THE POWER OF COMMUNITY

THE JACKA COMMUNITY BATTERY PROJECT: AN ANALYSIS

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Cover image: Stylised map showing proposed habitats for the striped legless lizard in Gungahlin, ArchivesACT 91/1907

Illustrations: Caddie Brain

Acronyms

3Ai - 3A Institute
ACT - Australian Capital Territory
ANU - Australian National University
BSGIP - The Battery Storage and Grid Integration Program
CPS - Cyber-physical systems
DNSP - Distribution Network Service Provider
FCAS - Frequency Control Ancillary Services
kW - Kilowatts
ML - Machine learning
MW - Megawatts
NEM - National Energy Market
VSD - Value Sensitive Design
WA - Western Australia

Executive summary

Governments and energy companies are increasingly interested in a new form of community-scale energy storage, known as a community battery. It has the potential to solve some of the significant issues faced when trying to integrate greater amounts of renewable energy into the broader electricity network, while increasing access and reducing costs for a wider range of users. In a broader sense, systems like community batteries could help drive a fundamental paradigm shift around energy by establishing energy generation as a local and collective activity, while driving a broader global movement that could address some of the most complex challenges of our time – a necessary and urgent transition to a zero-emissions society.

The home of the first community battery on the east coast of Australia may be on traditional Ngunnawal country in the suburb of Jacka in Canberra's north. In designing a new phase of the suburb, called Jacka 2, the Australian Capital Territory (ACT) Government plans to connect solar panels on each house to a shared community battery that charges and discharges based on machine learning algorithms.

As a new type of cyber-physical system, there are a number of ways the community battery can be optimised – to make a profit, reduce the energy bills of participants, store the excess solar energy being generated locally or smooth out peaks in demands. It is difficult to realise all of these goals simultaneously due to trade-offs that exist between them, demonstrated by the initial modelling of four different scenarios of use based on different ownership structures. This presents the ACT Government with the challenging task of deciding how to optimise and for whose benefit.

Increasing energy equity is of growing importance to the ACT Government as part of its commitment to developing zero emissions suburbs and realising broader sustainability goals. But without adequate community involvement, the battery may be deployed inequitably and may be economically unviable. If some of the possible for-profit models are realised, community benefit and involvement may be entirely absent, making it simply a battery system, as opposed to a *community* battery system. Yet it is difficult to establish community values, priorities and preferences since the community at Jacka 2 is yet to exist. Therefore this research asks:

How can the community battery in Jacka 2 be scaled from concept to reality in a safe, responsible and sustainable way that prioritises the interests of the Jacka 2 community despite the absence of that community at the present time?

We apply a combination of six different research methods and consider potential emergent properties to offer the ACT Government six key recommendations about how to more comprehensively consider the needs and wants of the future Jacka 2 community inviting them into the development and design process. In doing so, the community battery has the potential to grow identity and a sense of ownership around this system contributing to a fundamental shift in the perception of energy generation as a local and collective activity.

Summary of recommendations

1. Engage, and engage now

The ACT Government needs to engage, and engage now, to adequately map localised community needs, preferences and requirements, build decision-making capacity regarding operational and optimisation models and grow buy-in for the project.

Informed by the following research methods: Leverage Points, semi-structured interviews, direct and indirect stakeholder *mapping*

2. Communicate how it works

The ACT Government should build community understanding and engagement by developing tools to communicate the intent of the community battery system, how it works and what impact it will have.

Informed by the following research methods: Leverage Points, semi-structured interviews, direct and indirect stakeholder mapping

3. Don't focus on models, focus on values

In thinking about the design of this battery, and when communicating it, we recommend that its designers think and talk primarily in terms of the values it embodies and promotes, rather than how the model works.

Informed by the following research methods: direct and indirect stakeholder mapping, Country Centred Design

4. All in: reconsider opt out

Reconsider the value of offering an opt-out mechanism for the community battery at Jacka 2.

Informed by the following research methods: semi-structured interviews

5. Appearance and placement matter

In selecting the location and appearance of the community battery, the ACT Government should avoid producing inequities and explore opportunities to validate and reinforce a sense of ownership and collective activity through the battery's physical presence.

Informed by the following research methods: observation, semi-structured interviews, Country Centered Design, speculative fiction

6. Interfaces matter

Implement an interface as part of the community battery system for optional usage by participating households.

Informed by the following research methods: Leverage Points, semi-structured interviews, speculative fiction

Full recommendations are outlined here.

The complexity and adaptability of cyber-physical systems makes communication and decision making particularly challenging. These recommendations are offered as a way of viewing these complex decisions through a community lens while highlighting opportunities for far deeper engagement with the system. The outcome at Jacka 2 has the potential to offer a unique test case for not only the details of the technical deployment but also of a community engagement model that ensures the safety, sustainability and responsible deployment of community batteries elsewhere. In doing so, it would assist in confronting one of the most complex challenges of our time - the necessary and urgent transition to a zero-emissions society.

Introduction

A community battery is a mid-sized energy storage solution that stores excess energy generated from multiple users' solar powers during the day for later use. In capacity, a community battery is smaller than large grid-scale storage solutions, but between ten and one hundred times larger than the storage of individual domestic solar batteries. Its usage can be optimised in different ways depending on the desired outcomes of the system. For example, it can be used to maximise profit for the operator or increase savings for the consumer. It can also be optimised for maximum possible storage of solar energy or for smoothing peak electricity loads for the broader grid.

Once deployed, a community battery may simply look like a white box; and as a system that enables us to store and share excess renewable energy, its rationale may seem clear. But in development, the community battery is more of a 'black box'[1], with many unknowns and complex decisions to be made about how it will work.

The Australian Capital Territory (ACT) Government is currently designing a new phase of the suburb of Jacka (Jacka 2) which is located on traditional Ngunnawal country in Gungahlin (Canberra's north). The design includes a plan for 5kW solar systems on each house connected to a pilot community battery (or batteries).

The stakes for success are high. The ACT Government's commitment to renewable energy and sustainability is underpinning Jacka 2's community battery plan. If successful, Jacka 2 could help prove the viability of community batteries as one of a broader set of tools available to governments in responding to the significant challenges of climate change and the transition to a net-zero emissions economy. It could help build capacity and stabilise the electricity grid. The Jacka 2 project could also serve as a model for larger scale implementation of community batteries across the ACT and the eastern seaboard.

In order to succeed, community acceptance and trust will be critical. Securing that buy-in is more likely if the community is engaged and can see the benefits the battery will bring. It is less likely if those benefits are perceived to be unequal or unfair. A consequence of poor community engagement could be people opting out of the system, increasing costs for everyone else and potential unviability of the whole system. If some of the possible for-profit models are realised, community involvement and benefit may be entirely absent, making it simply a battery system, as opposed to a *community* battery system.

So how does the ACT Government maximise the chance of project success in the absence of a community for consultation in Jacka 2? In other words:

How can the community battery in Jacka 2 be scaled from concept to reality in a safe, responsible and sustainable way that prioritises the interests of the Jacka 2 community despite the absence of that community at the present time?

This question is the subject of our analysis. To answer it, we employed six research methods (Appendix 1). We also thought carefully about a particular feature of complex systems - namely, the possible emergence of new system properties resulting in major unintended consequences. We then mapped potential emergent properties (Appendix 8) and used our analysis to address these where relevant.

The result of this work is a set of six recommendations and a systems map designed to help the ACT Government think about how to keep the community in the community battery. Our goal is that these

[1] Systems theorist Mario Bunge describes a black box system as one where the constitution and structure of the box are altogether irrelevant compared to what it actually does: "only the behavior of the system will be accounted for" (1963, pp. 346).

recommendations will contribute to the transformation of the community battery from its current black box state into a white box, or something far more vivid entirely.

Context

The benefits of community batteries

With a capacity of 100kW to 5MW, community batteries are a form of community-scale energy storage. Physically about the size of a shipping container, a community battery is designed to be accessed by multiple users, typically houses with their own individual solar PV systems, enabling them to store excess energy generated by the households' solar panels during the day for later use - effectively a demand management service (Shaw 2020, p.8).

As Australia's energy generation transitions away from fossil fuels, there will be an increasing demand for electricity and renewable electricity in particular (Bruckner et al. 2014, p. 7). Community battery systems have the potential to help in meeting that demand, providing a flexible range of benefits depending on the optimisation of machine learning algorithms. These include:

- reduced hardware and start-up costs for low income households wanting to access renewables (access to a community battery system is anticipated to be significantly cheaper than an individual household storage system (KPMG 2020, p. 16));
- reduced energy bills for participants by selling energy back to the network at peak times;
- peak shaving, the lowering and smoothing of peak loads, which is a particular issue for solar generation;
- improved self-consumption of rooftop solar;
- increased hosting capacity across the network (Shaw et al. 2019, pp. 8-9).

These benefits cannot all be maximised at the same time. Significant trade-offs between them occur as a result of the algorithm optimisation.

The only operational community batteries in Australia are currently in Western Australia, where the network operators are government-owned (Vorrath 2020). Matthew Keighley, a Project Officer from the ACT Government's Suburban Land Agency (see Key Stakeholders) attributes the absence of community batteries on the east coast of Australia to limited industry knowledge of the technology. "They're still going for bigger and better, or smaller and household-scale," he said. "We see this [community batteries] as a nice in-between". Implementation in eastern Australia is also limited by the privatised structure of the National Energy Market (NEM) that connects Queensland, New South Wales and the ACT, Victoria, South Australia and Tasmania. Current NEM regulations prevent networks from buying and selling energy directly to customers (Rae 2020). A third-party entity such as a 'retailer' may be required to own the battery and to enter into separate contractual arrangements to purchase excess energy from the community battery and on-sell that to consumers. That said, there are significant barriers for some parties in owning and operating a battery. While large-scale energy generators such as power plants or energy-producing communities such as those wanting to pool their excess solar energy, can technically own a battery, they can not sell the energy unless they are a registered market participant (Chirgwin 2020).

The Jacka community battery

The ACT Government is planning to invest in a community battery system for Jacka 2, a new stage of development for the small suburb of Jacka, which is on the northern outskirts of Canberra adjacent to the New

South Wales border (see Appendix 2 for more information).

The system could consist of either a single battery in a central site within the Jacka 2 community or several smaller batteries across multiple locations in the suburb. Either way, the system would service between 600-700 new houses. During an interview, Keighley described the ACT Government's intent in investing in this system for Jacka 2 as an opportunity to realise a strategic "mix of priorities". These can be categorised into four main aims:

- Increasing energy equality in Canberra by allowing a wider range of residents to access low-maintenance and affordable renewable energy through the community battery.
- Moving towards an all electric zero-emission suburb by growing the hosting capacity of solar energy across the network.
- Developing a socio-technical solution that resolves network issues whilst providing benefits to the community.
- Realising the ACT Government's goal of leading innovation by providing a test-case for this technology that may potentially lead to the eventual scaling of the system elsewhere across its jurisdiction.

Operational models

The question of who owns and operates the battery is one of the most fundamental and significant decisions remaining for the Jacka community battery project. To gather information to help inform this decision, the ACT Government contracted the Battery Storage and Grid Integration Program (BSGIP) at the Australian National University (ANU) to model and test the financial and energy flows of four possible ownership models:

- **Third party owned community battery:** A local council, community group or not-for-profit entity owns and operates the battery, which is optimised to maximise profits for participants. Potential savings generated by the battery are redistributed or returned to the community through reduced bills. In this model, participants are charged double the energy transport cost for the charging and discharging of the battery, which means without a discounted local transport cost, the battery is hardly utilised and hence unviable. However, Distribution Network Service Providers (DNSP) can allow a discount on a case-by-case basis.
- **Third party owned, for profit model:** An aggregator or company owns/operates the battery to maximise profit. In this case, the BSGIP found the battery was underutilised, because maximising profit would entail charging and discharging the battery in response to price spikes in the market rather than effectively utilising the locally generated solar energy. Simulations showed that the third party owned community battery can make almost as much money as the for-profit battery for its owner (BSGIP 2020, p. 22).
- Two additional ownership models were tested by the BSGIP, where the battery would be owned by the DNSP. We have not included further details of these models, as the DNSP for the Jacka project, Evoenergy, has already indicated that it does not want to own the battery.

