will only in rare cases easily fit in with existing home aesthetics in Australia.
- Though significant progress has been made in the drafting of DER standards, and existing standards are carefully followed (see DR AS/NZS 5139:2017 Electrical installations – Safety of battery systems for use with power conversion equipment) (Standards Australia, 2017a,b,c), safety standards will likely need to be expanded in the future and this may create further complexities when retrofitting batteries and other behind-the-meter technologies in homes.

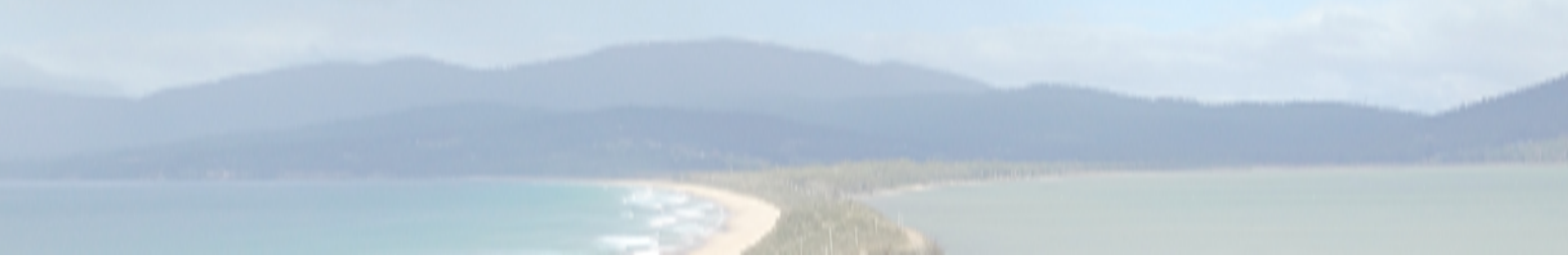
Technology issues at the installation

All but one household had some degree of criticism of the technology installed during the Trial; or reported issues encountered with install or use of the technology. This is to be expected from a new technology, and provides a fruitful source of learning for any future deployment of DER. Issues raised varied from rather minor to significant: out of a total of 66 post-install and year one interviews with 34 households, there were only 9 instances of interviews where no technical issues at all were reported. Common issues faced by participants included:

- Challenges understanding the Reposit tech support and app interface. There was also significant confusion about the functionality and benefit of the Reposit box.
- Lack of communication from their installer about the basic functionalities of their installed technology, TOU tariff, and different financial benefit streams of their system led to 29 households reporting problematic information gaps. Many participants felt frustrated they did not have information to best use their technology (and six (out of 33) households specifically reported this to us in interviews).
- Technical glitches: faults emerged in many parts of the hardware, and there were glitches in software integration and in electricals. Overall 72 mentions were made of installation, hardware, electrical and software related issues over the 66 post-install and year one interviews. For some households issues were slow to resolve, stressful and frustrating. For others, their installers resolved technical issues easily and in a timely way.

Householder emotions in response to the technology

Emotional responses of householders to the technology warrant our attention. Firstly, there is well established research that demonstrates that emotions and ethical intuitions are equally, or in some cases even more important than reason, in making moral decisions about technology. Enthusiasm for a technology reveals that it would likely provide benefits for our wellbeing. In contrast, anger or indignation can reveal potential violations of trust or fairness principles



(Roeser 2012). Emotional responses are not the opposite of reasonable ones, but rather both emotion and reason are drawn on in daily decisions and evaluations.

Secondly, when people lack critical information or in situations of uncertainty, their evaluations tend to be based on affective (emotional) beliefs of trustworthiness rather than only on deliberate cognitive evaluations (Rodriguez-Sanchez et al 2018). Given the initial unfamiliarity most householders had with the concept of network support, as well as with the individual parts of the installed CONSORT technology (PV, batteries, Reposit box), we anticipated at the outset that perceptions of trust would be particularly important for trial participants. This overlaps with research from the sociology of risk that trust (and familiarity) is crucial in situations of perceived risk and uncertainty (Tulloch and Lupton 2003).

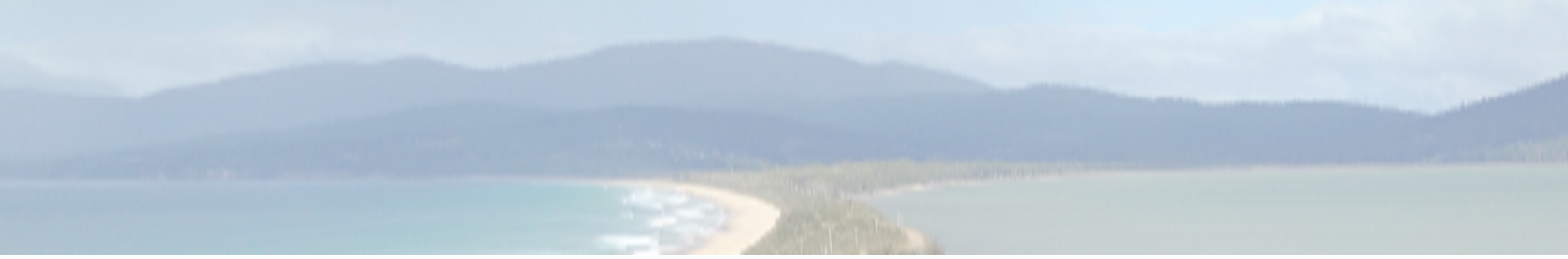
In summary, we focus on emotions of householders as a key finding in this report because they form a key part of householder moral judgements of the suitability of a technology, which provides us with an indication as to whether the CONSORT technology is likely to be accepted elsewhere.

Emotions and overall technology acceptance

In deciding what emotions to focus on, we drew on relevant research that found that anger or hostility (in terms of negative emotions) and relaxation and enthusiasm (for positive emotions) were the strongest predictors of policy acceptance. Our analysis, summarised in Table 1, provides an overarching view of emotions of householders over the course of the Trial. Importantly, positive emotions such as ‘relaxation’ and ‘feeling confident’ dominated the householder responses. However, the cases where anger and resistance were experienced are instructive for any future efforts to scale up the installed CONSORT technology.

Twenty three households (out of 32) were overall relaxed and confident in the technology and the trial, but experienced some level of frustration and confusion, and therefore had criticisms of the installation and the technology. Within this group, 10 households were very to highly engaged in monitoring and understanding their technology and, partly, as a consequence of this, often provided quite detailed feedback and critique. Also within this broader group, 13 were much less interested in engaging in the detail (for various reasons), and, had much less specific feedback to provide. Interestingly, only 1 household was highly enthusiastic, relaxed and had no specific criticism of the technology.

Overall, 9 households expressed more negative emotions in regards to the technology and experience of installation such as anxiety, frustration, and even anger. For 7 of these, the perceived benefits and positive emotions (such as enthusiasm) eventually offset the negative emotions, to the point where they had overall accepted the technology by the time of the year one interview. Confusion and frustration about the specific values of the technology, and how to effectively use their technology tended to be high within this cohort. Finally, for 2 households (BT101 and BT116), the anxiety and anger they felt about their experiences with the technology was correlated with a perception that the system did not benefit them, to the



point that they no longer wanted to share energy with the network, but rather they just wanted the battery to be used for their own purposes. Distrust in the electricity system was strong for one of these households and a high winter bill (a negative experience) tipped the households into a mode of technology dismissiveness. This finding fits with social research on policy acceptance, which found trust to be a critical factor (Rodriguez-Sanchez et al 2018).

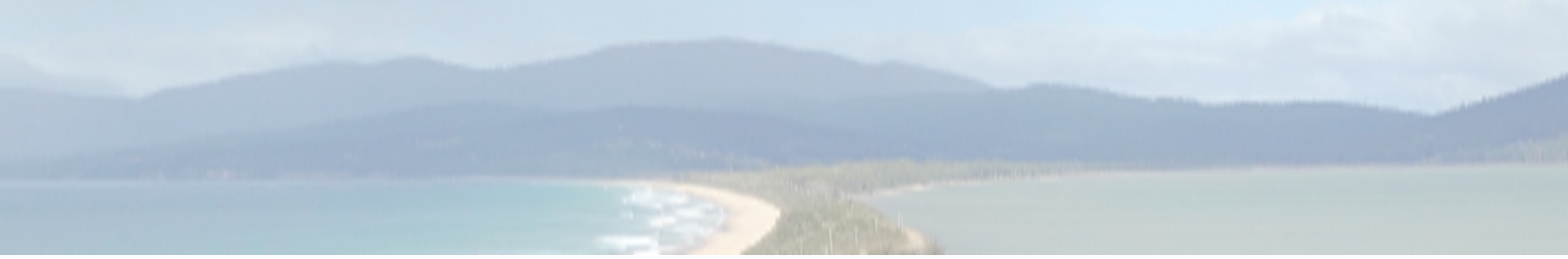
Emotions over time

In terms of tracking emotions over time - from post-install to year one interview - 22 householders' emotions remained relatively stable over the course of the trial, 6 become slightly or quite a bit more negative, and 4 householders' emotions became slightly more positive.

The experiences that triggered slight to strong negative emotional reactions for the 6 householders were: slow and problem-ridden installation, technical glitches with the installed CONSORT technology or with the electrical connection, confusion and anxiety about whether they fully understood the technology, a high winter bill, anger at a lack of information and appropriate technical support (a sense of feeling neglected), distrust in providers (e.g. Reposit and TasNetworks), and disappointment about value of network support payments and not understanding why this was the case.

In terms of the 4 households whose emotions became slightly more positive over time, the factors that triggered this included: becoming more familiar with the installed CONSORT technology (Household BT110), enthusiasm of having the battery as backup during a 3-day network outage (Household BT113), and experience that their system was performing well.

Summary of household emotions about the technology and Trial	Number of participants	Sub-group	Number of participants
Relaxed and confident in the technology and the Trial, but experienced some frustration, confusion and therefore had criticisms	23	Spent time thinking about the technology, and provided detailed feedback. Some in this group had technical backgrounds	10
		Time poor, technology not a priority, and provided minimal detailed feedback. Some in this group had technical backgrounds	13
Relaxed, confident, enthusiastic about the technology. Minimal criticism.	1		



Anxious and cautious about the technology, but this is offset by other perceived benefits. Often very confused about the technical workings and specific benefits.	7		
Anxious, and cautious about the technology, remained unconvinced that it would suit them by the end of the Trial. Often angry about some aspect of the technology and Trial process.	2		

Table 1. Summary of key emotion states of householders and final view of the installed CONSORT technology by the end of project. *Note: Data in this table is based on the final household 'position' at the end of the Trial (year one interview), but is also informed by the other interviews (x2).*

Key implications

Given the importance of householder emotional responses to new technology, communication strategies that only focus on technical information could limit uptake. Both positive and negative emotional turning points provide insight into how to improve communication and relationships with householders. General distrust in the electricity system can play a background role in mediating acceptance of the technology. When this is compounded by several negative experiences, this can lead to new DER technology being dismissed as unacceptable.

Coping strategies

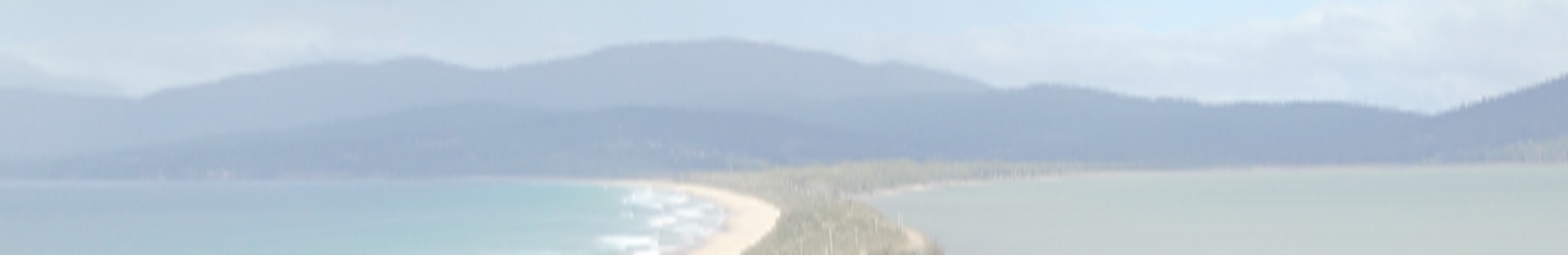
Competence with installed technology

Confusion and feeling incompetence around the installed CONSORT technology was a significant source of negative emotion for many householders. There was a spectrum of householder responses regarding how strongly they wanted to understand the technology. Over time this shifted as households adapted to the technology, and/or coped with a lack of information to meet their specific needs. Over time, coping strategies included:

1. Reframing the technology from something that needs their active input and understanding, to a technology that can be seen as 'set and forget'.
2. Taking control and keeping the perceived risk at bay by dismissing the technology (i.e. by opting out of network support) (coping styles adapted from Braithwaite (2009)).
3. Maintaining a basic level of monitoring of the installed CONSORT technology, but basically trusting it is acting in the householders' interest.