The choice of model is important because it is one of the most significant factors affecting the relationship between the system and the community, the way it is operated and for what purpose. All models are possible, they simply present different value propositions, and regulatory barriers.

The choice of ownership model could have implications well beyond the community of Jacka. As one of the first community batteries on the east coast of Australia. (Mannheim 2020), the way this fundamental question is resolved may create a precedent for implementation across the NEM, reinforcing the need to consider ownership models carefully and with consideration of broader scaling implementations.

Emergent properties

Complex systems like the community battery contain many components and layers of subsystems with multiple, non-linear interconnections that are often difficult to recognise, manage and predict (Marashi & Davis 2006, p. 1536). This can result in 'emergent properties' that arise as a result of the interaction of components in the system and cannot be explained by looking at the properties of the individual components in isolation (Leveson 2011, p.64). Emergent properties are often described as 'unintended consequences' and are a particular feature of complex systems because it is difficult to anticipate all the ways that components in a complex system will interact and what may result.

Identifying scale and levels of change and the associated emergent properties at the design stage can help developers plan for unintended consequences, even where the specific consequences themselves cannot all be identified.

We mapped potential emergent properties of the community battery (Appendix 8) and used these to inform our analysis. In framing our recommendations, we focussed on one potential emergent property in particular, the possibility of an emergent strong community spirit or significant conflict.

Key stakeholders

Systems are designed by people. The culture and values of developers are tightly woven into the design and implementation of systems, such as cyber-physical systems (CPS) (Friedman & Hendry 2019, p. 2). Therefore, any attempt to understand a system must consider the social content and cultural values of those at the wheel.

In acknowledgment of this, we conducted a full stakeholder analysis (Appendix 3).

Drawing on the stakeholder analysis, we identified the following key stakeholders, whose views significantly informed this report:

- Matthew Keighley, Project Officer, Sustainability and Land Release, Suburban Land Agency, ACT Government
- Dr Hedda Ransan-Cooper, Research Fellow, Social Science Program, Battery Storage and Grid Integration Program, College of Engineering & Computer Science, The Australian National University
- Dr Marnie Shaw, Research Fellow, Research School of Electrical, Energy and Materials Engineering, College of Engineering & Computer Science, The Australian National University and Research Lead, Battery Storage and Grid Integration Program, College of Engineering & Computer Science, The Australian National University
- Rachel Aalders, 3A Institute Masters student and Gungahlin resident

We collected the views of these stakeholders via a series of semi-structured interviews conducted between August and November 2020 (the interview schedule is included in Appendix 4).

Definitions

There was significant variation in the way key terms were defined across our major stakeholders (Appendix 5). Acknowledging that definitions have the power to shape the problem being addressed, we have integrated these perspectives into our definitions below.

Cyber-physical system

This analysis is grounded in the research interests of the 3A Institute at ANU, which is developing a new branch of engineering focused on taking CPS to scale safely, responsibly and sustainably. Geisberger and Manfred offer one of the most detailed definitions of CPS in current use. According to them, a CPS is an embedded system that uses sensors and actuators to affect physical processes by interpreting and storing data to mediate interactions with the physical and digital worlds (2015, pp. 25-26)[2]. If embedded within the broader energy network, the community battery meets this definition, with both sensors and actuators managing the storage and flow of energy in and out of the battery based on an algorithm that can be optimised to meet the different priorities of its developer and/or owner (BSGIP 2020, p. 5).

Community

A community can refer to "a group of people living in the same place or having a particular characteristic in common" (Oxford University Press 2020).

In terms of the definition of community as it pertains to the community battery at Jacka 2, we are looking at the community as the group of people who are living or will live in Jacka 2 and will be impacted by the community battery system. This definition includes both people who will participate in the battery and those who may choose not to participate.

[2] The definition also requires that the human-system interface be multimodal. The community battery interface has yet to be designed, so it is not clear whether it will meet this criterion. For the purposes of this analysis, we will assume that the interface will be multi-modal and that the community battery is therefore a CPS. This assumption is reasonable given the trend towards multiple modes of access via apps, browsers and other platforms incorporating touch, voice and type recognition.

While some stakeholders view the community as a collection of anonymous users whose excess electricity can be pooled into a battery, we view the community as members of a group sharing a sense of place, common interests and above all, an essential service, energy.

Scale

Scale is the ability for a system to function as intended when it changes size or volume. It often implies increase or expansion (Rouse 2020).

The scale being investigated by this report is the realisation of the Jacka 2 community battery project from concept to reality. Specific factors related to this process of scaling include:

- battery size and quantity: the scale of the system's storage capacity
- geographic coverage: the territory served by the location of the community battery system i.e. the suburb of Jacka 2
- community coverage: the number of dwellings accessing the community battery i.e. approximately 600-700 houses
- localised system implementation: how control systems, network integration and governance are established i.e. the selected operational model
- network infrastructure: the impact on the broader grid i.e. how the batteries at Jacka 2 affect broader grid performance and any impact to energy prices in the ACT

Sustainable

This report considers the term sustainable from two dimensions:

- Environmental sustainability, which we define as considering the impact the system and its

components have on the environment now and in the future.
- Economic sustainability, which we define as the economic viability of the project, i.e. the financial capability of the system to self-sustain.

Our definition of environmental sustainability draws on the field of sustainable development under which sustainable development is viewed as an ability to "meet the needs of the present without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development 1987). All stakeholders recognise that realising the project sustainably will also require consideration of the full life cycle of the selected battery, including decommissioning and disposal.

Our definition of economic sustainability draws on our stakeholder interviews that indicated a view that unless the project is economically viable in the long-term, it may fail and therefore be unsustainable.

Responsible

Acknowledging that the word responsible is a broad and contested term, this research considers responsible from two relevant angles:

- Equity: Creating a system that can maximise access to renewable energy to the larger society.
- Engagement: Ensuring a representative sample group of stakeholders are part of the development process.

In using these definitions, we are not using 'responsible' to refer to *responsibility* (which is linked to accountability, particularly for adverse outcomes). Instead, we are drawing on concepts from socially responsible engineering, which focuses on the implementation of engineering as a responsible practice, one that has the ability to shape the direction of technology development "to maximize the service to the larger society" (Doorn 2012). Responsible development also requires "management of human relationships with the natural environment so that economic, social and cultural needs are met and ecological processes and diversity are maintained" (Law Insider 2020).

In other words, we are choosing to focus on the connection between how a responsible design can result in responsible outcomes based upon the engagement of those who will be impacted most by the decisions taken.

Safety

Community batteries are not implemented without risk. The notion of safety is a broad concept that is generally understood to mean "secure from threat of danger, harm or loss" (MacMillan Dictionary 2020).

In terms of the Jacka community project, its key stakeholders all viewed physical safety as an integral factor. They also mentioned a range of other forms of safety, which fall under the following five categories:

- Physical safety: preventing harm to users by minimising the risk of explosions, fires, accidents, and air and noise pollution.
- Structural safety: preventing damage or impacts to broader infrastructure networks or ensuring adequate system security so it cannot be hacked.
- Economic safety: ensuring the community battery meets financial goals and does not cause financial stress or burden for users.
- Privacy: considering access or restrictions to personal or consumption data flow.
- Cultural safety: relevant protocols are met to ensure appropriateness and ongoing usage within diverse communities.

Therefore throughout the analysis, we have specified which form of safety is being considered.

While none of the interviewed stakeholders directly identified cultural safety, we have included it in acknowledgement that technology is not designed within its social and cultural context, it is designed by it (Dourish and Bell, 2009, p. 778).

All six safety outcomes may be difficult to achieve simultaneously due to trade-offs that can exist between them. They are offered as a structure to consider the overall balance and opportunity costs of selecting different optimisation models of the community battery. To ensure some of these safety outcomes are met, additional regulatory frameworks and compliance oversight may also be required.

Recommendations

1. Engage and engage now

Whether or not the system is viewed by the community in Jacka 2 as a "community battery", will depend on if and how the community is engaged in the design process.

While broader consultation is taking place as part of the development application process for Jacka 2, a community engagement plan for the community battery specifically is yet to be established. Keighley says that it intends to test the feasibility of the models before seeking to engage the community.

The fact that Jacka 2 does not yet exist certainly presents a challenge for beginning community engagement, but should not mean that the community is excluded from the design and development process, however embryonic. Failure to do so could result in poor understanding of the goals behind implementing the battery and reluctance or refusal by the community to use it. Ultimately, this could produce tension within the Jacka community, as well as lead to a failure of the ACT Government's goals in implementing the project in the first place.

The ACT Government needs to engage, and engage now, to adequately map localised community needs, preferences and requirements, build decision-making capacity regarding operational and optimisation models and grow buy-in for the project.

Community engagement could take place via:

- formation of a reference group or steering committee
- engagement of an existing local residents' group from the Gungahlin area
- formation of a representative council of residents from across Canberra that may represent Jacka's future demographics
- a survey or consultation process with community members from across Canberra
- additional research into community views on the community battery within the context of Jacka specifically.

This recommendation will re-centre the community in the project by:

- actually involving them in its design
- giving the community power through decision making (transforming decision making from a top-down to a bottom-up structure)
- ensuring a culturally, socially and economically appropriate operational model
- growing advocacy for the battery and generating interest in it ahead of land sales
- growing trust and transparency
- reducing the risk of adverse outcomes by including a wider range of perspectives/views.

Any community engagement process should seek a diversity of views that are actually used to inform the design and development process. Science Fiction Prototyping (Appendix 1) could also offer a fun and inclusive process to link the developers of this new technology to future users and unpack potential implications within a broader social and cultural context.

We acknowledge that there are risks to this approach. Community engagement prior to adequate testing of models may create the possibility of consulting on unviable models. As Keighley said in an interview, "If we go out now, and we haven't even decided what the business or ownership model is going to be, are we promising too much? What is it we're offering?". Even so, early engagement to deepen understanding of the community's values and opinions could actually inform model selection or indicate preferences that apply across the models. We judge that the risks of not engaging early outweigh the risks in doing so.

The methods of investigation that informed this recommendation: Leverage Points, semi-structured interviews, direct and indirect stakeholder mapping

Analysis of the community battery system using Meadows' Leverage Points (Appendix 1), in combination with semi-structured stakeholder interviews and our stakeholder mapping process (Appendix 3), enabled us to identify an absence of 'information flows' between the developers of the battery project and the community (where information flows refer to the structure of who does and does not have information (see Appendix 6). This key deficit presents a major opportunity for intervention in the system to produce better results for the community.

It is not uncommon for community engagement to be limited throughout technological development processes. As Ransan-Cooper described, new energy technologies solutions tend to be developed upstream without involvement of those who will be affected by it. This is how the Jacka 2 project is currently being approached as Keighley demonstrates. "We want it [the community battery] to be there when the first residents move in, so they know what they're getting into. And we want to make sure that even before that stage, we've got an ownership and governance structure so that we can market that to the community." Rather than reflecting a lack of desire to engage the community, the idea of presenting the community battery as a fait accompli could also reflect the ACT Government's determination to deliver an efficient, timely, innovative project that will present valuable lessons for wider deployment.

Yet research shows that technology that prescribes usage and predicts community behaviour without consultation carries a higher level of risk of failure (Thomas 2006, p. 1). By formalising a community engagement process with adequate representation from a range of stakeholders (as identified through the direct and indirect stakeholder mapping process in Appendix 3), the community battery will *enable* usage rather than *prescribe* it.