Support seeking strategies

Pride in being self-reliant and stoic is a common way of coping with challenges among Bruny islanders. Not wanting to "be a whinger" prevented may householders from seeking support



early, or as often as required. As noted above, as social researchers many of the strongest anxieties were saved up for our interviews, rather than contacting the official technical support.

Implications

Coping strategies used by householders in the face of experiences of confusion and frustration present some risk to the scalability of DER network support. For response 1 (above), it is possible that householders become so disengaged with the technology that they fail to notice if it is experiencing glitches. The group with response 2 are unwilling to engage in network support. Response group 3 would be the type of response that would be most preferable for scaling-up network support; and more analysis of this group would be helpful moving forward.

Longitudinal analysis: behaviour change and Reposit app usage

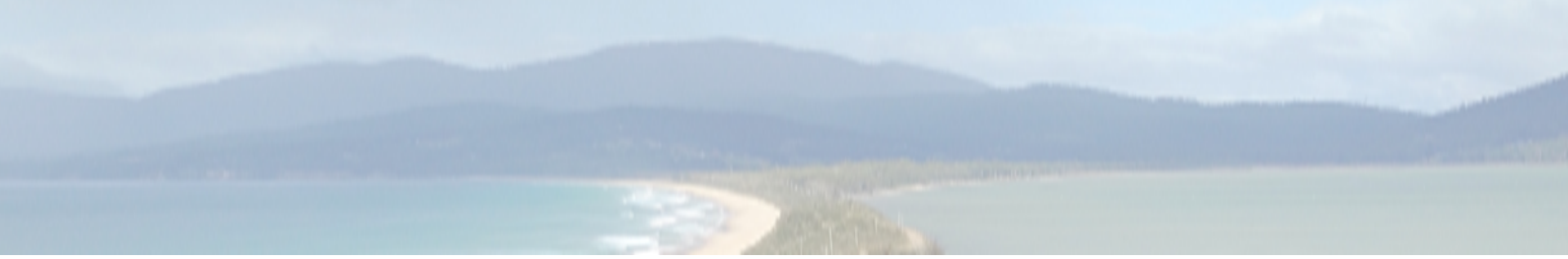
Longitudinal studies of household DER response, such as the Bruny Trial, are important for better understanding what household changes are durable or persistent, and which are transient, i.e. prompted by the initial change in energy set-up and/or technology, but which do not last. There is little existing research on the persistence of household behaviour changes in relation to batteries, because household uptake of batteries is relatively new. Here we report on two interrelated aspects of household changes: changes in energy behaviours and practices, and changes in use of the Reposit app.

It is worth noting here that many of the household changes we report on in this section were not necessarily directly about the new technology, but were prompted by more indirect changes associated with the trial, for example, a switch to TOU tariff, and a greater awareness of energy use because of participating in the Trial. Nevertheless we report on these changes here in subsection 1 (‘Installed technology, controller and interface’) because they are substantively related to the technology installed.

Behaviour change over time: energy behaviours and practices

Types of energy behaviour change reported to us were mostly to do with changing the timing of energy use activities, rather than stopping behaviours. Typical activities mentioned by Trial households included changing the timing of clothes washing, dishwasher, showering, heating (space heating and hot water), and use of the oven.

Looking at household behaviour change *over time* with the cohort of 30 households with whom we completed both post-install and year one interviews we observe a few key trends. First, the majority of households (c.two-thirds) are consistent with their behaviour change over time, i.e. what they reported to us regarding behaviour change in interview in the immediate post-install period was the same as what they said they were doing a year later, in our final interview. Of the 9 households (out of 30) that did alter their behaviour change patterns over time, there was a mix of directions of change: 5 households had not changed their behaviour in the immediate period after installations, but had done so a year later; 4 households moved



in the opposite direction – they reported behaviour change just after installation, but not a year later. Second, the key prompt for changing the timing of household activities was the new TOU tariff that most households switched to on joining the Trial, rather than the Reposit notifications about free energy (on sunny days when battery is fully charged and solar PV generation is spilling over onto grid), although there is of course some overlap. For example,

> **“Interviewer:** So, do you think you’ve changed how you use energy in the house since the technology was installed?
> **Householder:** Yes. Probably. Now that I know that during the day I can do all my washing in the day rather than maybe later at night after, when the tariff was cheaper. I just can do what I want during the day and know that I’m not paying extra for it.” (Household BT101, Dec 2017- post-install interview)

and

> **“Householder:** But we do tend to do our main - because we're not both working all the time - we do our main sort of electrical stuff during the middle of the day, at off-peak times.
> **Interviewer:** And that sounded like you had already of thought that previously?
> **Householder:** We'd already started doing that - when we changed to off-peak power - peak and off-peak [TOU] tariff - which is around, I think, we changed in about October [2017], I think. We changed, like, we don't do the washing during the morning or evening. We do that during the middle of the day. And I do most of my workshop things, where I use power, during the middle of the day.” (Household BT129, March 2018 - post-install interview)

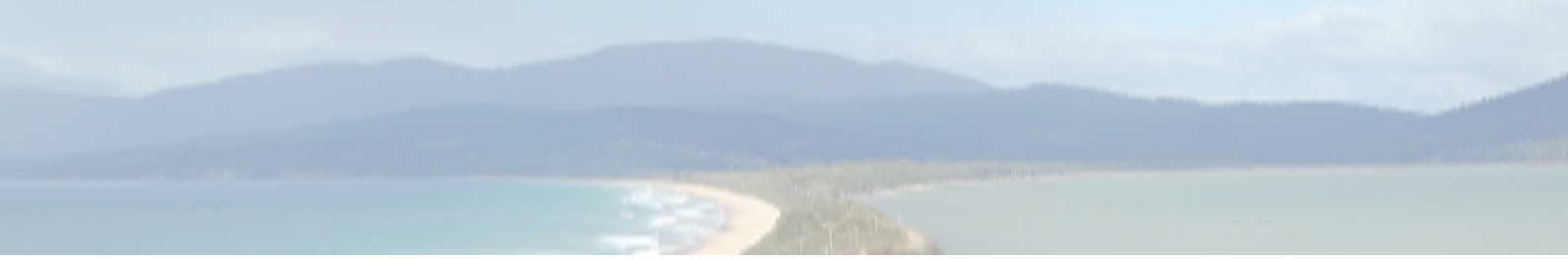
There is evidence this householder attentiveness to, and awareness of, the TOU tariff became stronger over time, with slightly more households mentioning the TOU tariff in the year one interview, and having a knowledgeable discussion about it, compared with just after installation (year one interview-12 households (40%); post-install interview-10 households (33%)). For example:

> **“**With the benefits of the Tariff 93 [TOU] we clearly know that we’re on peak charges between 7 and 10 [am], so between 10 and 4 during the day like now, we would actually – if it was a cold day – the heat pump would be cranked up a couple of notches now and then we’d turn it back at 4 o’clock in the afternoon when the peak [starts]...And then crank it up later in the evening again if we need to.” (Household BT112, Aug 2018 - year one interview)

However, some households have not been able to change their behaviour at all (4 out of 30), explaining to us that they do not have the flexibility to change:

> “**Interviewer:** Have you changed habits around using particular items, at particular times of the day; like doing washing, or vacuuming?
> **Householder:** No. No. I don't do washing, and certainly don't vacuum, as you can see!” (Household BT106, Aug 2018 - year one interview)

and for diverse reasons;



> "**Interviewer:** So do you feel like your habits have changed at all? So, for example, when you do washing or vacuuming or when you use the dishwasher or -
> **Householder:** No, I haven't got onto this thing. I haven't got onto this thing [Reposit app], and I should. Because my day is dictated by what I need to do, I haven't had the flexibility. But there will now be days when I could put the washing machine on at a time. At the moment, it's early in the morning … so that it frightens the tiger snake […]
> **Interviewer:** But would the importance of scaring away the tiger snakes still be the key?
> **Householder:**Yes, it would be on a sunny day in the morning." (Household BT115, Oct 2017 - post-install interview)

including in some cases because they are already very low energy users (2 out of 30 households):

> "**Interviewer:** Although it's early days, do you think you've changed how you use energy in the home since the technology was installed?
> **Householder**: No. No.
> **Interviewer:** And why do you think you've not changed?
> **Householder:** 'Cause I'm living the same as I was before the technology was there…[…] We shower the same amount per day, we have the lights on the same amount per day, and the fridge is on for the same amount of hours, so there's not much more we can do without – yeah, to try and lower our energy consumption than what we're already doing. (Household BT131, Nov 2017 - post-install interview)

Changes in Reposit app usage over time

Use of the Reposit app by Trial households was to obtain two main types of information: i. feedback on their energy use and solar-battery system; and ii. real-time notifications of their battery use by the network, and notifications about when to consume energy (when their battery is full and their solar is generating).

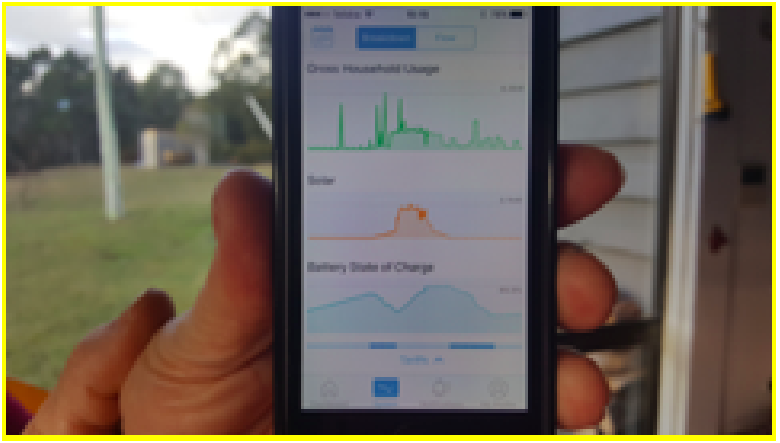
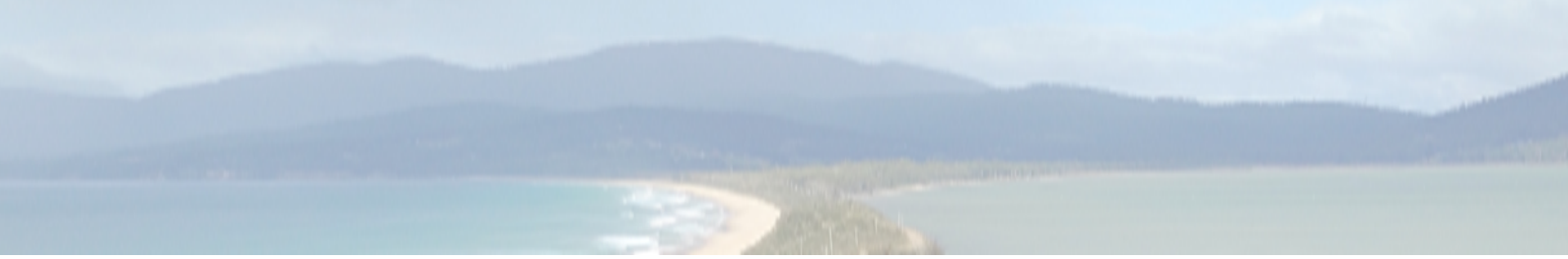


Plate 1: Example of Reposit app on a householder mobile phone, showing feedback data



Most of the Trial households used the Reposit app: 73% were using the app c.2 weeks after the installation (22/30), and 70% were using the app a year later (21/30).

The majority of households (25/30; 83%) were consistent with their use of the Reposit app over time, i.e. what they reported to us regarding usage of the app in interview in the immediate post-install period was the same as what they were doing a year later, in our final (year one) interview. Of the 5 households (out of 30; 17%) that did alter their Reposit app patterns over time there was a mix of directions of change:

- 3 households had not started using the Reposit app in the immediate period after installations, but had done so a year later
- 2 households moved in the opposite direction – they reported Reposit app usage to us just after installation, but not a year later.

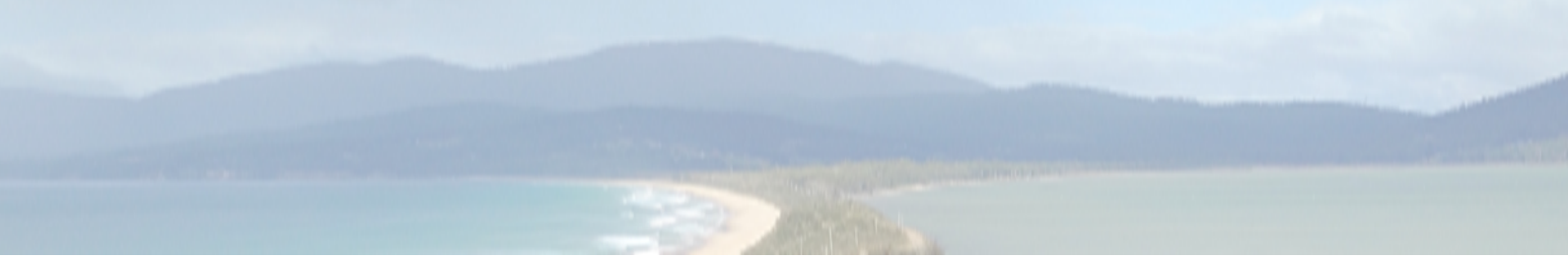
Overall, we found households to still be very engaged with the app over time, a year or so after their installation, for example:

> "**Interviewer:** Would you say you're a person who monitors electricity regularly now then? Or sometimes?
> **Householder:** Sometimes.
> **Interviewer**: Is it a weekly thing or every few days?
> **Householder:** Every few days, I'd say. You know, when you flick between Instagram, Facebook and your Reposit app in bed. There you go!" (Household BT106, Aug 2018 - year one interview)

And there is evidence that householder understanding of their energy use had increased through use of the Reposit app:

> "**Interviewer:** What motivates you to have a look at it [the Reposit app] ? ... In terms of your motivation is it just because it's easy access, it's there, it's an app on your phone so it's easy to check..?
> **Householder:** Yeah, pretty much because, like you say, it's so easy to just have a look at. But also, just to make sure everything's working fine and there's no issues.
> Because I'm not there [on Bruny full-time] so that's one way of keeping an eye on it, making sure that everything's working the way it should be too. And also, like you say, being the app - which makes it very easy to access at any time to look at as well and it gives you a fair bit of information, what you need to know." (Household BT105, Sept 2018 - year one interview)

But for those households who had not yet used the app just after installation (8), most of them (7) were persistent non-users, a year later. Reasons given for their lack of engagement were lack of information at time of installation, time constraints and/or a more general reluctance to use technology, including smart phones, in some cases because of poor internet service, for example:



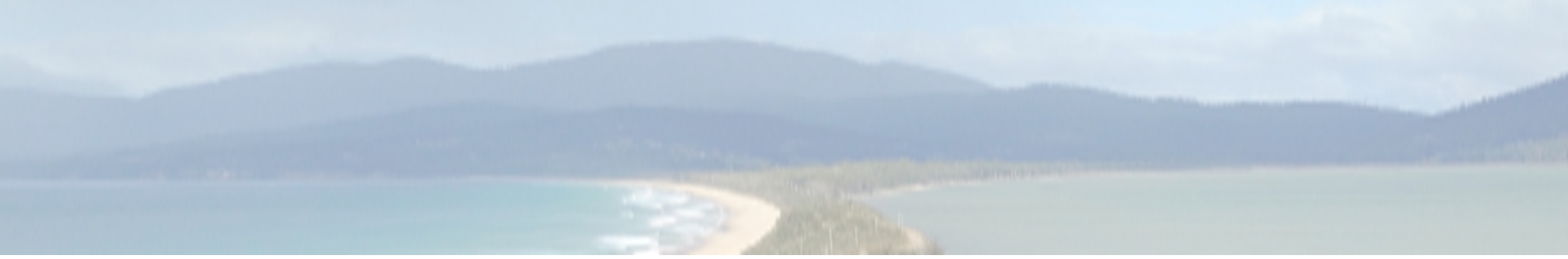
> "**Interviewer:** Have you looked at the information about your solar generation and energy consumption and battery behaviour that's provided through the Reposit app?
> **Householder:** No, not at all. I haven't even looked at it yet because, well, I'm waiting for the time and the children. We'll do it one weekend.
> **Interviewer:** So have you downloaded the app, or has one of your sons downloaded it?
> **Householder:** No, not yet. No. It will all happen. One's coming back from uni in a week or two. He's been very keen to get it organised, so it's something that he and I can do together." (Household BT123, May 2017 - post-install interview)

> "**Householder:** We haven't got phone coverage here - I've got to do it on the internet, but I only check my internet twice a week that's all. And I just can't be bothered looking at it because I'm not interested in it. If it's done it's done, I get paid so much, but I can't be bothered just checking it.
> **Interviewer:** And it sounds like when you're checking twice a week on the internet there'd be a lot to do at that time.
> **Householder:** I've got enough; I don't even like doing emails. I'm not a technical person and my partner doesn't like it either so I just can't be bothered with it.
> **Interviewer:** Does that include checking on the system working as well?
> **Householder:** I check that it works, I keep my own little record to see what's happening every week since it was installed just so I can see it's working.
> **Interviewer:** So you're checking it in a different way perhaps?
> **Householder:** I just check it with a physical check because I just like to write down what it's done, what we've used." (Household BT129, Aug 2018 - year one interview)

As indicated by Household BT129 in the quote above, we observed that our Trial households also used other forms of information and feedback, not only the Reposit app, for example:

> "**Interviewer:** ... what do you think about the information provided? You've said the inverter seems to be very good information.
> **Householder:** They are providing different information but the inverter seems to be – if you only have one choice, I'd choose the inverter, but I look at both [Reposit and inverter]." (Household BT119, April 2017 - post-install interview)

Use of other types of feedback was the case early on in the Trial, post-installation, but also a year later at our final interview. The inverter app and inverter portal (i.e. direct viewing of inverter screen) were the most commonly cited alternative forms of alternative energy information cited by households (12/30; 40%), along with traditional electricity bills (2/30; 7%).



Subsection 2 – Finance and pricing-related householder responses

This subsection outlines several finance and pricing-related considerations and questions explored in the Trial, and reports on householder responses. This section should be read alongside economic analysis and value of system findings (see Reward structures Final Report by Chapman et al (2019)).

What motivates? Are financial motives salient?

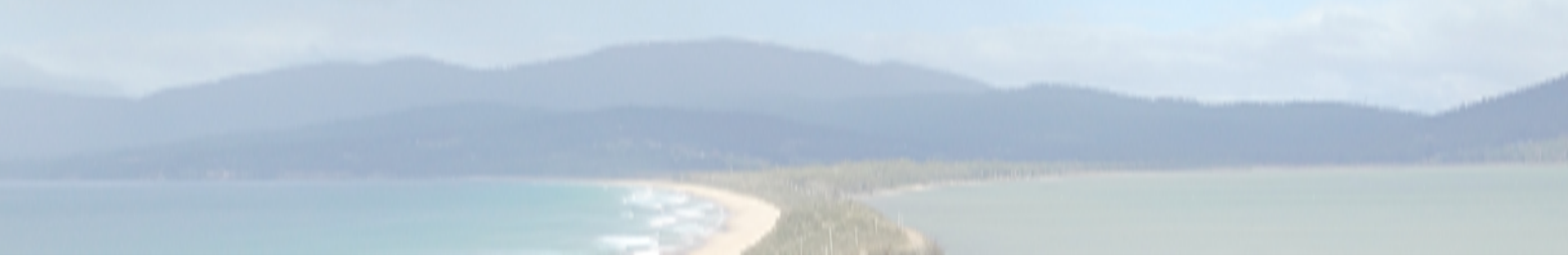
People's motivations are important to understand during the design of all systems and technologies that they interact with. Within CONSORT, understanding of Trial household motivations was sought in interviews. Identifying participants' motivations (or drivers) in this Trial allowed exploration of assumptions made pre-Trial that householders would be motivated to take part in trading energy because of the opportunity for financial rewards and to reduce electricity bills.

In this particular Trial NAC and Reposit used price to negotiate trade of energy. However, both NAC and Reposit have the flexibility to adjust what they measure and can respond to other household preferences (or outcomes), as long as these preferences are represented in certain ways. This means that both NAC and the Reposit controller can adjust how they negotiate with and respond to DER systems and can factor in various preferences and outcomes[2] - they do not have to rely on price-only negotiations. In this Trial though it was price and financial reward that was used to compensate households for use of their battery.

While we found that financial considerations were important to householders, we also found a plethora of other household motivations were influential in relation to the decision to install and use DER. Findings about non-financial motivations may be helpful when deciding what outcomes or preferences software platforms such as NAC and Reposit use to structure their interactions with households.

In pre-installation interviews we asked about the importance of the cost of bills and about motivations to be involved in the Trial more broadly. While cost of bills and saving money was mentioned as an important motivator by 31 of 36 pre-install households, only 6 of these answered that they were only motivated by finances. Another 4 households responded in a

[2] Other incentives such as comfort, self sufficiency or environmental impact could be used within NAC and Reposit if there is an appropriate financial representation. For instance, AEMO have a Value of Customer Reliability priced at $41,534/MWh, meaning that is the price customers place on having reliable electricity. Similar pricing models could be implemented in the Reposit system, although creating user interfaces capable of quantifying these values would be non-trivial and require development. To date, lowering the household energy bill as much as possible is the only incentive available. In effect this assumes that finances hold critical sway in household decision making around energy.



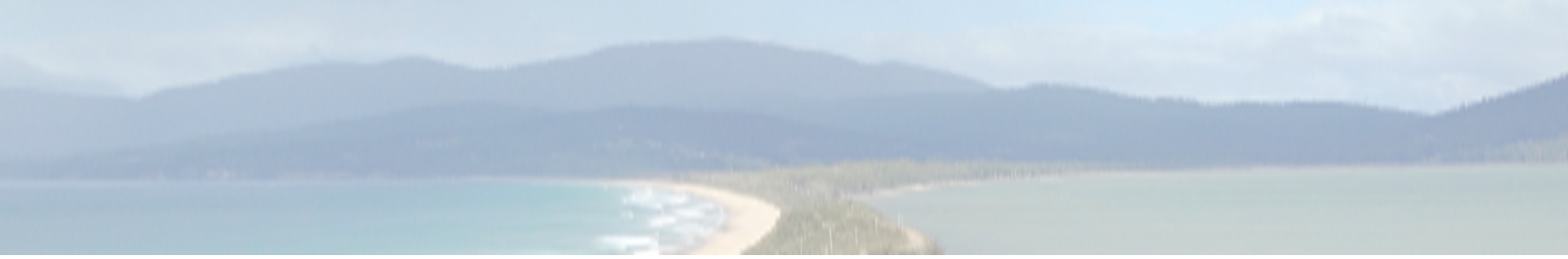
way that suggested they were mainly motivated by financial considerations, but had one or two other (likely less important) motivators, such as interest in the new technology and being opportunistic.

Over the duration of the Trial, as households engaged in further interviews and became more familiar with us as researchers, other motivations were forthcoming. Household BT101, for example, elaborated at the post-install interview that she had always wanted solar, and at the year one interview explained further that she was used to managing by herself and liked to be in control of her own resources. She also elaborated that her motivations were underpinned by environmental and sustainability concerns: “It would help the world’s issues a lot if all this was for everybody” (August 2018 - year one interview). Additionally, Household BT101 was interested in going off-grid. This more in-depth revealing and explanation of motives over time was expected, and is common in longitudinal social research: participants tend to become more comfortable discussing issues over time as repeat social research is conducted. We have observed over many projects that participants may hold back on discussing personal values in initial interviews, while they get to know and assess the researchers and the project.