This recommendation will help the system go to scale safely, responsibly and sustainably in the following ways:

- Community engagement is a necessary condition of responsible scaling as per our definition of responsible.
- Putting the community at the centre of the project through adequate engagement is a feature of responsible engineering practices which reduce the chance of harm to the community, or more widely.
- Community input ensures economic and cultural safety.
- Engaging the community in the project design will minimise the likelihood of mass opt-outs

thus helping to assure economic sustainability (see Recommendation 4 for further detail on the possibility of opt-outs).

2. Communicate how it works

Effective communication tools could make or break community consultation and/or involvement in the development of the community battery. Implementing Recommendation 1 well requires a suite of clear communication tools.

The ACT Government should build community understanding and engagement by developing tools to communicate the intent of the community battery system, how it works and what impact it will have.

Semi-structured interviews revealed the often impenetrable amount of technical terminology and jargon in use across the energy sector. This acts as a significant barrier to community involvement. Interviews further revealed a lack of effective and clear communications tools to inform and build support in the community. In particular, there is no current systems map of the community battery system that could demonstrate the placement of the battery, interaction between components or their integration into the broader grid.

Furthermore, communication tools could be used to help explain how the battery might look and where it will be located, thus addressing some of the challenges we raise in Recommendation 5.

This recommendation will re-centre the community in the project by:

- making the project accessible to a wider range of stakeholders; demonstrating and demystifying the relationships between components
- facilitating the development of a common language through which to discuss the community battery and prevent misunderstandings
- promoting community contribution to the design and function of the battery, and increasing buy-in for the project more broadly.

In implementing this recommendation, it is important to recognise that not all community members will want access to the same kinds of information. As Ransan-Cooper outlined during an interview, some will not want or require a technical understanding of the system. That said, simply knowing that such information exists and is accessible builds transparency and trust in the system.

The methods of investigation that led to this recommendation: Leverage Points, semi-structured interviews, direct and indirect stakeholder mapping

As previously outlined, undertaking a Leverage Points analysis (Appendix 6) identified the absence of 'information flows' between the battery project and the community. The development of communication tools is a core intervention that could improve information flows within the community and between key stakeholders, serving as a way of articulating and coordinating different perspectives and rationales of key actors.

As an initial contribution to such a suite of tools, we developed a systems map of the community battery system (Appendix 7). It shows feedback loops, interdependencies and the internal dynamics of the system in a simple and narrative-driven way that incorporates no technical jargon. We acknowledge that some of the battery's workings are dependent on the operational model selected. Hence, in its current form, the map focuses on the bigger picture, on fixed elements as opposed to the detail of the regulatory framework or machine learning optimisation required for each model.

During semi-structured interviews, we drew on the views of our key stakeholders to iterate the systems map, ensuring the development of a representative model.[3] In doing so, we realised that in addition to the benefits the map could bring in enhancing explainability of the system, it could also act as a boundary object[4] for the stakeholders we consulted. We came to this conclusion through watching how the discussions generated by the systems map exposed differences in the underlying assumptions and values of our key stakeholders. Thus, the systems map, collectively developed, brought together the imaginaries, visions and mental roadmaps of its developers and went some way in exposing and unifying the many ways a community battery system can be used and understood by a diverse range of stakeholders.

This recommendation will help the system go to scale safely, responsibly and sustainably in the following ways:

- Facilitating community engagement is a key criteria for responsible implementation of the system according to our definition of responsible. Providing tools to communicate clearly with the community is an essential part of realising this recommendation.
- As a community engagement tool, the map promotes cultural safety and facilitates a responsible design process which may anticipate or reveal key misunderstandings between stakeholders and/or the community.
- As a starting point for visual representations of increasing complexity and technical sophistication, the map may help ensure physical safety of the system by ensuring that key stakeholders are on the same page regarding the operation and integration of key components during the development stage.
- By clearly representing the community as a collective of people managing a shared resource, the map can help to define the community to itself, promoting the sustainability of the system by helping users to value the battery as a joint asset.

3. Don't focus on models, focus on values

Technologies are never value neutral. Electricity networks are especially rich embodiments of value systems that promote the interests of some stakeholders over others. In developing and applying technology, community interests are most likely to be served when people can express what is important to them from the outset, rather than being forced to choose between models that have already been chosen for them upstream. Similarly, when certain choices are unavoidable, communities need to know what values each option embodies, so they can decide if they share those values.

In thinking about the design of this battery, and when communicating it, we recommend that its designers think and talk primarily in terms of the values it embodies and promotes rather than how the model works.

An obvious example of this is in the way the battery's machine learning algorithm is designed: does it optimise for maximum power production and supply across the wider grid beyond Jacka 2, thereby reducing emissions for the largest number of people? Or does it

[3] We also cross-referenced the map with our direct and indirect stakeholder map to ensure that key stakeholders represented in the systems map were adequately represented and not overlooked.

[4] Boundary objects are objects "which have "different meanings in different social worlds but [whose] structure is common enough to more than one world to make them recognisable, a means of translation" (Star and Griesemer 1989, p. 393).

work to maximise profit on the power it generates and sells, thereby benefiting the community of generators financially? Clearly the values of the first option prioritise decarbonisation, while still hopefully providing cheap power, while the second option reverses that priority.

This recommendation has two imperatives:

1. Seek to know the values of the community
2. Examine and express any model in terms of the values with which it is best aligned

The first is made more difficult by the lack of an existing community in Jacka 2. However, as suggested in Recommendation 1, there are ways of addressing this challenge. Meanwhile, despite the understandable reluctance to project precise values onto the future community, we argue that some level of assumption, ranging from statements of the obvious to the more contentious, could be made at this stage, in order to keep the community at the centre of the project. We hold that it is fair to assume that community members would want to save money on electricity; further we suggest that it is fair to assume that the community would value the reduction in emissions the battery facilitates, both at a personal and community level. These assumptions are supported by research of Australian residents showing they want national and local action on climate change and are willing to make personal changes in line with those values (Ransan-Cooper 2020, p.2.).

On the second, Ransan-Cooper's report *'Stakeholder views on the potential role of community scale storage in Australia'* demonstrated that different groups (e.g. householders, retailers, etc.) recognise that each model represents a particular set of values and that model selection is thus inherently political. The report also acknowledged that trade-offs that may favour one set of values over another will be required (2020, p. 1).

Engaging with the community using language that clearly demonstrates which interests and values are being prioritised within each model would give the community the best chance of making informed decisions about the system.

This recommendation will re-centre the community in the project by:

- identifying and prioritising community values
- increasing the likelihood that the final battery design is aligned with these values
- helping focus design on what the battery *should do* for this community rather than how a battery *could* work
- encouraging the community to interrogate the technology and feeling empowered to critique it increasing buy-in and sense of ownership.

The methods of investigation that led to this recommendation: direct and indirect stakeholder mapping and Country Centred Design.

The stakeholder mapping process (Appendix 3) helped us to consider different underlying values and compare them with the larger system goal. It raised questions about whose values might be considered more important in selecting the model and while designing the system. Freedom of choice, individual rights and control, healthy competition, profit, social good, and environmental sustainability are some of the values prioritised by different stakeholders within the system.

The importance of ensuring culture and values are embodied throughout project design and development was also reinforced by participation in a Country Centred Design workshop with Angie Abdilla from Old Ways, New.

This recommendation will help the system go to scale safely, responsibly and sustainably in the following ways:

- An alignment of the developers values with those of the community will encourage community participation, and promote economic sustainability and cultural safety.
- Successfully embedding community values in a system is a key element of responsible engineering, which is more likely to create sustainable systems with potential for longevity.

4. All in: reconsider opt-out

The battery has potential to shift perceptions of energy away from an individually assessed utility to a collective, shared resource.

Based on the operational model selected, the ACT Government may plan to provide an option for Jacka 2 residents to 'opt-out' of participation in the community battery. This could include choosing not to participate in the scheme when moving into the suburb or opting-out after a period of participation in the scheme.

On one hand, offering an opt-out would make the owner of the battery accountable to the community. If the owner fails to adequately prioritise community interests, users or potential users of the system could simply elect to opt-out. An opt-out would also allow community members who feel their values are not aligned with the model to elect not to participate.

That said, providing an opt-out option assumes that community members are able to assess the system and decide whether there are other options better tailored to their particular interests. According to Ransan-Cooper, this assumption is an extension of existing deep-rooted problems that plague the energy sector in Australia. During an interview, she highlighted that energy sector systems are built in a way that places the onus on the consumer to research whether a system serves their interests and whether there are better options available. However, consumers often just want to know that the system is fair and that they can "trust that it's fair". Thus, while it's important to inform and involve consumers in key decisions around setting up and operating the system, the system should not be built around requiring the consumer to constantly monitor it.

In addition, a significant disadvantage of offering an opt-out mechanism is the potential for the system to become economically unsustainable. If a certain threshold of non-participation is reached, the concept of a collective asset and shared storage may have no value. During an interview, Rachel Aalders, a current resident of Gungahlin highlighted the impact of individual behaviour on the project as a whole, "if everyone's going to remove themselves, then does it become a cost to me to stay in the battery? Whereas if everyone stays in the battery, it's still probably better than buying your own? I think part of the appeal of something like a community battery is the idea of social good".

Reconsider the value of offering an opt-out mechanism for the community battery at Jacka 2.

This recommendation will re-centre the community in the project by:

- creating a stronger sense of community through the knowledge that all community members are connected through participation in the community battery
- removing the burden of continual monitoring of the system, allowing them to make a decision about whether participation in a community battery is aligned with values before they purchase a house in Jacka 2
- ensuring that all community members share in the benefits of the community battery and that none are excluded
- creating long-term relationships and a sense of ownership between the community and the

battery, rather than individuals viewing it as a short-term, financially convenient option.

The methods of investigation that led to this recommendation: Semi-structured interviews

Conflicting views expressed during our semi-structured interviews highlighted the issues that may arise if community members are provided an opt-out option. To the ACT Government, providing an option to opt out is considered part of consumer rights. “It has to be. We’re legally bound by having freedom of choice as consumers. You don’t want to be locked into a tariff scheme that may not be really reducing your energy bills as much as you thought or as much as other companies can.”. However, during an interview, conflicting views were expressed by Aalders. "You start to lose that collective benefit if everyone pulls out. So I would think as part of the construction, they would have to incentivise people in some way to remain in the system.” The benefits of collective ownership and of investing in the future with other people are called into question when one can opt-out. The risks of an opt out raise questions about equity, inclusion and the viability of the project, and also increase the financial risk for those individuals who remain in the scheme. Members who can afford to purchase individual storage, which is reducing in cost year on year (Stevens 2019), may prefer to opt-out and enjoy significant reduction in bills. On the other hand, members who cannot afford to purchase individual storage such as some renters, will be at risk of having higher bills than previously anticipated. While the intent of the government is to provide freedom of choice, the consequences of that freedom may be detrimental to the concept of shared storage, the community and to energy being viewed as a collective resource.

This recommendation will help the system go to scale safely, responsibly and sustainably in the following ways:

- By facilitating economic sustainability, which in turn facilitates environmental sustainability (failure of the project due to poor economic sustainably will lead to failure of the environmental sustainability goals).
- Ensuring certainty for residents when they buy-in to the community by removing the chance that their participation in the scheme may be diminished by others opting out.

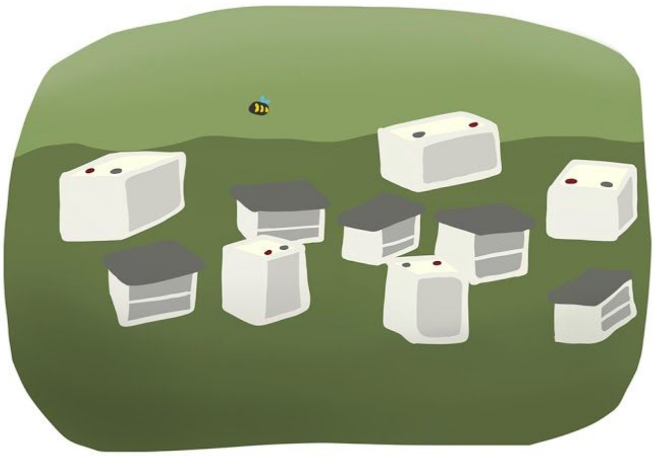
5. Appearance and placement matter

The appearance and placement of the battery could have a significant impact on how it is perceived by the community and whether it is accepted or causes conflict.

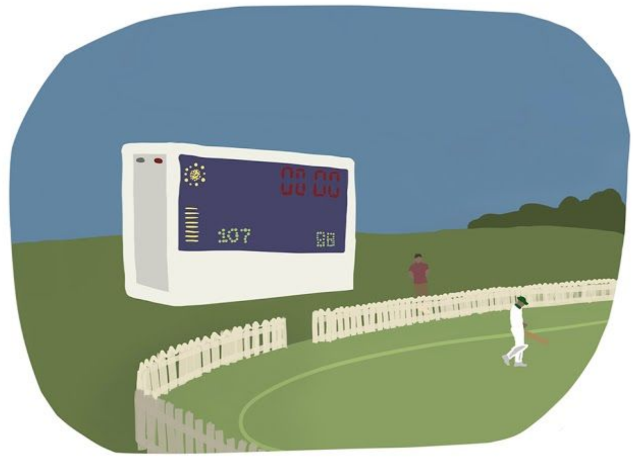
Early research indicates that residents have low expectations for how the battery will look. If anything, they anticipate it could be poorly integrated into the landscape, even unattractive. When asked to describe what she envisaged, Aalders pictured “a huge battery stuck in the middle of town somewhere, a humongous box that would have a ribbon cutting ceremony as its launch would be a political event… then teenagers would come and tag it and birds would poo over it.”

Even without the presence of undiscerning birds, the battery will be an obvious mark on the landscape. Typically, they are the size of a shipping container (Shaw 2020 p.8) and can reflect proprietary branding (for example, Tesla has built its brand around batteries that look like smooth, shiny white boxes). The batteries produce noise from the cooling fans. And no matter how the battery looks to begin with, if ongoing maintenance is not considered, the external-facing components could age poorly. In other words, the battery could become a blot on the landscape and a source of community conflict as a result.

With respect to the placement of the battery, the ACT Government is still deciding whether to use a single



Prototype 1: A distributed community battery system shown dispersed within a bee apiary - a kind of natural security system.



Prototype 2: The community battery could be located at the Jacka 2 sports grounds, powering a digital scoreboard.

battery in one location or several batteries dotted around Jacka 2. The outcome of this decision will be determined based on grid integration, physical safety and noise constraints. Proposed locations have been earmarked in each case, typically in residential areas and close to houses (a matter of metres away in some cases).

Placement of the batteries close to residential areas raises some issues of equity. How will the standard of living of residents in close proximity to the battery be affected (due to the physical presence of the battery and any noise it produces for example?). Could proximity to the battery depress house prices? What risks to the physical safety of residents does proximity to the battery present (including as a result of possible fires or other accidents)? Are there locations that could mitigate these concerns and turn the battery's physical presence into an asset? Careful consideration of appearance and placement may mitigate these risks. If done well, the battery could even become a symbol of the community's unique values and identity.

In selecting the location and appearance of the community battery, the ACT Government should avoid producing inequities (such as variegated impacts on house prices) and explore opportunities to validate and reinforce a sense of ownership and collective activity through the battery's physical presence.

Turning the battery into a positive communal focal point that does not disproportionately impact certain individual residents could occur in a range of ways including:

- The battery could be painted or integrated into a public artwork representing the value of the project and local community.
- The battery could be integrated into communal areas where its negative aspects (size, noise etc) could be ignored or even turned into an asset. For example, the battery could be integrated into the sports fields (which also form a part of the ACT Government's plans for Jacka 2), perhaps doubling-up as a digital scoreboard powered by the battery. Or the battery could be placed at the local shops with a display showing performance data such as emissions reduced, energy saved or stored or financial savings reinforcing their involvement.
- As outlined in Recommendation 6, an interactive interface on the battery itself may

also drive a sense of place in representing real time activity and potential behaviour change.

- The battery could be placed in a central precinct among a set of other community-based activities such as within or surrounding a community garden, playgrounds or a bee apiary (offering a kind of natural security system).
- Ensuring a regular maintenance schedule for the external-facing components is agreed to in the battery operation contract and providing residents a mechanism to lodge requests for maintenance in response to unforeseen events (such as vandalism/graffiti or excessive attention from birds).
- Involving the community in decisions about appearance and placement (within the constraints imposed by the requirement to be close to sub-stations etc) (see Recommendation 1 and Recommendation 2).

This recommendation will re-centre the community in the project by:

- helping to create a unique character for Jacka 2 and giving residents something to feel ownership of and be proud of[5]
- integrating the values of placemaking (see below) into Jacka 2's design
- reinforcing ongoing engagement and the community values underpinning the use of the system
- retaining equity by ensuring that particular houses are not disproportionately negatively affected in terms of noise, visual impact, physical safety or economic disadvantage
- growing mindfulness and awareness of overall energy consumption.

The methods of investigation that led to this recommendation: Observation, semi-structured interviews, Country Centered Design and speculative fiction

Key stakeholders all acknowledged in interviews that the battery needed to sit within the community, not external to it, given the requirement for it to be in close proximity to existing grid infrastructure (such as electricity sub-stations) in order to function. Considerations of how the battery's location would affect residents and how it might look appeared to be a low priority compared to these issues about integration into existing infrastructure.

However, our ethnographic observation of the site of Jacka 2 indicated that without conscious efforts to integrate the battery, it could look incongruent with its surroundings. This began our thinking about how to integrate it and what it should and could represent. These observations were complemented by a workshop with Angie Abdilla from Old Ways, New, which also addressed traditional Indigenous connections to place and notions of placemaking.

The ACT Government defines placemaking as a 'philosophy for planning, designing and managing public space that encourages community leadership in the evolution of a place' and as 'an iterative collaborative process of creating places that people love and feel connected to'. Placemaking is viewed by the ACT government as a 'people first' approach, putting the community at the core of the process (City Renewal Authority - ACT Government 2020, p. 12).

Country Centred Design, on the other hand, views placemaking more holistically. "Human-centred design puts reductive user groups at the centre of all decision-making, resulting in often individualistic and

[5] Making the battery present, salient, attractive and useful could build community consciousness (in contrast to the way utilities are traditionally out-of-sight and out-of-mind, and exist largely beneath the consciousness of the community).

economic outcomes. Our process, Country Centred Design looks at the needs of Country first and incorporates a holistic and integrated decision making process." (Abdilla, 2019). This approach can help designers build technology that focuses on how technology integrates into our lives rather than solely improving efficiencies (Abdilla 2019, p. 69). This is deeply relevant to energy technologies, in encouraging us to think about how and why we are using energy and how we can best resource those needs, as opposed to simply asking how we generate more and transport it more efficiently. Drawing on this idea, we can foresee that focussing too much on efficiencies such as maximising the capacity of the battery, the amount of sun the solar panels are exposed to and the economic benefits of the system may hide the potential value that the battery possesses for the community and Country.

To help us tease out what that value could be, we employed speculative fiction techniques to develop two visual prototypes to help challenge core assumptions about the battery's appearance and placement (above). This allowed us to consider the battery within a broader social and environmental context. (Further consideration and limitations of this method are available in Appendix 1).

This recommendation will help the system go to scale safely, responsibly and sustainably in the following ways:

- Community involvement in decisions about placement and appearance is critical to responsible scaling (as per our definition of responsible).
- Consideration of equity outcomes is also critical to responsible scaling (as per our definition of responsible).
- The location of the battery could be used to promote economic sustainability of the systems by keeping it front of mind for residents and promoting ongoing usage.
- The placement of the battery is critical in meeting physical safety goals (proximity to infrastructure as well as fire and accident proof).

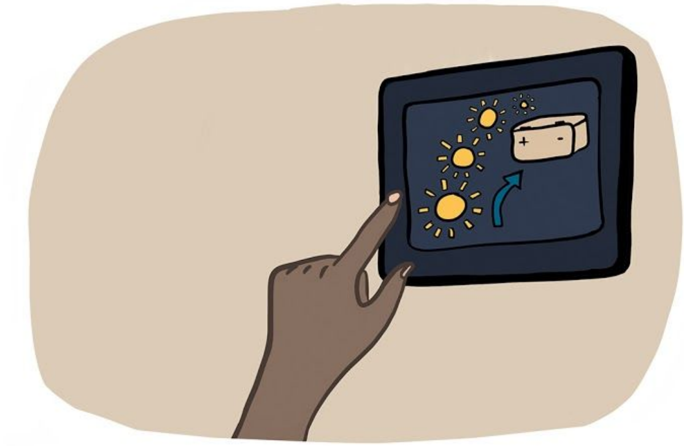
6. Interfaces matter

Innovative interfaces have the potential to contribute to addressing some of the biggest problems facing the energy sector around behaviour, trust and accountability (Hammer et al. 2015, p. 268). Ongoing community engagement with the battery requires a way for residents to understand how it is functioning, what it is doing and how they are benefiting. The community needs a way to communicate with the battery.

Implement an interface as part of the community battery system for optional usage by participating households.

The interface could be simple, complex, visual or numeric. There are a range of possible interface designs addressing a range of different purposes. Some possibilities include:

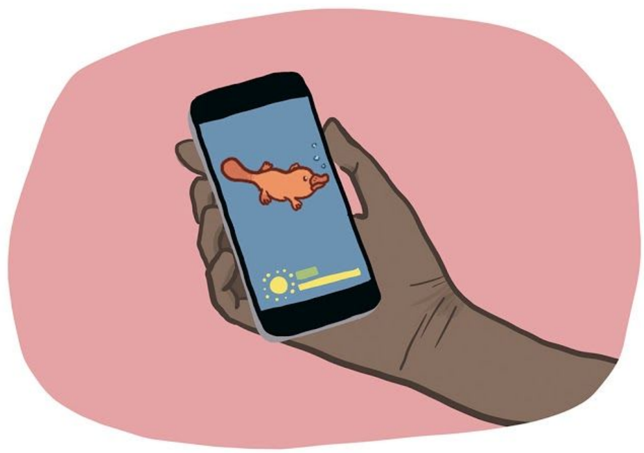
- Each house has a touchscreen panel that allows them to see key indicators regarding the battery's performance and their own contribution to it.
- An app is available allowing households to review energy usage and overall battery performance (energy or financial).
- Gamification strategies, a kind of 'energy tamagotchi' drives engagement with the battery and community energy savings.
- The battery has an interface showing key performance metrics. For this to be effective, it should be integrated with considerations around placement (Recommendation 5).



Prototype 3: A wall interface displaying battery performance and personal energy generation and consumption data.

Prototype 4: A traffic light interface indicating available battery capacity (as used on the Isle of Eigg, see footnote 6).

Prototype 5: An LED light interface could indicate battery perfomance or capacity by glowing in different colours.



Prototype 6: Energy data could be represented through a gamification approach that encourages reduced energy consumption - a kind of 'energy tamagotchi'.

- The battery has an LED casing that changes colour depending on a chosen metric (for example, the battery's charge/discharge status, or the amount of solar being generated in the community at the time). Considering it may predominantly discharge at night, the visibility of the battery at night could become a feature (and could possibly even be integrated into cultural events such as Canberra's annual *Enlighten* festival).
- The battery features a simple traffic light system to indicate when the battery is charging, discharging or indicating capacity.[6]
- Changing the layout and structure of the power bills that users receive to incorporate information about the battery.