Household motivations for participating in the Trial mentioned to us in the pre-install interviews are listed below. Note that the number shown in the list below is the combined overall count of motives that belong to that one topic, and each different motive raised was counted once per interview, per household:

- financial motives – 56
- environment/sustainability motives– 29
- community care and value motives – 17
- interest in technology – 16
- being part of a trial – 15
- network aware motives – 11
- a focus on batteries to solve issues – 8
- has existing solar – 7
- liveability of the home – 3
- interest in off grid – 2
- situation or person ready to go (ahead with installing the tech) – 2
- motivated by the trial making all the effort (for them) – 1
- influenced by install quote – 1
- feel good factor – 1

As can be seen in the list above, financial motives were most commonly raised, which appears to be at odds with our analysis above. However, it is important to note that we asked households specific questions about cost and affordability of bills in this interview, which therefore inherently prompted more discussion on financial topics.



Battery back-up

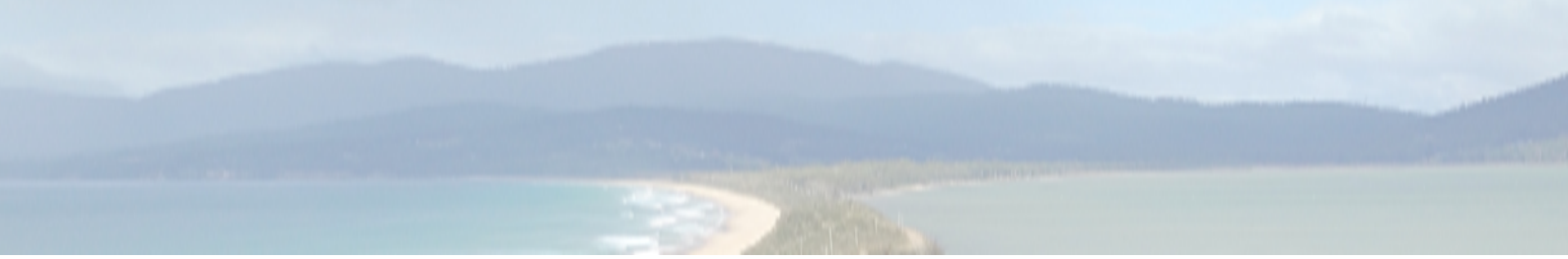
A key tension highlighted in the Trial was the value householders placed on having back-up power available from their battery, during times of network outage. It was expected by our industry partners that householders would be happy to share their battery with the network if they were well-paid for its use, but our findings suggest this is not necessarily the case. Battery back-up was mentioned specifically by 8 households at the pre-install interview as a motivation (see above). We also asked households at the post-install interview to rank a list of uses for their battery so that we could understand what was most important to them in relation to their battery. The answers they could choose from were: store power for later use; store power for trade with the network; help manage/make best use of our tariffs (minimise bill); store power for backup if power goes off; to be more environmentally friendly; to be more independent in my/our electricity generation; and 'other'. The most popular number ranking was 'to store power for later use' (11 of 32 respondents). Overall, the top 3 answers were 'to store power for later use', 'to help manage/make the best use of our tariff/s (minimise the bill)', and 'to store power for backup if power goes off'. It is important to note that, besides the number one ranking, the rankings were spread across all the answers in a way that doesn't show any clear-cut standouts. This indicates that there were, again, a number of motivations. The category 'other' offered no new categories.

Network support payment types

Two Network support payment types were trialled (see Reward Structures Final Report by Chapman et al for further detail). An Energy Reserve payment type was trialled March 2018 to July 2018, and an Energy Use payment type was trialled July 2018 to March 2019. Household participants were asked about their opinions of the two network support payment types in their year one interviews.

In general terms, householders reported that they were not motivated to change energy practices because of these payments. The main reasons for this lack of effect was because households: had not really thought much about the payments and their potential impact; or saw the payments as a small extra (as 'little cherry on top', or a 'bonus') to being involved in the Trial and not as the main saving or financial benefit; or saw the payment as a necessary payment for the extra use of their batteries (the use of their stored energy and the wear and tear on their battery).

When asked which network support payment type was prefered, most householders did not have a preference between the two types: Energy Reserve and Energy Use. Those who did express a preference (5 out of 30 households) all chose Energy Reserve due to a perception it would pay them more (as they saw it had to reserve more than would be potentially needed). Many participants in interviews were prepared to engage and think about the payment types, but notably, all households processed the idea of the payment types *during* the interview, indicating in most cases that this was the first time they had thought in much depth about the network support payment types. There were only a small number of householders who



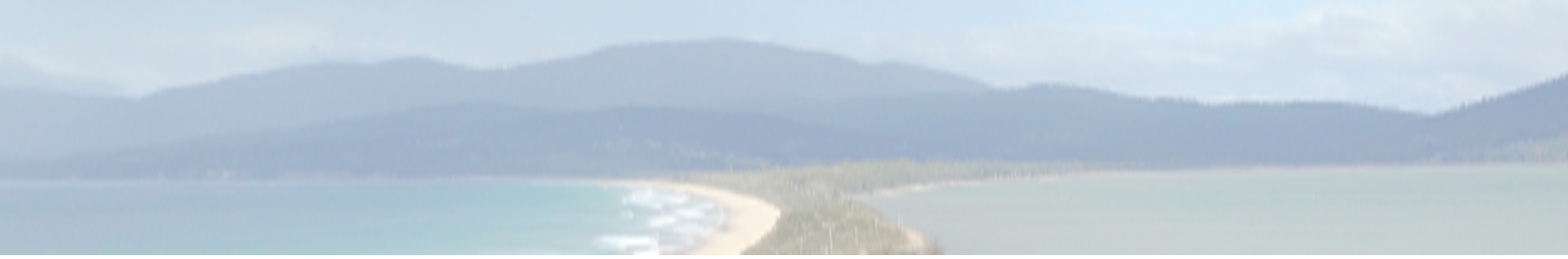
reported having reviewed the videos about the network support payment types, circulated to Trial households in 2018, again indicating only modest levels of engagement by Trial households with the network support payments trialled as part of CONSORT. Six (out of 30) households observed, when asked about preferences related to network types, that there were bigger priorities for them. Although one householder recognised that their position as a retiree meant they likely didn't have the same financial pressures as others (for example big family) households and that if they were in a different financial position, they might pay more attention. Eleven (out of 30) households commented that there wasn't enough detailed information to make a choice between the payment types, because they couldn't see the workings behind the summary grid credit amounts shown in the Reposit app and couldn't see a price per kilowatt/hour, or the kilowatts they traded from their batteries. It is important to note that offering variable (differential) payments for different batteries in certain locations on the network was discussed in our social research interviews, but was difficult to pursue in depth because householders did not have any clear experiences of this phenomena. Variable payments were effectively tested alongside NAC during the Trial, but were not actually applied to household payments. Householders continued to received $1/kWh throughout the different network support payment approaches. In future programs it would be useful to further scrutinise variable payments with DER owners.

Related to our social research on the payment types and energy trading, we also explored with household what they thought about different Trial household batteries sharing different amounts of energy with the network. The majority of Trial households had not thought through (or been informed clearly) about the fact that each battery in the Trial could be sharing different amounts of energy. We asked households whether they thought it was fair and equitable that different amounts of battery power were shared across the Trial households, for technical reasons (including network issues, battery capacity and household battery use). These technical reasons were generally accepted by Trial households. A number of households were interested in talking about fairness, particularly when they thought the installed CONSORT technology might not be completely fair (for example, Households BT101, BT104). Household BT117 commented that they really had to rely on the Trial commercial organisations (Reposit and TasNetworks) to make sure it was all fair:

> "I guess I've relied on TasNetwork and the Reposit to make it fair and equitable so that they're calling on all the battery trial participants in approximately the same way." (Household BT117, October 2018 - year one interview)

Through our social research with Trial households about network support payment types, energy trade, and fairness a number of observations emerged:

- the majority of the householders made efforts in the interview to engage and think through this fairly complicated area of questions on energy trade, and to converse at some length about it, even though they did not have much background on the subject;
- a number of households actively worked on improving their understanding during the social research interviews, by asking the interviewers for more explanation;



- there was a tension between high winter energy requirements in Trial homes and the timing of energy trading from batteries;
- it appeared that while many households were currently (fairly) uninformed about technical network issues, they were equipping themselves with better understanding, and would likely be able and willing to engage further on these topics in the future.

Household awareness of network operations and NAC

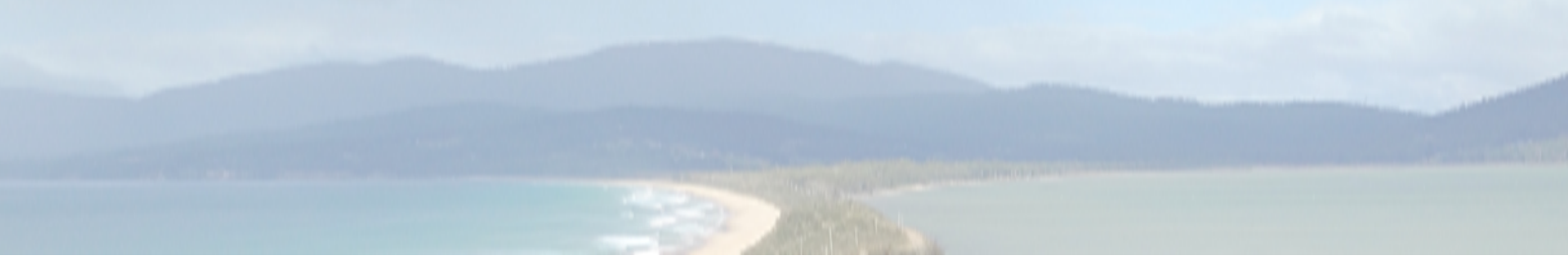
Overall householders had very little awareness of the NAC as a concept or as an 'agent' in their energy trading within the Trial. The social research team believe this was mainly due to four issues. First, the NAC was not something tangible or physical and was only rarely mentioned, from the householder perspective. There is no physical piece of technology on the householder-side that allowed them to recognise the NAC as a 'negotiator' that interacts with their battery-solar system. The lack of a physical entity to identify with was exacerbated by energy trading with the network being irregular. The implications of this lack of awareness of NAC were apparent in the final focus group with households (in February 2019). At the focus group NAC was re-explained and yet, was still immediately confused with Reposit controllers by a number of participants (Final focus group, Bruny Island, 4th Feb 2019). This response suggests that in future there may be a need to give the NAC a greater presence in households (if this is judged to be important commercially, or otherwise).

Second, because 'the NAC' was an unfamiliar term and described a new concept, attempts were made by CONSORT to provide understandable descriptions of its function. This was achieved by describing actions on the network side using accessible (more easily understood) terms, as well as metaphors. The NAC as a specific term was therefore not very familiar to households. The Trial documentation tended to use words such as 'coordinate', 'negotiate', and 'notify' instead of the term 'NAC'. For example, in the Participant Information Sheet:

> 'ANU will use participant household and network-wide electricity data to develop and test software that will enable solar power and battery systems to optimally meet household energy demand while also helping to manage the electricity network' (CONSORT Battery Trial Participant Information Sheet, June 2017 version).

Further, the Trial website mentioned NAC but also used other descriptors such as 'automated planning and scheduling', 'automatically and optimally coordinat[ing] a large number of batteries' and as a 'a deployment of batteries' (CONSORT 2019).

Third, from our social research observations, we suggest that householders may have registered NAC as an 'agent' more clearly if they had experienced the full function of NAC, i.e. using variable or differential pricing. As noted above, differential pricing (i.e. differential payments based on individual value to the network, rather than the flat rate of $1/kWh) was not fully trialled in real-time for households during the Trial. The Trial tested the Shapley



heuristic towards the end of the trial but only tested it alongside NAC (see Reward Structures Final Report by Chapman et al (2019)).