[6] Shaw mentions the successful implementation of a traffic light interface on the Scottish Isle of Eigg. It notifies the community at times of low renewable supply (Ottery 2010).

This recommendation will re-centre the community in the project by:

- developing a sense of community ownership and buy-in
- allowing residents to understand and monitor what the battery is actually doing
- potentially encouraging changes in energy behaviour (increasing mindfulness leading to reduced consumption at critical times, greater awareness of overall community usage)
- developing trust in the system by offering transparency, explainability and accountability.

Finally, well-designed interfaces have the potential to help address one of the most significant energy issues for communities across Australia - trust. Consumers have a well-documented and deep-rooted mistrust of the way energy is managed, specifically with the profit-driven approach of retailers and their disregard for the consumer (Ransan-Cooper 2020, p. 47). According to the results of an Energy Consumers Australia survey conducted in 2017[7], consumers believe they are getting better value from their banks and mobile phone providers than the electricity market. They are also not confident that they will be able to derive better value for money in the future (INDAILY 2017).

If the battery is managed well by a trusted body and incorporates an open and transparent interface, it could help dispel this mistrust, at least within the Jacka 2 community. During an interview, Ransan-Cooper alluded to this, saying that customers ultimately want to know the system is fair and to "be able to trust that it's fair".

In designing interfaces, the different thresholds for information saturation of different users and issues of privacy should be kept in mind. On one hand, Aalders thought the interface should definitely offer increased access to personal energy consumption data: "Even if I didn't necessarily use [the data] - I would want access to it, because for me it's part of ownership and being able to understand things... more broadly, there's real benefit to increasing data literacy, which is in itself another way of potentially building community," she said.

On the other hand, Ransan-Cooper and Keighley emphasised in their interviews that users would have different views about how individual consumer information should be handled and about what volume of information from battery indicators is appropriate and relevant. There are also equity implications in terms of gender roles within households, as well as privacy risks particularly in terms of who has access to personal consumption data (from the network or retailer through to landlords) which will require consideration and potentially compliance with regulatory frameworks and legislation as well. While some may find the idea of their personal consumption being monitored in order to generate community statistics intrusive and in violation of their privacy, others may define a successful community battery as one that requires the least engagement possible. Quite simply, not everyone will want to engage with an interface and nor should they have to participate in it. We suggest that any interface system should be optional and variable.

The methods of investigation that led to this recommendation: Leverage Points, semi-structured interviews and speculative fiction

Interfaces are one of the most powerful interventions that could transform 'information flows' within the system, a priority identified in the Leverage Points analysis (Appendix 6). While all interviewed stakeholders recognise the importance and potential of interfaces as a communication and accountability tool, they also acknowledged that adequate consideration of what form it should take and what it should represent is yet to occur. During an interview Shaw said, "it's not something

[7] The survey covered 2019 households and 280 small businesses.

that we've actively looked at, but we've talked about the idea... And not just from a technical perspective, but also from a social perspective to help people feel some ownership of it. But this has never been done before."

To provide some ideas to start the process, we used speculative fiction to develop four visual prototypes (above) to help both the ACT Government and other readers imagine a range of future possible interfaces and place them within the broader social context in which the battery will be used. (Further consideration and limitations of this method are available in Appendix 1.)

This recommendation will help the system go to scale safely, responsibly and sustainably in the following ways:

- By increasing buy-in and acceptance of the system, good interfaces can help maintain interest and encourage use, thus ensuring economic sustainability.
- Ensuring that the use of any interface is safe by making it voluntary and making sure it meets any privacy standards.
- Acceptance and sustained use also maximises the emissions reductions achieved, thereby promoting environmental sustainability.
- Through building community engagement, good interfaces contribute to a micro-cultural sense of the community as a collective of battery users with a valued resource in common, promoting cultural safety.
- Building a CPS offering appropriate transparency for the user is an example of responsible engineering in practice.
- Good interfaces develop accountability in offering users the power to easily monitor the actions of administrators, and in ensuring the administrators know this, thereby discouraging mismanagement and ensuring sustainability of the system through ongoing usage.

Conclusion

Community batteries offer an opportunity to shift fundamental perceptions of energy generation, by establishing it as a local and collective activity, while driving a broader global movement that could address some of the most complex challenges of our time - a necessary and urgent transition to a zero-emissions society.

The Jacka project will provide an invaluable test case for a range of operational models and optimisations that offer a complex set of trade-offs between different sets of values. The choice of model will determine which of a range divergent futures materialises for Jacka 2, potentially offering residents significant savings on their energy bills while building a strong sense of community identity as the beating heart of an innovative and sustainable new suburb.

As Ransan-Cooper says, whether or not the proposed storage is actually viewed as a *community* battery will depend on how householders are engaged in the design and how the benefits are distributed (2020 p. 1). Keighley concurs, saying that decisions around the model will determine "who owns the risks and who gets the benefits".

In making those decisions, we have argued that the community should be engaged at every step along the way. Only in this way can the risk of project failure due to lack of interest, conflict or unequal outcomes be avoided. Our six recommendations are designed to help achieve this and to ensure that community values, however defined, are hard-wired throughout the system at Jacka 2 - from communicating with the community in the design process early on, through to the potential for ongoing engagement based on the battery's placement, appearance and interface. They are suggested as ways of navigating through the highly complex set of decisions that cyber-physical systems require of us.

New kinds of systems powered by machine learning present an increasingly complex set of choices and risks for developers that did not exist with more traditional systems. The various ways in which algorithms can be optimised raises multiple questions: Whose goals and values is the optimisation aligned to? Why is it being optimised in that manner? Who makes the decision on how it is optimised? Who benefits from the optimisation and who may be disadvantaged by it? Can the system be trusted to work fairly? During the design and management of the system, tensions and conflict may arise from the multiple choices available. This is difficult to communicate and end users can feel overwhelmed by the level of information, level of technicality and number of alternatives they need to assess in order to be left with a fair, efficient, cost-effective service. Meanwhile, making safe, responsible or sustainable evaluations of and decisions about the boundaries or limitations of a system can also sit in opposition to modern philosophies about the consumer's right to choose - something the ACT Government is currently navigating at Jacka 2.

And these decisions matter.

As one of the first batteries on the east coast of Australia, the Jacka 2 project could provide other jurisdictions with not just a technical use case for this technology, but also a community engagement pathway for implementing their own community batteries in a way that is responsible, sustainable and safe.

If community batteries scale in this way, there is the potential for them to help transform how we think about energy generation and consumption, meeting the needs of diverse communities across Australia and beyond. Ultimately, they could be part of a suite of tools that drive a paradigm shift (the most powerful of Meadows' leverage points) across the energy sector, potentially demonstrating that energy production can be about more than market competition and profit. In other words, the Jacka experience could inspire Australians to step back and reconsider what they want their energy future to be, and to become a core part of it. The realisation of this potential is exactly what we should be designing cyber-physical systems like the community battery to achieve: a new set of highly adaptable tools that can transform society for the better.

References

3A Institute, Australian National University 2020, *Research,* viewed 12 October 2020, https://3ainstitute.org/research

Abdilla, A 2019, Old Ways, New: How the world's oldest living culture can help shape sustainability, *The Green List*, viewed 4 November 2020, https://thegreenlist.com.au/listing/worlds-oldest-living-culture-can-help-shape-sustainability/

Abdilla, A & Harle, J 2019, *Decolonising the Digital: Technology as Cultural Practice*, Tactical Space Lab, Sydney.

ACT Government 2020, *Now we're cooking with ... electricity! Gas no longer a requirement in Canberra suburbs*, viewed 16 October 2020, https://www.cmtedd.act.gov.au/open_government/inform/act_government_media_releases/rattenbury/2020/now-were-cooking-with-electricity!-gas-no-longer-a-requirement-in-canberra-suburbs

Australian Bureau of Statistics 2020, *Jacka (SA2)(801041118)*, viewed 15 October 2020, https://itt.abs.gov.au/itt/r.jsp?RegionSummary&region=801041118&dataset=ABS_REGIONAL_ASGS2016&geoconcept=ASGS_2016&datasetASGS=ABS_REGIONAL_ASGS2016&datasetLGA=ABS_REGIONAL_LGA2017&regionLGA=LGA_2017&regionASGS=AS

Australian War Memorial 2020, Albert Jacka, *Australian War Memorial*, viewed 14 August 2020, https://www.awm.gov.au/learn/schools/resources/case-studies/albert-jacka

Beckert, J 2016, *Imagined Futures: Fictional expectations and capitalist dynamics,* Harvard University Press, Cambridge.

Borning, A & Muller, M 2012, 'Next Steps for Value Sensitive Design' in *CHI '12: Proceedings of the SIGCHI Conference on Human Factors in Computing Systems,* 5-10 May, Austin, pp. 1125-1134, viewed 15 October 2020, doi:10.1145/2207676.2208560

Bruckner, T, Bashmakov, Igor A, Mulugetta, Y, Chum, H, de la Vega Navarro, A, Edmonds, J, Faaij, A, Fungtammasan, B, Garg, A, Hertwich, E, Honnery, D, Infield, D, Kainuma, M, Khennas, S, Kim, S, Nimir, H B, Riahi, K, Strachan, N, Wiser, R and Zhang, X 2014, 'Energy Systems', in OR Edenhofer, Y Pichs-Madruga, E Sokona, S Farahani, K Kadner, A Seyboth, I Adler, S Baum, P Brunner, B Eickemeier, J Kriemann, S Savolainen, C Schlömer, T Stechow, Zwickel and JC Minx (eds.) *Climate Change 2014: Mitigation of Climate Change*, Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge and New York.

Bunge, M 1963, 'A general black-box theory', *Philosophy of Science,* vol. 30, no. 4, pp. 346-358, doi:10.1086/287954

Chirgwin, R 2020, 'Community Batteries Benefit The Grid More Says Latest Research', *Solarquotes Blog,* 1 June, viewed 20 October 2020, https://www.solarquotes.com.au/blog/community-batteries-benefits/

City Renewal Authority - ACT Government 2020, *Great Place Guide*, viewed 21 October 2020, https://www.act.gov.au/__data/assets/pdf_file/0011/1615898/great-place-guide.pdf

'Community batteries: a cost/benefit analysis' 2020, *Battery Storage and Grid Integration Program, Australian National University, viewed 20 September 2020.*

Doorn, N 2012, 'Responsibility Ascriptions in Technology Development and Engineering: Three Perspectives', *Science and engineering ethics*, vol. 18, no. 1, pp. 69-90, DOI:10.1007/s11948-009-9189-3

Dourish, P & Bell, G 2014, 'Resistance is futile: reading science fiction alongside ubiquitous computing', *Personal and Ubiquitous Computing*, vol. 18, pp. 769-778, doi:10.1007/s00779-013-0678-7

'Electricity companies worse than banks: consumer survey', 2017, *INDAILY*, 7 July, viewed 29 October 2020, https://indaily.com.au/news/2017/07/07/electricity-companies-worse-banks-consumer-survey/

Evans, J 2019, 'ACT has '100 per cent renewable' electricity from today,But what does that mean?', *ABC News*, 1 October, viewed 16 August 2020, https://www.abc.net.au/news/2019-10-01/act-is-100-per-cent-renewable-but-what-does-that-mean/11560356

Friedman, B & Hendry, D G 2019, *Value Sensitive Design: Shaping Technology with Moral Imagination*, The MIT Press, Cambridge..

Geisberger, E & Broy, M 2015, *Living in a networked world: integrated research agenda cyber-physical systems (agendaCPS),* acatech STUDY, viewed on 2 October 2020.

Hammer, S, Wißner, M & André, E 2015, 'Trust-based decision-making for smart and adaptive environments', *User Modeling and User - Adapted Interaction*, vol. 25, no. 3, pp. 267-293, DOI:10.1007/s11257-015-9160-8

Harvey, P & Knox, H 2011, 'Ethnographies of place: researching the road' in J Mason & A Dale (ed.), *Understanding social research: Thinking creatively about method*, Sage Publications, London, pp. 107-119.