Fourth, and more broadly, understanding by householders of the network function and NAC were affected by how complicated the entire CONSORT system was. In the final focus group (Feb 2019) a number of householders explained that they were frustrated that they could not understand or follow decisions made by the installed CONSORT technology, or just in general understand the overall (network-wide) system, and saw it as lacking in transparency. For example, one participant commented:

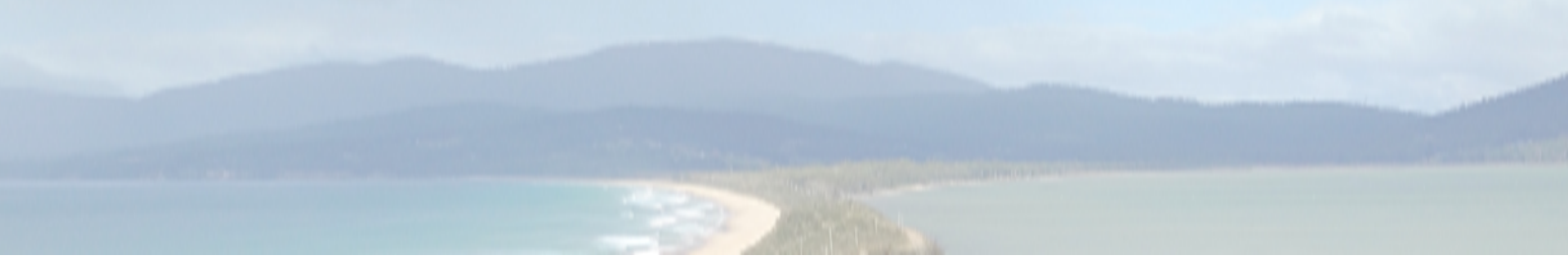
> "Well I think the fact that people are trying to clarify what all this means says something about how transparent the whole system has been, or hasn't been." (Household participant, Feb 2019 - final focus group)

There was also some dubiousness in this focus group that such a complicated system as NAC, with such a sophisticated algorithm, could work at scale. The focus group went on to further discuss the relative values of the installed CONSORT technologies and to apportion relevance and importance to the different payments and savings they received due to their DER system. It was clear that the overall system (including the functions and workings of the network and the technology and the various payments and savings householders saw) was complex to grapple with. One participant observed that the energy trade doesn't provide significant financial benefit:

> "I think a lot of people maybe where they're being tripped up, everyone seems to be talking about money and how much they're getting and how it works and all that sort of stuff. You have fallen into a trap of a misnomer, if you think you've put a solar system on your house to make money – right. You've [actually] put a solar system on your house to reduce your outward expenditure, and if you make five bucks a year out of it so be it. It really doesn't matter how much you make once you get to a breakeven point. But you're never going to have a big enough solar system on your house to make meaningful money. End of story." (Household participant - Feb 2019 final focus group)

Some participants in the focus group, after discussing various aspects of the DER/NAC Bruny Trial suggested that participating in DER is too complicated, and they would prefer others in the energy sector to do this work:

> "**Household participant 1:** I'll still go back to what I originally said in the first thing, I'd prefer to have the big generators do all of this themselves so we don't have to put up with all this stuff.
> **Interviewer:** Complexity?
> **Household participant 1:** Yeah, and just buy it at a greener, cleaner rate.
> **Household participant 2:** Blessed are the peacemakers.
> **Household participant 1:** So a solar farm will make more sense. But we know that.
> **Household participant 3:** We're an experiment."
> (Multiple household participants - Feb 2019 final focus group)

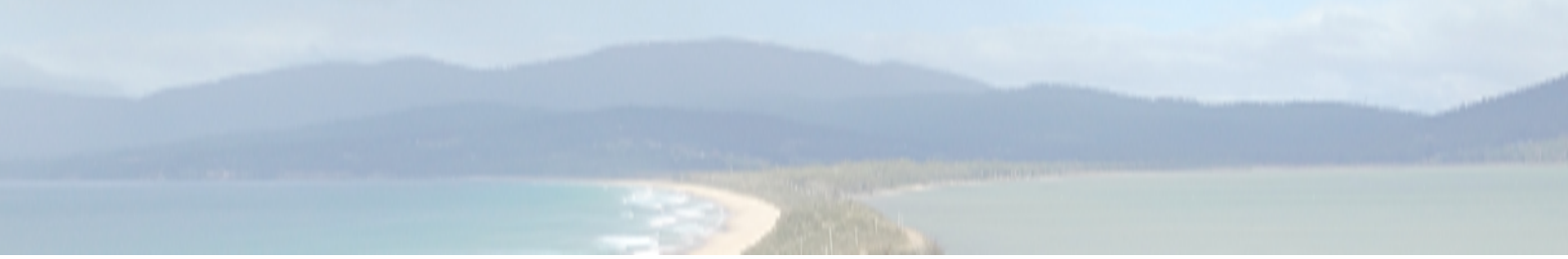


The impact of tariffs

Issues related to tariffs that arose over the course of the Trial highlight some useful learnings that can be applied to future programs. Of the 34 Trial households, 21 changed to the TOU tariff sometime over the course of the Trial. In the Participants' Solar and Battery System Financial Performance Final Report, Franklin et al (2019) identified that there were significant differences in financial rewards coming from the Reposit component of the solar-battery system for households who changed to the TOU tariff, compared with those who stayed with their existing flat-rate tariff. In other words, households were significantly better off financially in relation to Reposit managing their system if they switched to the TOU tariff. A key finding for social research was that tariff-related decisions had significant ongoing effects on householders, particularly in terms of their clarity around energy management and in terms of ongoing financial rewards. Householder thinking about tariffs dominated other types of pricing innovations being trialled by the CONSORT team.

Over the course of the Trial, we observed numerous moments where there were issues with householder decision-making about tariffs; or where details of tariffs had become confused. There were several moments in the process of installing TOU tariffs where complications arose:

- There was the initial decision about whether or not to switch to the TOU tariff. This decision was made by households alongside other complicated technology choices, and often in a rush. This decision was sometimes helped by installers and sometimes not. Households reported to us being unsure about which tariff would be most beneficial. The lack of clarity seemed reasonable considering the lack of useful data available at the time on outcomes from TOU tariff changeovers. Installers did not have sufficient experience with TOU tariffs and batteries at the stage of installation to be able to support households to make a completely informed choice.
- There was confusion about whether or not households had actually decided in the end to switch to the TOU tariff. We noted this confusion at post-install interviews when many households could not confirm what tariff they were on, with some still unsure at their year one interviews.
- Once householders had the TOU tariff (21 out of 34), as noted above, there were issues with making sure it was reported to Reposit. Reporting this detail to Reposit was important because the controller makes different decisions in relation to different tariffs. Reposit required this information to optimise battery and solar energy use in homes. There were many instances where Reposit did not receive accurate information about tariff types. If installers did not tell reposit about TOU, householders had to, but householders often did not know this. This meant that a number of householders were listed with Reposit under the wrong tariff for significant lengths of the Trial. Even at the analysis phase, the team found that the tariff data needed to be checked, and lists from TasNetworks and Reposit did not always correlate.
- Around the installations, if they decided on TOU, householders had to also wait for a meter change over, which often occurred a little bit apart from the install of the



CONSORT technology. To complicate meter change overs further, Aurora took over meter changes from TasNetworks during the Trial because of an AEMC rule change. This shift to Aurora significantly delayed a number of meter change overs (which meant that once meter change overs were done, householders might have forgotten to let Reposit know their new tariff).

- When TOU was up and running for Trial households, they needed to make sure they knew what times were on and off peak - we observed that some households knew this and some did not.

Households reported not having changed over to the TOU tariff because they were: advised against it by their installer; were waiting for their installer to do it and either lost track or found their installer hadn't followed up; or, didn't feel they had enough information to make the change (during a time when many other decisions were being made).

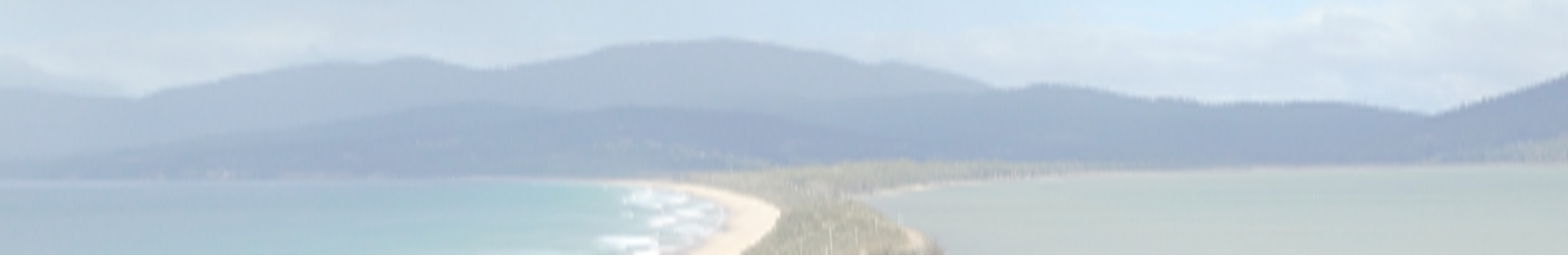
That important details like household tariffs were hard to have recorded and tracked was no surprise to the CONSORT team. Reposit are not allowed to directly check details (and have a policy of letting householders come to them with problems); and, as noted, TasNetworks also had to transfer meter change overs to Aurora in the middle of the Trial (due to new regulator requirements). Aurora were not involved in this Trial so there were further difficulties with tariff details being cross-checked.

For scaling-up to a national program, it is important to consider that poor understanding of tariffs, poor communication about tariffs and also poor data transfer between organisations is a significant concern. System and meter details that will affect DER performance must be shared between organisations, but this may not be allowed when competition rules are in place. While householders are prepared to share these details, it is risky to rely on them to do so as there were significant barriers - noted above - that created difficulties in passing on tariff information in a timely manner.

Subsidies and Payback

Householders reported to us that they would not have purchased a PV-battery system without the Trial subsidy. Of all the Trial households, the range of personal contributions was $2,000 to $26,600, with an average of contribution of $4,700. One household explained the importance of the subsidy:

> "Oh, I think the subsidy was very good. I wouldn't like to see it become less, because I think it'll just eliminate – I mean, if the Trial's going to continue on, if it's going to be in the capacity of the Trial thing, I think that subsidy is fantastic. And I wish the government would take on board to give the general public a subsidy to, you know, promote solar power. I think it's – it should be everywhere available for everybody. And a much better subsidy than what they used to give. I think it's really important." (Household BT101, August 2018 - post-install interview)



Related to subsidies, householders also discussed likely payback periods (both as spontaneous comments and due to prompts). Some households had thought about this in some detail, while others had not dwelt on it much or at all. Payback periods of 5 to 10 years were commonly thought to be reasonable. With the significant $16,000 CONSORT subsidy, a number of households felt they would have their installed CONSORT technology paid off within this 5 to 10 year payback period. A handful of householders pointed out that further understanding of costs, future rewards, system and battery durability and wear and tear from trading energy was needed to truly identify paybacks. Payback information and suggestions were provided by installers and some provided a formal payback figure. However, most households worked out what they thought about a payback themselves. A number of householders did this spontaneously in interviews.

Conclusion

In summary, the Trial has operated as a 'living laboratory', affording us the opportunity to test ideas and new technologies, with the intention to upscale. Bruny Island successfully operated as a rigorous test case for new DER interventions, because of its rural location, high proportion of shack owners and non-average demographics.

Social research in the Trial has produced new qualitative data on how householders respond to DER. Our key findings, which we have reported on here, concern the installation of the new technology, householders' emotional responses to the technology, how household behaviours changed over the course of the Trial, and household reactions to new pricing arrangements (payment systems, tariffs, and rewards).

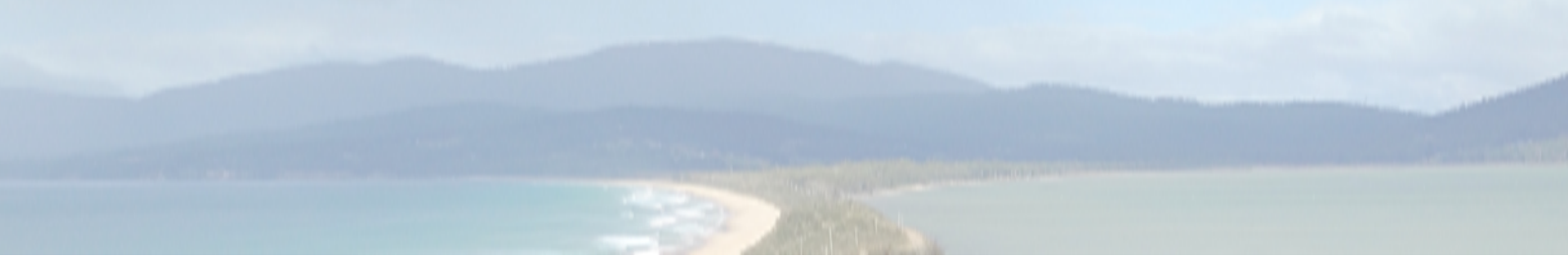
The social research of the Bruny Island Battery Trial set out to explore the response of householders to the photovoltaics (PV), battery and household control system (Reposit) installed for the Trial. Our core research questions, as outlined in the original project proposal, are summarised here along with our key findings:

How do householders respond to

- *the control system's interface and what actions do they take (in relation to the control system);*

  Key findings:

  - most households downloaded and used the Reposit app and took action in response to the Reposit feedback and notifications
  - installers varied greatly in terms of the level of education and support they provided for households about the control system, and this affected how householders interacted with Reposit, and how much they used the app
  - initial household changes in behaviour and use of the Reposit app have persisted over the course of the Trial, for the majority of households



    - types of household energy behaviour change were to do with changing the timing of energy use activities, rather than stopping the activity, e.g. timing of clothes washing, dishwasher, showering, heating (space heating and hot water), and use of the oven.
    - householders' emotions - particularly beliefs about trustworthiness - affected the actions taken by householders and how engaged they were with the Reposit app
    - awareness of the NAC was low amongst Trial households - it was generally not differentiated from Reposit.

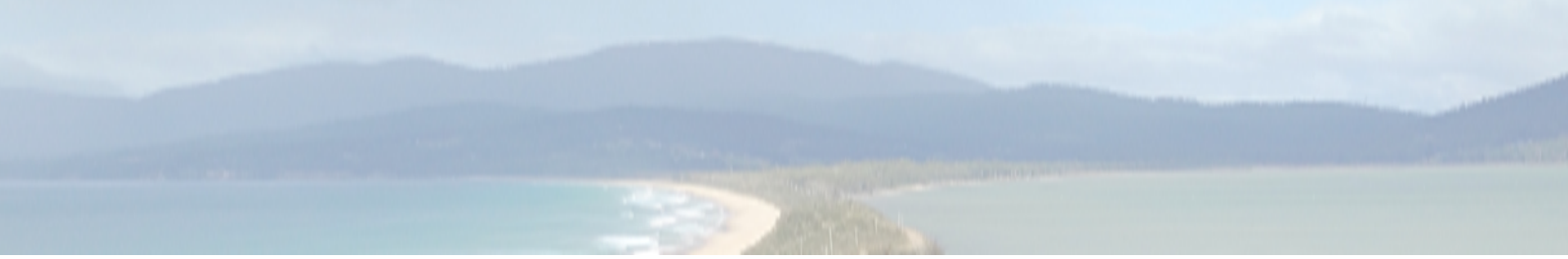
- *the combined PV-battery technology, and the new peak electricity pricing enabled by it?*

    Key findings:

    - financial considerations are important to our Trial households, but a plethora of other issues and motivations (e.g. community values) influenced what households thought about third-party use of their DER
    - it was expected by our industry partners that householders would be happy to share their battery with the network if they were well-paid for its use, but our findings suggest this is not necessarily the case. A key tension in the Trial was the value householders placed on having back-up power available from their battery during network outages
    - most householders did not have a preference between the two types of network payment that were trialled: Energy Reserve and Energy Use. On prompting, those who did express a preference (5 of 30) all chose Energy Reserve due to a perception it would pay them more
    - the new TOU tariff was a central concern of Trial households, and this issue overshadowed other pricing and rewards innovations
    - the CONSORT subsidy was central to households participating in the Trial.

Our emergent findings over the course of the Trial were broader than the initial research questions, and included:

- the importance of the technology installation process: the installation process was not a discrete, one-off event, but rather a diffuse process that for most households took some time and was not straightforward; the householder experience of the installation influenced their ongoing attitude towards the Trial;
- householder emotions were varied, and important in how households engaged in the technology. For those households experiencing negative emotions, coping strategies included taking control and keeping the perceived risk at bay by dismissing the technology (e.g. by ceasing use of the Reposit app);
- the strong influence of tariff changes, which for most households coincided with the installation of their new technology: a significant number of households did not change



to the TOU tariff, despite analysis showing they would have been better off financially to do so. Further, the process of changing tariffs involved several steps, and was not straightforward, meaning a number of households were not certain what tariff they were on a year after installation;

- there are some organisational gaps in new household-DER-network configurations, such that key tasks are not necessarily happening, e.g. education about the installed (combined) DER technologies, ongoing troubleshooting, tariff changeovers. Households are the ones who tend to be adversely affected by such gaps, and will report on them in their own words, but perhaps only if prompted by a trusted independent person (e.g. during a social research interview).

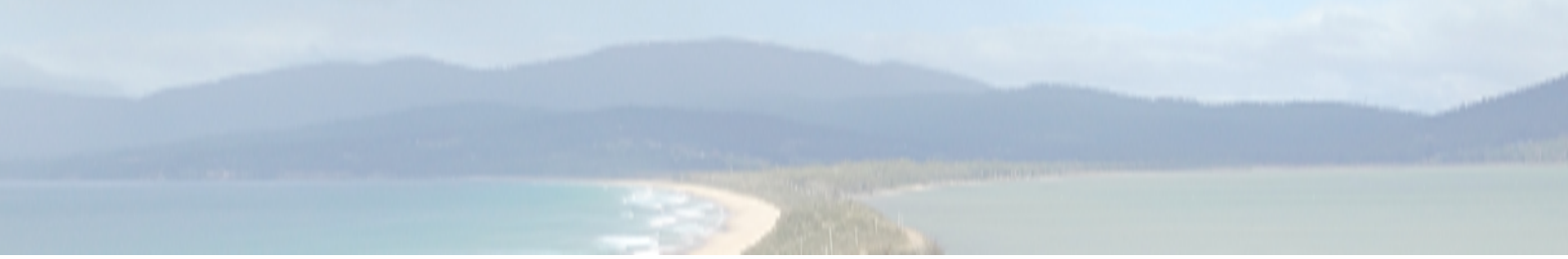
Recommendations

A common sentiment amongst industry and government reports on DER is that householders are uniformly willing and unproblematic participants in DER sharing with networks. Our CONSORT social research challenges this assumption: households are diverse, and the context in which households make decisions (about their energy and other things that affect their energy use and technologies) is crucial to better understanding their receptiveness to DER and DER preferences.

The key overall lessons from our social research on the Trial, along with recommendations about how to respond, are as follows:

- Householder participation in DER is not certain; it cannot be assumed that householders are willing to participate.
- Householder responses to DER are diverse, and expecting that households will have a uniform and predictable response to any particular DER intervention is unrealistic. For example, some Trial households were responsive to price signals, others much less so; some households used the Reposit app regularly, others did not download it.
- The households in our Trial on Bruny Island are not typical early-adopters, and our findings therefore give a good insight into issues that might be encountered with DER programs elsewhere that similarly adopt a network area or geographical focus, that necessarily comprise a diverse mix of householders.
- The combining of various technologies to create DER systems in homes has created a complex system that goes beyond information and knowledge available on any one technology.

  Recommendation: be more cautious in projections about household sharing of DER and where possible substantiate projections and modelled scenarios with ‘real world’ social research data. Plus, consider the type of organisation likely to be able to provide knowledge support about the overall DER system.



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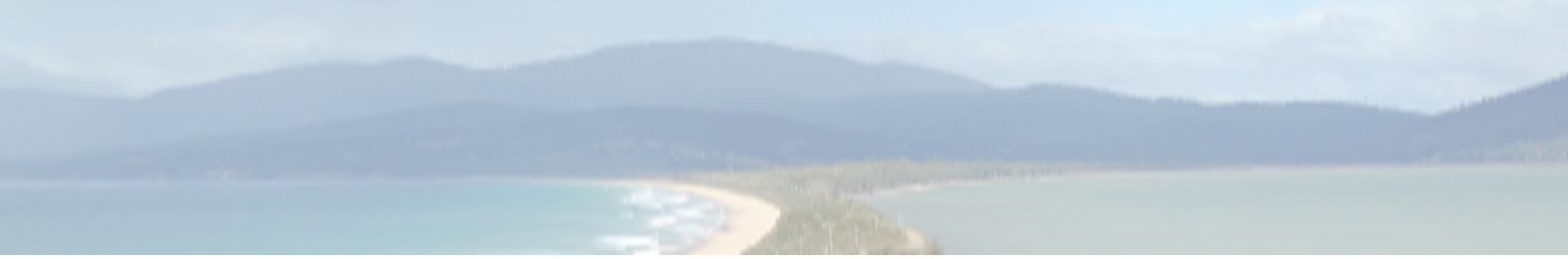

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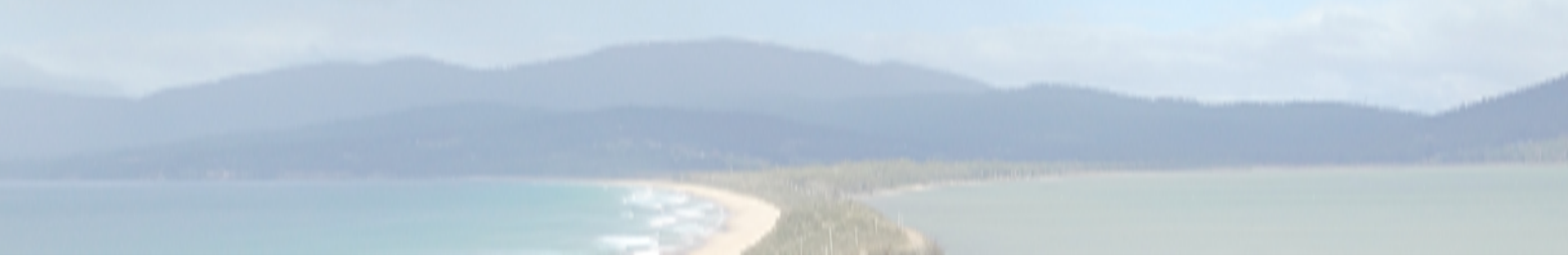

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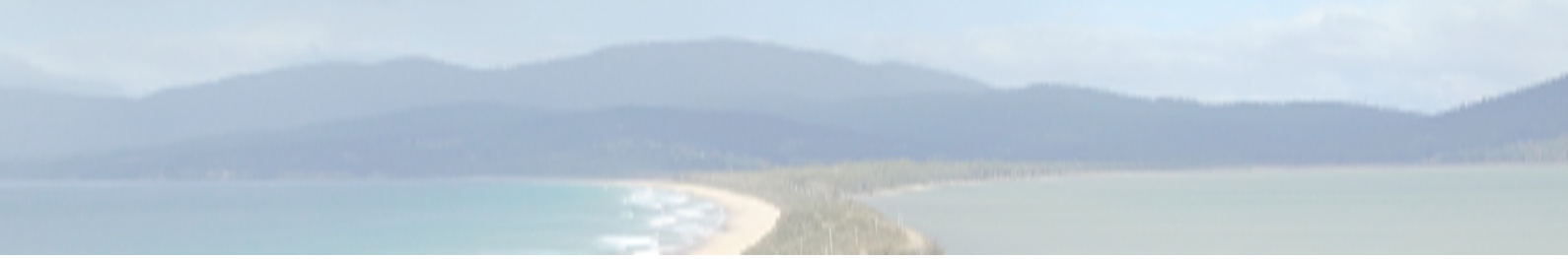
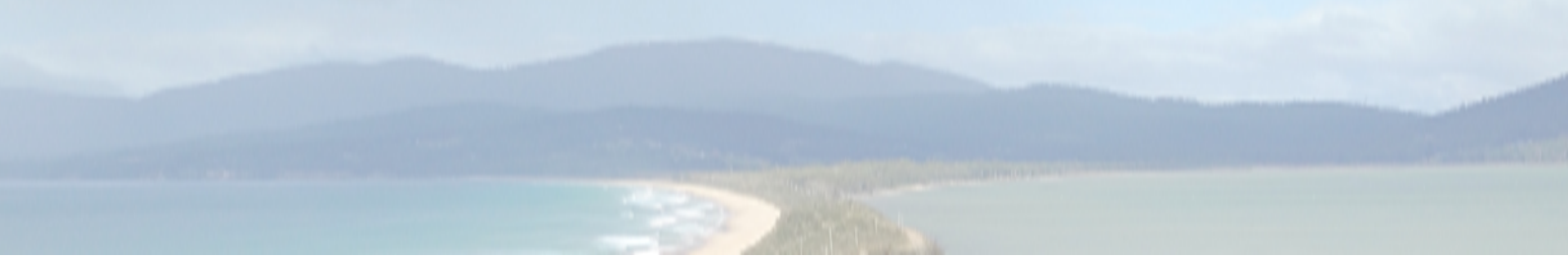