'Jacka 2016 Census Profile' 2018, 25 October, viewed 31 October, https://mygungahlin.com.au/jacka-2016-census-profile/4149/

Jasanoff, S & Kim, S 2015, *Dreamscapes of Modernity: Sociotechnical Imaginaries and the Fabrication of Power*, The University of Chicago Press, Chicago and London

Jervis-Bardy, D 2019, 'Canberra population sprints past 420,000, new figures show', *Canberra Times,* 27 March, viewed 12 October 2020, https://www.canberratimes.com.au/story/5992052/canberra-population-sprints-past-420000-new-figures-show/

Johnson, B D 2011, *Science Fiction Prototyping: Designing the Future with Science Fiction*, Morgan & Claypool, California.

KPMG 2020, *Ausgrid Community Battery: Feasibility Study Report*, AusGrid, viewed 28 October 2020, https://www.ausgrid.com.au/-/media/Documents/Reports-and-Research/Battery/Ausgrid-Community-Battery-Feasibility-Study-Report-2020.pdf.

Law Insider 2020, *Definition of responsible development*, viewed 24 October 2020, https://www.lawinsider.com/dictionary/responsible-development#:~:text=Definition%20of%20responsible%20development,-Search%20Within%20responsible&text=responsible%20development%20means%20the%20management,and%20natural%20diversity%20are%20maintained

Leveson, N G 2011, *Engineering a safer world: systems thinking applied to safety*, The MIT Press, Cambridge..

Maani K E & Cavana R Y 2007, *Systems thinking, system dynamics: Managing change and complexity*, Pearson Education, Auckland.

'Safely', 2020, *MacMillan dictionary online*, viewed 20 September 2020, https://www.macmillandictionary.com/dictionary/british/safely

Mannheim, M 2020, 'Shared community battery may be trialled in solar-powered Canberra suburb to stabilise energy supply', *ABC News,* 5 June, viewed 10 October 2020 https://www.abc.net.au/news/2020-06-05/community-battery-may-be-built-in-new-canberra-suburb/12266938

Marashi, E and Davis, J P 2006, 'An argumentation-based method for managing complex issues in design of infrastructural systems', *Reliability Engineering & System Safety*, vol. 91, no. 12, pp. 1535-1545, doi:10.1016/j.ress.2006.01.013

Meadows, D H 2009, *Thinking in Systems - A Primer,* Earthscan, London.

Old Ways, New 2020, *Country Centred Design*, 28 October, https://oldwaysnew.com/#country-centred-design

Ottery, C 2010, 'Eigg Islanders wins top prize for giving', *The Guardian*, 2 July, viewed 4 November 2020, https://www.theguardian.com/environment/2010/jan/13/eigg-wins-green-energy-prize

'Community' 2020, *Oxford Languages, Oxford University Press dictionary online* viewed 2 November 2020, https://www.google.com/search?sxsrf=ALeKk02_0gkZqIWoonHwaZRRuBx4VoAccg%3A1604562680207&ei=-K6jX76VDluv9QOSq57ABQ&q=community+definition&oq=community+defin&gs_lcp=CgZwc3ktYWIQARgAMgwIIxDJAxAnEEYQ-QEyCAgAELEDEIMBMgIIADICCAAyAggAMgIIADICCAAyAggAMgIIADICCAA6BAgAEEc6CQgjECcQRhD5AToECCMQJzoHCAAQsQMQQzoECAAQQzoECC4QQzoFCAAQsQM6AgguUN0aWPsgYNA9aABwAngAgAHUAYgBwQiSAQUwLjUuMZgBAKABAaoBB2d3cy13aXrIAQjAAQE&sclient=psy-ab

Rae, M 2020, 'Citizens required to power community batteries', *The Battery Storage and Grid Integration Program*, viewed 17 October 2020, https://bsgip.com/news-events/news/citizens-required-to-power-community-batteries/

Ransan-Cooper, H 2020, *Stakeholder views on the potential role of community scale storage in Australia*, Battery Storage and Grid Integration Program, Australian National University, viewed 15 September 2020.

Rose, D B 1996, *Nourishing terrains: Australian Aboriginal views of landscape and wilderness*, Australian Heritage Commission, Canberra.

Rouse, M 2020, 'Scalability', *TechTarget*, viewed 27 October 2020, https://searchdatacenter.techtarget.com/about

Schensul, JJ, & LeCompte, MD 2012, *Essential Ethnographic Methods: A Mixed Methods Approach,* AltaMira Press, California, viewed 10 October 2020, https://ebookcentral.proquest.com/lib/anu/detail.action?docID=1031972

Shaw, M, Sturmberg, B, Mediwaththe, C, Ransan-Cooper, H, Taylor, D & Blackhall, L 2019, *Operating a community-scale battery: electricity tariffs to maximise customer and network benefits,* Battery Storage and Grid Integration Program, Research School of Chemistry, Australian National University, viewed 15 September 2020

Star, SL & Griesemer, JR 1989, 'Institutional Ecology,'Translations' and Boundary Objects: Amateurs and Professionals in Berkeley's Museum of Vertebrate Zoology', 1907-39, *Social Studies of Science*, vol. 19, no. 3, pp. 387-420, (online Jstor).

Stevens, P 2019, 'The battery decade: How energy storage could revolutionize industries in the next 10 years', *CNBC*, 30 December, viewed 19 October 2020, https://www.cnbc.com/2019/12/30/battery-developments-in-the-last-decade-created-a-seismic-shift-that-will-play-out-in-the-next-10-years.html

The Ohio State University 2020, *What is Speculative Fiction?*, viewed 5 November 2020, https://u.osu.edu/lemon243eng4563/what-is-speculative-fiction/

Thomas, D 2006, *Placemaking: An Urban Design Methodology*, Routledge, New York.

Value Sensitive Design Lab 2020, *About VSD*, viewed 29 October 2020, https://vsdesign.org/vsd/

Vorrath, S 2020, 'Sixth Tesla community battery installed in Western Australia PowerBank trial', *One Step Off The Grid*, 29 June, viewed on 18 September 2020, https://onestepoffthegrid.com.au/sixth-tesla-community-battery-installed-in-western-australia-powerbank-trial/

World Commission on Environment and Development 1987, *Report of the World Commission on Environment and Development*, Oxford University Press, Oxford.

Note: No reference to interview data has been provided in the reference list. The transcripts are stored at the '3A Research Date Store' managed by the 3A Institute

Appendix 1 - Research methods

Direct and Indirect Stakeholder Mapping

SYSTEM METHOD

Systems are designed by people. The culture and values of developers are tightly woven into the design and implementation of CPS. Therefore, understanding the values of project stakeholders is critical to analysing any system. To understand the values present in the community battery project, we applied a method developed by Friedman & Kahn as part of VSD to map both direct and indirect stakeholders in the system. The resulting stakeholder map can be found at Appendix 3. VSD is based on the recognition that the development of technology is not value-neutral, and that the moral and technical imagination we bring to systems informs their design and making (Friedman & Hendry 2019, p. 2). Direct stakeholders are parties who interact directly with the system or its output. Indirect stakeholders are those who are not engaged in the design process but may still be impacted even if they never or rarely interact with the system as end-users. VSD also encourages researchers to consider their own values as well as those of non-human actors (Value Sensitive Design Lab, 2020).

Limitations

Identifying stakeholders for a community project where the community is not yet in existence is deeply problematic, as is an assessment of the influence and importance of non-human or environmental actors (since the environment arguably directly supports all activities on Earth). Placing stakeholders and drawing the boundary around who is included and excluded as part of a stakeholder mapping exercise is deeply reflective of the researcher's own value systems.

Semi-structured Interviews

COMPLEMENTARY METHOD

This analysis used multiple rounds of semi-structured interviews with the Jacka community battery project's key stakeholders: the ACT Government, the Battery Storage and Grid Integration Program at the ANU and a Gungahlin resident. The approach to these interviews was a combination of in-depth, exploratory and open-ended techniques to allow for flexibility in the formulation and structure of the interview questions, also informing the interpretation of all responses as relevant and neither right nor wrong. This allowed us to obtain information regarding the system's origin story, identify cultural domains informing key decisions regarding system design and orientate the system in terms of broader sociopolitical contexts and trends (Schensul & LeCompte 2013, pp. 134-135).

Limitations

We acknowledge that the perspective of a single Gungahlin resident cannot be considered broadly representative of community views. It should also be noted that the stakeholder interviews informing this research took place during the COVID-19 pandemic partially on video conferencing platforms. The face-to face interviews that were possible were designed to meet strict social distancing requirements. Since much communication is non-verbal, these constraints did affect the fluidity of interviews and ability to develop rapport. We were particularly grateful for the patience and enthusiasm of our interviewees considering this difficult context.

Leverage Points

SYSTEM METHOD

Donella Meadows' Leverage Points framework offers 12 points of intervention in a system where a small change could lead to a large shift in behaviour (Meadows 2009, p. 145).

We conducted an analysis (Appendix 6) using this method to:

- identify points of possible intervention in the community battery system, especially where they were counterintuitive and hence overlooked;
- explore the various components of the system and the interdependencies that exist between them;
- narrow the focus of our research; and
- assess and critique our recommendations.

Our analysis showed that intervening at the 'information flows' level was of key importance in addressing community priorities, thus our report focuses on this intervention level.

Limitations

Meadows' approach is a work-in-progress. It is highly flexible and open to varied and diverging interpretations.

Country Centred Design

SYSTEM METHOD

To complement other observational methods, this analysis considered the principles of Country Centred Design, an Indigenous methodology used to inform the development of technologies for places, spaces and experiences. It requires four stages - culture, research, strategy and technology - for the "restoration, revitalisation, health and wellbeing of Country and its communities" (Old Ways, New 2020). This method, born of one of the oldest and most sustainable cultures on the planet, is of significant interest considering the possible alignment between the methodology's aims and the idea of the community battery as a specifically place-oriented technology that has the potential to build perceptions of energy as a shared resource.

Limitations

As non-Indigenous researchers, we are acutely aware of the sensitivities and limitations in applying this method. Having sought clarification from the method's developer (Angie Abdilla of Old Ways, New, from whom we received a workshop as part of the 3A Institute Masters program,) we did not apply this method directly given concerns with cultural appropriateness. However, we suggest the use of this method in future, in partnership with Indigenous communities, to inform recommendations and decision-making frameworks.

Observation

COMPLEMENTARY METHOD

Places are dynamic and fluid, influenced by the evolution of the environment, the movement of people and the plans they enact that set in course a complex set of impacts, however deliberate or anticipated (Harvey and Knox 2011, p. 107-119). For place-based technologies such as the Jacka 2 community battery, geography, perceptions of place and broader relationships to the environment have the potential to profoundly influence the system's design.

Ethnographic observation is what can be seen through the eyes of the researcher filtered by their interpretive frames (Schensul & LeCompte 2013, p. 88). As much as possible, we attempted to centre notions of place beyond a primarily human viewpoint. Taking an approach similar to Rose in *Nourishing Terrain*, we looked at place "as a living entity, with a yesterday, today and tomorrow and a consciousness and will toward life," observing air, land, living organisms and other objects of landscapes that exist now while considering how they may be impacted by new technology (1996, p. 7). This beyond-human perspective is of particular relevance considering the Jacka community battery's overarching intent, as described by its stakeholders, in addressing anthropogenic climate change.

Observation was undertaken by visiting the Jacka 2 site with some of the project's key stakeholders. This orientated us with our site of study while allowing us to

observe, to a lesser degree, stakeholder behaviour within the field, which offers some revelations regarding attitudes towards place, potential system impact and responsibility.

Observing the site has helped conceptualise the graphic design and the colour scheme of the entire report.

Limitations

Ongoing observation with a wider range of stakeholders at different points in time would have been more beneficial.

Speculative Fiction

COMPLEMENTARY METHOD

Speculative fiction is often described as the 'what-if?' genre. It allows us to imagine a world different from our own. It is a broad umbrella term that includes various approaches, including but not limited to, science fiction, fantasy, and dystopian fiction (The Ohio State University 2020).

Within speculative fiction, we used a combination of science fiction prototyping (SF prototyping) and sociotechnical imaginaries to produce a series of six possible alternative imaginaries of the battery's placement, appearance and its interfaces (see Recommendation 5 and Recommendation 6).

Science fiction prototyping is the development of short stories, movies or comics as a formalised step in the technological development process to forecast and communicate an infinite range of potential impacts of new technologies by interpreting them in broader social and cultural contexts (Johnson 2011, p. 121).

Sociotechnical imaginaries is a tool that explores how technology is being imagined rather than being built. These imaginaries are a co-production of technology and society (Jasanoff & Kim 2015, p.19). Decisions that are taken in the present are not solely influenced by past and present experiences but are equally influenced by perceptions of the future (Beckert 2016, p. 35).

The resulting six prototypes are aimed at challenging some basic assumptions regarding the battery's placement, appearance and interactivity while positioning it within an imagined social and environmental world or context.

Limitations

While visualisations of any system can help to communicate its behaviours, possibilities and potential implications, they can also put images or expectations in the mind of the viewer, as though those realities are somehow fixed. For a system as flexible and variable as the community battery in terms of appearance and function, any representations are only one possibility, where there are many others. The researcher must also be conscious of how diversity is represented in these visualisations as they may be addressing some audiences and not others. A balance of gender and skin tone was achieved across the visual prototypes developed for this research.

Time allowing, the application of a speculative fiction process such as a science fiction prototyping workshop with a diverse range of current and prospective community members could open up new kinds of conversations about community values regarding community batteries.

Research stance

In many instances, it can be useful for the reader if the researcher is more visible in the writing (Borning & Muller 2012 p. 1126). Hence, as researchers we acknowledge that our own understanding of the system is influenced by our own experiences, backgrounds and perspectives. We are a group of four with diverse backgrounds spanning public policy, communications, engineering and business strategy, with no prior experience working within the energy sector. In conducting this research, our goal was to critically and objectively analyse the community battery by using a selection of concepts and methods from a range of disciplines introduced to us during our Masters in Applied Cybernetics at the 3A Institute at ANU, with an overarching focus on how cyber-physical systems can be taken safely, responsibly and sustainably to scale.

Appendix 2 - Jacka

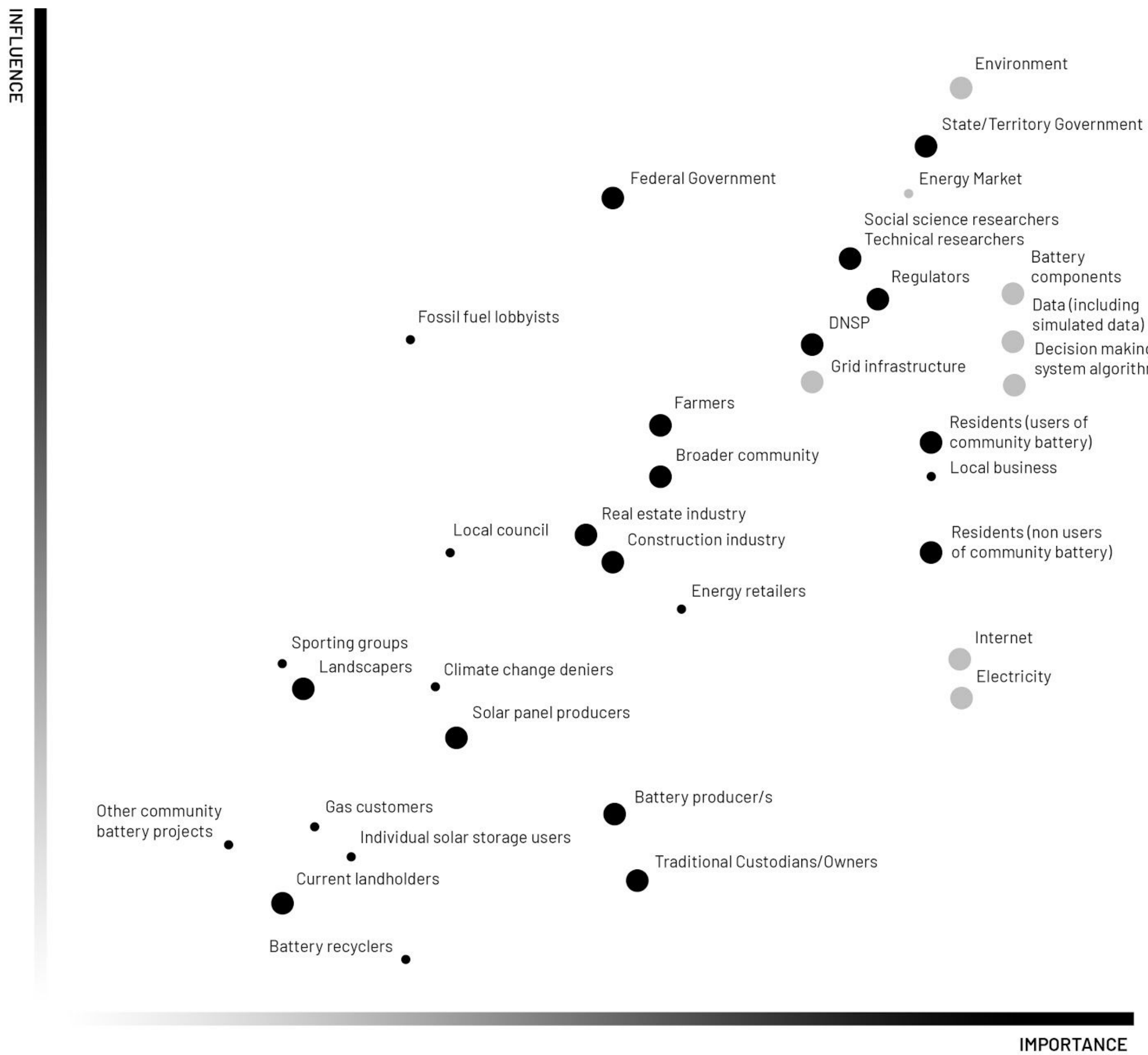
Jacka is a new suburb on traditional Ngunnawal country in Gungahlin in Canberra's north in the ACT. It was gazetted in 2001 (My Gungahlin 2018) and named after Albert Jacka, Australia's first Victoria Cross recipient (Australian War Memorial 2020). The development of the suburb began in 2013, with around five streets completed by 2017. The ACT Government is now extending the suburb, a staged development known as Jacka 2. The ACT Government has incorporated the idea for the community battery into this stage of the design to store unused energy sourced from 5kW PV systems attached to the 600-700 new houses. Jacka is integrated with Evoenergy's low-voltage electricity network, and Jacka itself will be an all-electric suburb (only the second gas-free suburb in the ACT)(ACT Government 2020).

Jacka's current population is relatively small, with just 735 existing residents. This limits the available demographic data. Nevertheless, in order to provide context for the battery system's origin story, some demographic observations about Jacka are included here on the assumption that they may provide an indication of the possible demographics of Jacka 2.

Just over 40 per cent of Jacka's current population was born overseas, particularly in southern and central Asia. It is a young suburb, with a third of its population under 15 - the highest percentage of any suburb in any Australian capital city. Solar penetration currently extends to just 36 home units (Australian Bureau of Statistics 2020). While Canberra is the second fastest-growing city in Australia, Jacka bucks this trend as the suburb experiencing the greatest population decline at 4 per cent (Jervis-Bardy 2019). It is difficult to assess the significance of this decline in a very small population. However, it is noted that housing supply and affordability is a critical issue and high priority for the ACT Government that is being addressed partially through greenfield projects like Jacka 2.

As well as addressing broader population concerns, the ACT Government sees the development of Jacka as an opportunity to realise its environmental priorities and innovation agenda. From October 2019, the ACT was successfully offsetting 100 per cent of its electricity usage through investments in renewable sources as part of a broader commitment to zero-emissions and a reliable and competitive energy market (Evans, 2019).

Appendix 3 - Stakeholder analysis



- Indirect stakeholders
- Direct stakeholders
- Non-human stakeholders
- Human stakeholders

As discussed in Appendix 1, this stakeholder map identifies direct and indirect stakeholders for the community battery project at Jacka 2. Direct stakeholders are parties who interact directly with the system or its output. Indirect stakeholders are those who are not engaged in the design process but may still be impacted even if they never or rarely interact with the system as end-users. This map includes potential stakeholders as well, as a system yet to be deployed. VSD also encourages researchers to consider their own values (we have included ourselves as social science/technical researchers) as well as those of non-human actors (indicated above using grey) (Value Sensitive Design Lab, 2020).

Considering the system in Jacka 2 is yet to be deployed, the above map includes stakeholders who are presently involved in the design of the system as well as future stakeholders across the life cycle of the system.

While this mapping process was useful in identifying a broad range of stakeholders, we then augmented the VSD mapping method by assessing their importance to the project (stakeholders required for the system to be viable) as well as their influence on outcomes relating to it (influence on decision making capacity). This helped narrow our focus to five main stakeholders - the environment, social researchers, technical researchers, ACT Government and community (users & non-users of the community battery). Given the system is in its design stage, we chose to include these stakeholders based on their ability to influence the design and outcomes of the system as well as those most impacted - the community and environment. We also included energy retailers to draw out the value tensions that may exist.

Table 1: Stakeholder values in tension

Details	Safety	Sustainability	Equity	Reputation	Social Good	Trustworthiness	Financial Motivation
Community							
ACT Government							
Technical Researchers							
Social Researchers							
Environment							
Energy Retailers							

Whilst the above table shows the tensions between certain stakeholders (black represents higher importance given, white represents minimal importance given), we acknowledge our own values have significantly influenced this process.

Appendix 4 - Interview schedule

Audio recordings and transcripts for the interviews are stored at the '3A Research Date Store' managed by the 3A Institute.

Interviewee	Date Interviewed	Mode
Matthew Keighley Project Officer Sustainability and Land Release, Suburban Land Agency, ACT Government	17 August 2020 2 October 2020 2 November 2020 5 November 2020	Pre-interview In-person In-person Virtual report review
Dr Hedda Ransan-Cooper Research Fellow, Social Science Program, Battery Storage and Grid Integration Program, College of Engineering & Computer Science, The Australian National University	20 August 2020 19 October 2020 3 November 2020 5 November 2020	Pre-interview In-person In-person content review Virtual report review
Dr Marnie Shaw Research Fellow, Research School of Electrical, Energy and Materials Engineering, College of Engineering & Computer Science, The Australian National University and Research Lead, Battery Storage and Grid Integration Program, College of Engineering & Computer Science, The Australian National University	17 Aug 2020 1 October 2020 3 October 2020 5 November 2020	Pre-interview In-person In-person report review Virtual report review
Rachel Aalders 3A Institute Masters student and Gungahlin resident*	8 October 2020 4 November 2020	In-person In-person report review

*While Rachel Aalders was interviewed as a Gungahlin resident, we acknowledge that she is also a colleague and our friend from the 3A Institute. While we judged the intersection of her local Gunghalin knowledge and her knowledge of CPS made her an excellent interview subject, her views may not be representative of other members of the community.

Appendix 5 - Definitions

Across the major stakeholders of the Jacka community battery project, there was significant variation in how key terms were being defined.

While brief definitions are offered above in the body of the report, this appendix offers additional context for some definitions.