Appendices

Appendix A: Review of DER trials and studies in Australia

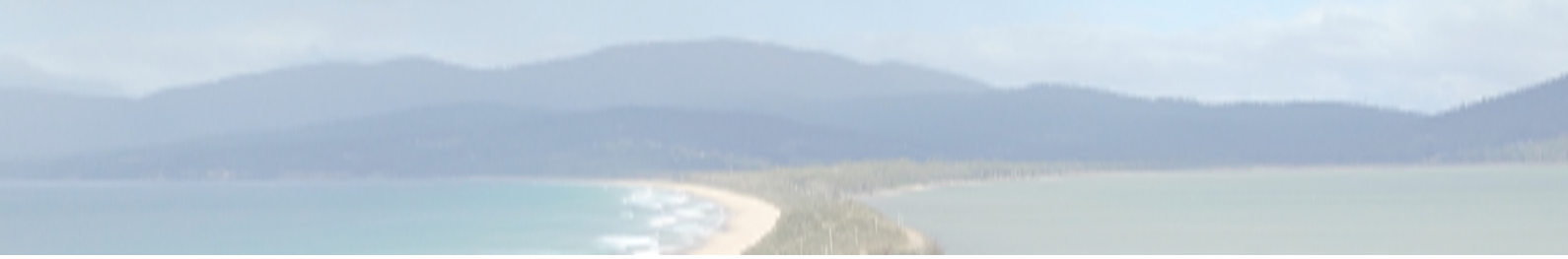
Here we provide short summaries of relevant DER trials and studies in Australia:

- '**Guilty as charged?'** by Fleming et al (2016) examined 'industry and consumer perspectives on battery storage technology safety' (ibid.:27) in Australia. Based on 24 interviews with electricians and 3 focus groups (with installers, consumers and the general public) they found: that perceptions and knowledge gaps for stakeholders and householders are 'rarely researched' (ibid: 31); there is significant concern about battery safety; and, an urgent need for policy to address knowledge gaps and safety issues.
- **Energex**, a Queensland energy company, undertook a 3 year trial (Sept 2016-2019) with 15 customers to better understand PV/Battery coordination with the grid (Energex 2017). Customers had batteries installed and combined with their existing solar. Energex observed battery installations and conducted surveys with customers, pre and post installation. While at the time of writing the trial is still underway, the pre and post surveys outcomes noted in the preliminary report identified behaviour changes to practices in half the participating households, but also identified households had made behaviour changes earlier, when solar was installed. Survey methods were used as their main form of household feedback and, while useful, provide relatively limited insight when used as the primary social feedback mechanism. Very little of the survey data was reported in the preliminary report (the main public source of information to date) so there is at the time of writing little to report on in relation to social responses.
- **Energy Consumers Australia** (ECA) and KPMG investigated PV and associated issues (KPMG 2017). The potential of batteries was explored and they identified that batteries are an opportunity, but are in their early days for consumers. The report warns that incentives need to align with consumer values; batteries need to become more cost effective; and 'further policy work is needed on a range of matters including regulation, standards and safety' (Executive Summary, no page number).
- **The Moreland Energy Foundation** supported by ARENA produced the 'Here Comes the Sun' study (2017). Based on historical power consumption data from medium density Melbourne suburbs, this study examined how grid-connected solar PV and storage systems could provide the 'behind the meter' power needs of users. In a formal interview with a Moreland Representative Veryan Hann (PhD student, Consort) was able to confirm a social focus to the project: 'One of the key aspects was to gauge the desirability – we did a survey of 200 people, and conducted a focus group and a forum. You can put all the policies in the world in place, but it doesn't mean people will use them' (interview with V. Hann, 7/02/2017).
- As part of the **SouthEast Region of Renewable Energy Excellence (SERREE) Project**, a Ginninderry Consumer Attitudes Study was conducted 'to explore the



benefits of involving the community at an early stage in the decision-making process for precinct-level renewable energy solutions' and to begin to 'address knowledge gaps surrounding the social dimension of renewable energy futures.' (Ginninderry, 2017:7). Based on future possibilities, the study sought understanding of community assumptions, expectations, perceived benefits, reservations and objections. The report concludes that (ibid.:35) there was value in involving the 'community in decisions about their energy futures at the early design stage'; that thoughtful user-centred design is required; and that that there is need for 'clear, targeted education and demonstration programs to support ...informed decisions'. .

- The Clean Energy Council and Energy Consumers Australia (2019) are involved in **'Behind The Meter'**, a project which consulted with professional stakeholders in order to develop behind the meter guidelines and codes for DER.
- **CSIRO and Energy Networks Australia** (2017) developed an **Electricity Network Transformation Roadmap** from consulting with stakeholders, including detailed scenario models. The focus of the Roadmap is in part on impacts on customers, but it is stakeholders and financial models that are discussed in most detail.
- The interim report **'Engaging households towards the Future Grid: experiences, expectations and emerging trends'** by Nicholls L, Arcari P, Glover A, Martin R & Strengers Y. (2019) is a qualitative study of around 50 households exploring their views and actions with regard to the changing nature of the grid in Australia. Three types of household participated in the study: early adopters of solar with either batteries or EVs, demand management program households, and households who have experienced significant blackouts. Three key challenges identified in the interim report are: reliability, distrust, and disengagement with the energy market.



Appendix B - Research Methods

Research methods were devised to capture how households:

- interact with the installed technologies;
- process and apply information supplied by the Reposit Power smart energy system monitoring and control platforms;
- respond to price rewards; and
- change their home energy use and management in response to the installed technologies.

The social research used the following qualitative research techniques:

- semi-structured longitudinal interviews (x3: one pre-installation and 2 post installation) over a two year period;
- focus groups (1 pre and 1 post installation);
- home observations related to energy loads and the technology;
- energy diaries (to capture 2 weeks when energy was being actively traded);
- observation of online forum discussions by participants/customers;
- literature reviews; and,
- observation of organization processes and policy context;
- interviews with CONSORT Trial team members and other DER stakeholders (as part of Hann's PhD thesis).

Research methods and data collection was spread over the three year Trial period in order to record initial and longer term responses to the installed technologies. Further detail is provided on all methods used below, including the relevant installation details.

Participant numbers in social research

Numbers of households reduced in later stages of the social research (see Table 2). Two households withdrew from the Trial after pre-install interviews but before installation of the technology. One household did not have a post install or a year one interview because their installation was so late there was no time to pursue any other interviews. One household sold their house after their post install interview. Two further households completed the post install interview and not the final interview because their installations occurred too late to complete the final interview.

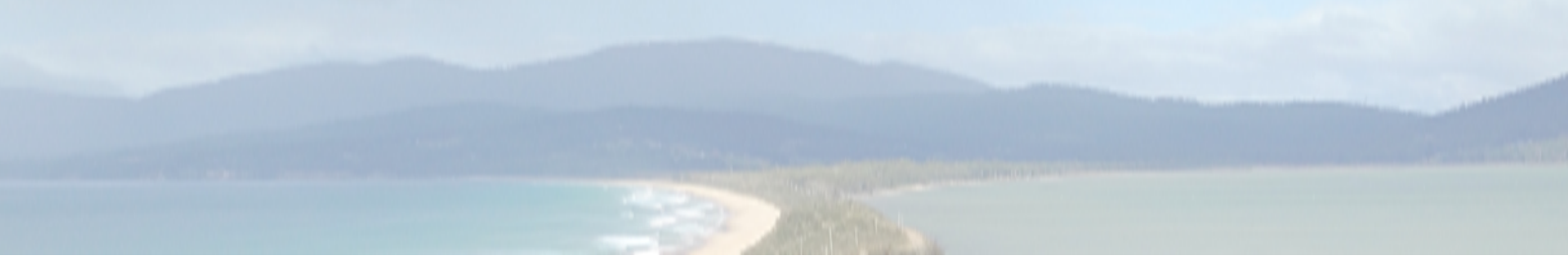


Table 2: Household participant numbers for the major stages of CONSORT social research

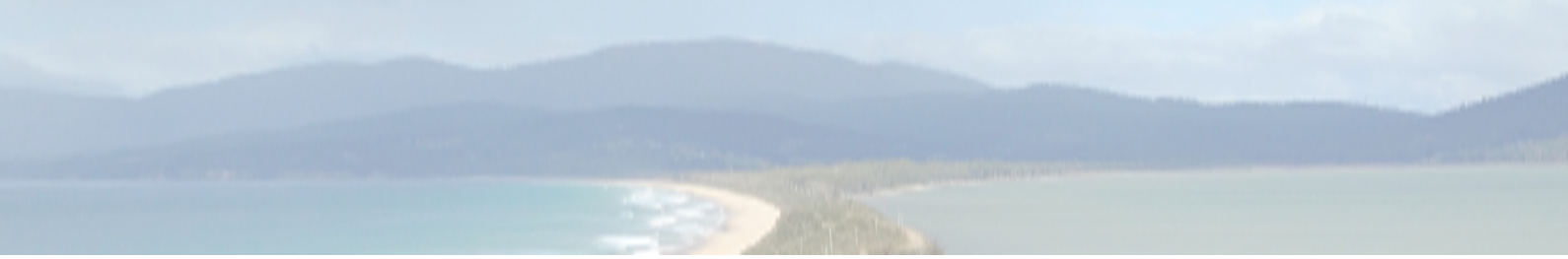
Household code	Pre-install interview	Post-install interview	Year One interview	House observations
TOTALS	36	33	30	33

Recruitment, information provision, and sampling

While the Social research team contributed to recruitment planning discussions, TasNetworks, CONSORT's industry partner, conducted recruitment. The social research team have sampled 100% of participants in the Trial (36 households at pre installation and 34 households at the end of the Trial). Open public information forums for potential participants were undertaken by TasNetworks on July 20th and 21st 2016. In these the Trial was introduced and explained. Householders who expressed interest were provided with the criteria for participation and the subsidies being provided. The information sheet for the project, which includes the social research information, was also handed out to potential participants at this stage. The information sheet explained that: all participants of the Trial take part in the social research; and participants could withdraw from the social science research if they withdrew from the study completely (as per contractual arrangements). This situation was unusual for a social science project and it meant participating householders were in a more constrained position than is typical (i.e. if they refuse to be interviewed then there is a significant penalty). Consequently all CONSORT households were notified that they would be able to withdraw social research data (if they were concerned) before being used in our analysis.

Householders were informed by TasNetworks of the subsidy in the initial application phase. The subsidy was large, and linked to the battery purchase. A part contribution was required by households ($2000 at a minimum). Households were able to pay extra for larger sized systems, specific features to be installed (such as back up circuits), and for any upgrades to systems that were needed to support the installation of the DER equipment. The average household contribution was $4,700 and the maximum contribution by a household was $26,600. Average contributions differed installer to installer.

Householders who wanted to take part in the Trial applied by the nominated due date for applications. Households volunteered to be involved according to their interest, ability to install



the technology in their homes, their self-assessed ability to pay the household contribution, and compliance with some pre-agreed criteria (e.g. spend majority of time on Bruny Island). Primary contacts in each house had to be over 18 years of age and full-time or part-time residents at Bruny Island. No specific sex or age range was targeted and no specific locations of the network were targeted.

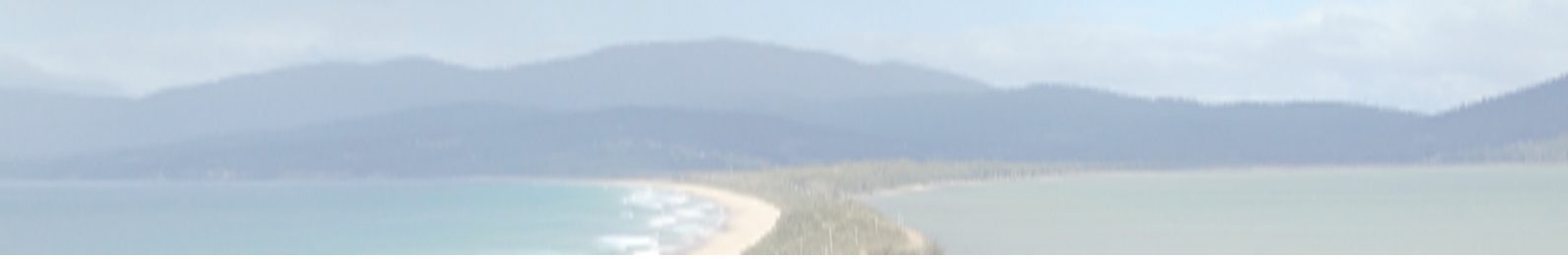
The CONSORT team were interested in permanent, rather than second home/shack residents and did have some interest in particular locations of the Bruny Island grid. However, as there was no way of knowing how interested householders would be in the Trial before applications were received, the team decided to put as few limitations on the applicants as possible.

There were 143 Expressions of Interest registered initially, which led to 118 applications being submitted. A probity advisor, overseeing the recruitment process for TasNetworks, randomly selected 35 households from the application group. With some dropouts, 29 households initially pursued installation quotes and submitted them to TasNetworks. A second round of three households were randomly selected from the remaining applications (that had not been selected previously) on 13 January 2017. A third round of participants were randomly selected from remaining applications in May 2017. Eight offers were sent out to householders in this third round and 4 of these households went ahead with installations and participation in the Trial.

Applicants who were selected for the Trial were provided with a list of approved specialist photovoltaic and battery technology installers they could choose from. Trial households were invited to another information evening held on Bruny Island 22 September 2016. At this forum, the CONSORT team provided further explanation to householders about the DER technology that was to be installed and further explained subsidies.

The Trial has no control group, but the study has gathered pre and post installation data from households. Control groups were not possible because the technology system being installed in households comprised innovative technologies, and there are no existing households with which to compare. Further, the householder behaviours/responses studied are to new technologies and to a new type of relationship with the electricity network. Consequently, a case-based and exploratory social research approach was used to explore the CONSORT technology, rather than a statistical, control based analysis.

Once householders chose an installer and signed their contracts, their installation of technology was booked in with an installer. TasNetworks provided household details to the social research team at this point, so bookings could be made for pre-installation interviews. UTAS researchers then contacted householders and (re)outlined our involvement with them. Social research information and consent forms were provided to households again at this point, where necessary.



Installations

In regards to install processes, participants were provided with a list of approved specialist photovoltaic and battery technology installers they could choose from. The installers had applied to TasNetworks to be involved, and went through a selection process. The installers chosen by householders provided a system design and a quote to households, as they would do for installation of photovoltaics. Households then decided whether to accept the quote, go ahead with an alternative installer or to drop out of the trial. TasNetworks informed the social research team when a household had committed to the installation, so that the social research team could then contact the household for pre-installation interviews.

Pre installation focus group

Social researchers held the pre-installation focus groups on the 22nd September 2016 on the same evening (after) a Bruny Battery Trial information evening. Special consent forms were handed out specifically for this focus group event, as it was possible that some participants of these focus groups may decide not to pursue an installation for the trial (and thus not be covered by the overall UTAS participation consent form).

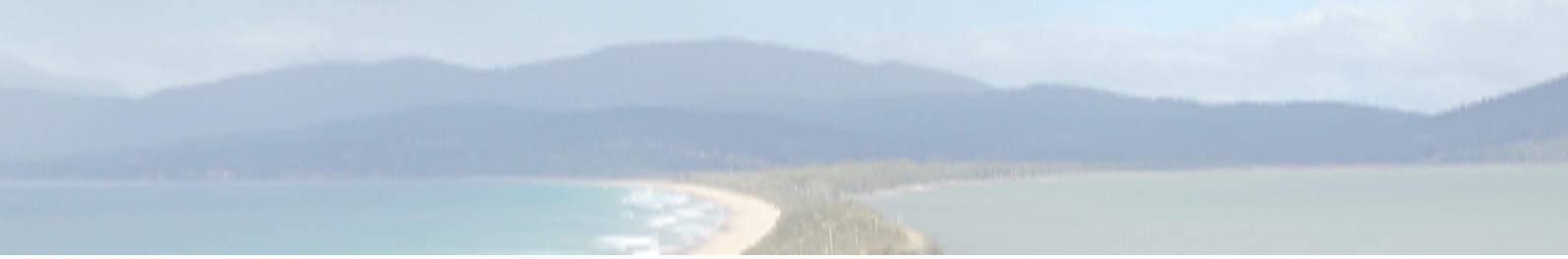
The focus groups were well attended with 17 participants in one group and 18 in the other. Topics covered in the pre-installation focus group were:

- The changing electricity generation landscape in Australia
- Electricity supply on Bruny Island for householders
- How householders think through energy use in the home
- Peak loads on Bruny Island
- Notions of prosumers
- Possible solutions to electricity supply issues, and
- Issues brought up by focus group participants.

The focus groups were approximately 1.25 hours long. Discussion on each topic was timed to ensure that each topic could be covered.

Pre-installation interviews

Pre-installation interviews with householders were conducted over the telephone and took around an hour to complete. Overall consent to be part of the social research and permission to record interviews were sought from households before beginning pre-installation interviews, as per our University of Tasmania Social Research Ethics Approval. Signatures were collected for the same consent form when researchers were on site in-person at post-installation interviews.



Interview times varied house to house as each household discussed subject matter differently and in a way they felt prioritised their own issues. Pre-installation interviews explored:

- Features of the participants' home that relate to electricity use;
- Participants' attitudes on electricity supply and electricity prices; and
- Participant's current use of energy/electricity feedback.

Online forum

An on-line forum/chat room was developed for household participants by TasNetworks in early 2017 in response to participants' calls for better access to information and each other. UTAS Ethics Approvals and informations sheets were updated at the time so that social research could observe the online conversations.

Post-installation (post-install) interviews

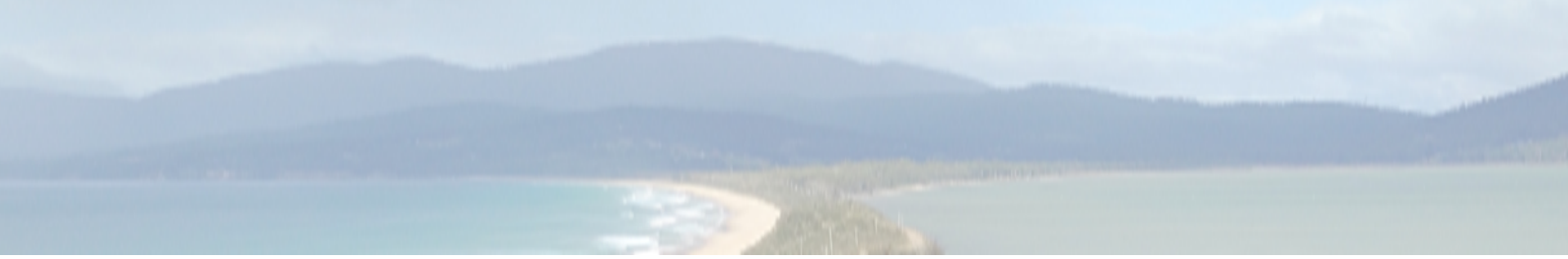
Once the technology was installed in homes, the social research team conducted post-install interviews to ask about installation processes and early experiences of (and responses to) the technology. Attempts were made to conduct these interviews about two weeks after installation, but this was often difficult due to technology install delays and logistics related to visiting for interviews.

Post-install interviews were face-to-face and conducted in participants' homes on Bruny Island (wherever possible). These interview were conducted November 2016 to July 2018, with the majority of post-installation interviews conducted by July 2017. The interviews were spread over a long time period due to delays to installations.

These interviews explored:

- The installation process;
- Participant's experiences so far in relation to the technology;
- Participant or householders' reactions to the Reposit controller device and the feedback information it provides; and
- Early and developing shifts in understanding, behaviour and attitudes that related to the CONSORT technology.

After completing the semi-structured interview, researchers asked householders to fill in a short questionnaire. Observations of physical features of houses were also conducted during the home



visit for the post install interview. Photos were taken onsite to assist in analysis and developing descriptions during reporting (from observations). If participants were uncomfortable with photos being taken, researchers did not take any. In the few cases where the researchers were not able to visit the home for this interview, they made sure they visited for the year one interview (later in the Trial).

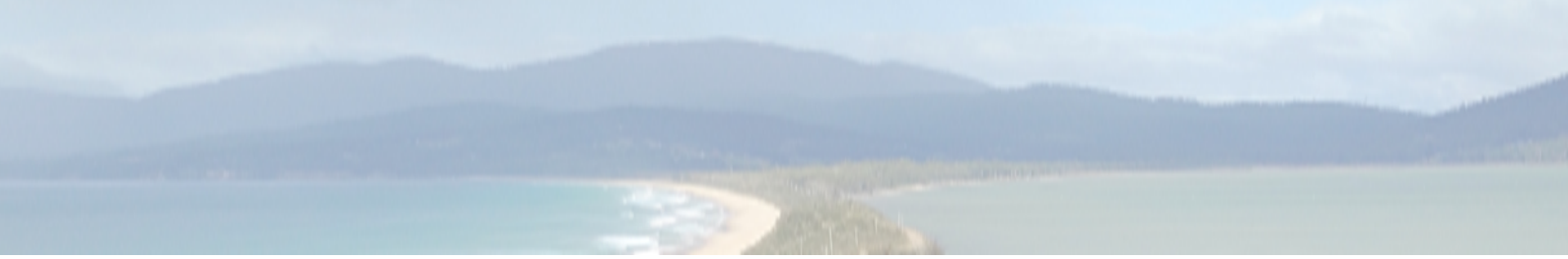
Face-to-face interviews at this stage in participant homes allowed for in-situ discussions about the technology set up, which provided more reliable and detailed data than if it had to be recalled later, or over the phone. Face-to-face interviews also allowed researchers to develop a better understanding of householders' and their household environments. The lengths of interviews/visits varied house to house as each household had different subject matter to discuss: the longest post-installation interview was around 2 hours (BT112) and the shortest around 25 minutes (BT116). Most of the interviews were approximately 1 hour long.

Energy Diaries

Energy Diaries were printed A3 pieces of paper that contained a table on each side - one for each week of July 2018 school holidays, which ran from 7th to the 21st July 2018. Diaries were sent out ahead of time to householders with a return (paid) envelope. The first week of the diary was during the 'energy reserve' payment types for the Trial and the second week of the diary was for the 'energy use' payment types (for descriptions of these energy payment types please see Rewards Structures report). After the energy diaries had been filled out by householders, they were either sent back to the social research team by post, or they were handed back to social researchers during year one interviews in August 2018. Diaries were filled out and returned by 28 households. Two household were not able to fill theirs out because they were away from home at the time.

Final ('year one') interviews

Final interviews were held in August and September 2018 to capture longer term experiences householders had of the technology and trading. At this stage, 2 post install interviews were also conducted with householders that had very late installations. Overall 30 year one semi-structured interviews were conducted, most were conducted face to face in homes. Due to difficulties organising mutually available times, some interviews were conducted over the phone, and one was conducted face to face, but off site at UTAS. These interviews took around an hour to complete - the longest going for over an hour and a half, and the shortest taking about half an hour. After completing interviews, researchers asked householders to fill in a short questionnaire.



Some photos were taken where needed to further support discussions on describe technology and related experiences.

This final interview explored:

- Experience of, and responses to, technology and feedback over time (solar, battery and Reposit controller)
- Shifts in understanding, behaviour and attitudes, and
- Pricing, rewards, tariffs and ideas of payback and value related to the installed system, from the householder/prosumer perspective, and
- Battery sharing with the network.

Final (post-install, year one) Focus group

The final focus group was held on Bruny Island on the 4th of February 2019 at the Bruny Island Bowls Club. The focus group ran from 5:30pm and went for 1.75 hours. Households were invited to the focus group after a random selection of householders was made. Households were invited via random selection to ensure that there were not too many people for one focus group. Ten participants attended (out of 12 RSVPs) saying they would attend. The focus group discussed:

- the financial value of systems based on information provided on values of systems,
- energy trading with the network
- support and information issues,
- the local Bruny context and its influence on the Trial.

Appendix C - Technology as installed: example images

Plate 2: Cupboard enclosing battery equipment (external)

Plate 3: Example of installation with no enclosure

Plate 4: Installation mounted on backboard, no enclosure, under cover

Plate 5: Installation example, external, no enclosure

Plate 6: Battery installed behind vegetation (under small eave)

Plate 7, 8 and 9: Examples of safety signs on the CONSORT technology. Note numerous safety signs were on each installation.