In particular, interviews with the project's key stakeholders revealed significant interchangeability across definitions of the terms "sustainably" and "responsibly", ranging from across issues of equity and access through to considerations of the battery life cycle. Although there is a close relationship between the two terms, we have chosen to separate them, based on the anchoring of this analysis in the 3A Institute research method investigating "safe, sustainable and responsible implementation" (3A Institute 2020).

Sustainable

Environmental sustainability: When we talk of the community battery system's environmental sustainability, we are examining its potential to meet the needs of both the present and future generations in facilitating a transition towards zero emissions. This aligns with the ACT Government's overall sustainability targets, that include all-electric suburbs. "We have to go as far as saying enough's enough, we need to make a change," Keighley said in an interview. In this sense, for the ACT Government, sustainability is realised through leadership and innovation.

Economic sustainability: Although the concept of economic viability was included in the definition of sustainability only by Ransan-Cooper, it plays a pivotal role in decisions to be taken to optimise the battery and to decide ownership. If the system isn't economically sustainable, its longevity is at risk, and the Jacka 2 model is unlikely to scale beyond Jacka, therefore having limited impact on future generations.

Responsible

Keighley stated that the ACT community is demanding a responsible agenda from the ACT Government to see increased environmental management and action on climate change.

Beyond environmental definitions, some project stakeholders also recognised that responsibility entails prioritising equity outcomes for people by providing wider and more affordable access to renewable energy for low income households. In addressing these concerns, there was also broad acknowledgement among stakeholders that responsible implementation requires adequate community involvement, governance and control and potentially the ability to veto a project.

Appendix 6 - Leverage Points analysis

Leverage points are points of power. They are points in the system where a small change could lead to a large shift in behaviour (Meadows 2009, p. 145). To recognise opportunities for intervention in a system, one needs to be able to identify these points.

To identify the various leverage points and analyse how interventions at different points might help take the community battery to scale safely, sustainably and responsibly, we used Meadow's twelve-point method. The process was exploratory in nature, facilitating a deeper understanding of the community battery system as a whole, the individual components and the interactions between them (Maani and Cavana 2007).

We used existing literature on the project alongside our interactions with stakeholders to raise various questions about interventions and how they might be used to take the system safely, sustainably and responsibly to scale. As the community battery is not yet in existence, the questions raised in Table 2 are based on potential future scenarios.

Our analysis revealed a significant opportunity for intervention at the 'informations flows' level, which informed the focus of this research. The leverage points are ranked in increasing order of their effectiveness to create system wide change, as given by Meadow's twelve point-method .

Table 2 - Leverage Points Analysis

CB - Community battery

Leverage Point	Possible interventions	Goal
12. Numbers Constants and Parameters (subsidies, taxes, and standards)	Will a guaranteed reduction to energy costs of CB members lead to a better uptake? Will a penalty for householders that opt-out of using the CB ensure continued participation? Will a subsidy on purchasing a house in Jacka powered by a CB, make clean energy more affordable to a larger audience? Will Jacka as a gas-free suburb drive up gas prices elsewhere?	Safe (economic) & sustainable Sustainable Responsible Responsible
11. Buffers Stabilizing Stocks relative to their flows	What is the ideal buffer that needs to be maintained to ensure the flows to each individual house are not interrupted even during a blackout? What is the minimum no. of households required to participate for the CB to be viable? What alternative exists if the algorithm does not prioritise discharging to household units when required?	Safe (structural) Sustainable Safe (structural)
10. Structures Physical systems and their nodes of Intersection	How is the CB placed to minimise fire and accident risk? What will it look like and will the battery make noise? How will its operation affect the broader grid?	Safe (physical) & sustainable Safe (physical) & sustainable Safe (structural), sustainable & responsible
9. Delays The lengths of time relative to the system changes	How long does the CB system take to build trust in the community in relation to the owner of the CB? Is there any delay between the ML algorithm receiving information and then acting upon it? How quickly can a complaint be responded to? How does this feedback influence change in the system?	Responsible Safe (structural) Safe (economic & structural), sustainable & responsible

8. Balancing Feedback Loops The strength of the feedbacks relative to the impact they are trying to correct	What is the balancing loop in place for each model to ensure the consumers and the battery owner owners' goals are met and values are embedded in the system? How does the system communicate with individual households and the network to balance charging and discharging? Is there an emergency cooling system to prevent overheating?	Responsible Safe (structural) Safe (physical)
7. Reinforcing Feedback Loops The strength of the gain of driving loops	Do reduced energy bills reinforce more or less energy consumption? Based on the choice of model, is there a possibility of the owner of the CB to form a monopoly and fulfil their own goals? Does the CB project help to create awareness of renewable energy?	Sustainable Safe (economic) & sustainable Sustainable
6. Information Flows The structure of who does and who does not have information	Who has access to information on how the battery works and who does not? How is the information conveyed and by whom? Are the modes through which information flows easily accessible? How were the interfaces designed? What is conveyed by sales teams to consumers? Does the user get access to their energy consumption data? Who else can access this data? What is the information that retailers may have but consumers do not? Do homeowners have rights to certain information of their tenants? Do the consumers understand the life cycle of the CB from inception to decommissioning?	Responsible, Safe (privacy) Responsible, Safe (privacy) Responsible Responsible Safe (privacy) & sustainable Safe (privacy) & sustainable Safe (privacy) & sustainable Safe (physical) & responsible
5. Rules Incentives, Punishments and Constraints	Will government mandates around the use of clean energy increase the influence of the CB system on the energy sector? Are the feasible ownership models allowed and/or viable under the current NEM framework?	Sustainable Safe (economic), sustainable & responsible
4. Self-organisation Power to add, change or evolve system structure	Who is responsible for maintaining the battery and the required infrastructure?	Safe (physical & structural) Responsible
3. Goals Purpose or function of the system	Do the various stakeholder goals align with each other? Who has the power to set the goal? How do different goals influence the way other points conform to the goal?	Sustainable & responsible Sustainable & responsible Sustainable & responsible
2. Paradigms The mindset of the system / ways of seeing / unstated social agreements	Can the CB change mindsets of those who prefer non-renewable sources? Can energy be viewed as a collective, share resources?	Safe (all forms), sustainable & responsible Safe (all forms), sustainable & responsible
1. Transcending Paradigms	Can our anthropocentric view of the world be changed?	Sustainable & responsible

This analysis revealed a particular focus on the 'information flows' level. It also inspired two additional questions that could affect the nature types of interventions possible.

1. What ownership model will enable the system to scale safely, sustainably and responsibly?
2. What role does the community (unestablished at the present time) play in ensuring the safe, sustainable and responsible scaling of the system?

Given the timeframe for this research, we decided to focus on question two. Through our interactions with Aalders, coupled with Ransan-Cooper's '*Stakeholder views on the potential role of community scale storage in Australia*' , it was clear that householders were open to the concept of shared community storage (2020, p. 1) . However, the piece of the puzzle that seemed to be missing was information around the system. For the community to make informed decisions regarding operational models and usage, they required information to unpack elements of this 'black box' system.

Table 3 - 3Ai Vector Analysis

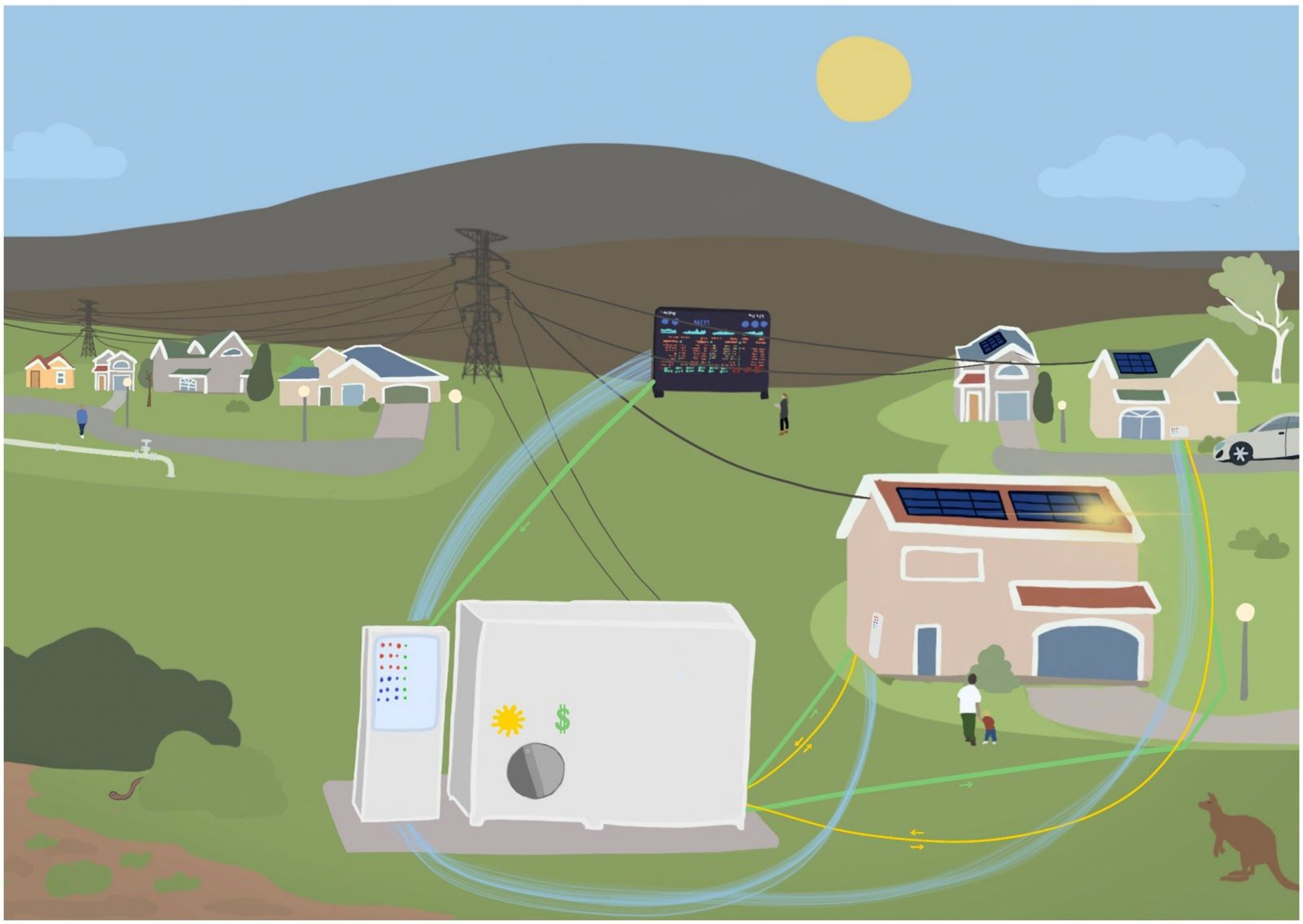
CB - Community battery

The 3A Institute vectors - agency, autonomy, assurance, interfaces, indicators and intent - can be used to analyse and understand complex systems. With a focus on community and information flows, we applied this framework to anticipate what questions potential users of community batteries across Australia might ask that could be addressed by improved or transformed 'information flows'.

Vector	Sustainable	Responsible	Safe (All forms)
Intent	What is the purpose of a CB? What does a CB do? What are the plans for this system longer-term?	Who benefits from a CB? Who owns the CB? Who is making money from my panels? Who is building the CB?	Will the planet be safe for my children? How are we going to get to zero emissions?
Indicators	What is the difference in benefit of this battery vs the giant Tesla battery the government announced it would buy? If I'm involved in the CB can I just use more power?	Will the CB make my power cheaper? What is the cost of being part of a CB? If household batteries drop in price will the CB still be viable?	
Interfaces	Will the CB help me reduce my power usage?	Can I monitor the battery? Will I get access to my data? Does this system have AI in it? How do I know what it's doing? And that some other house isn't getting more power than me? Can my landlord see my data?	Who will see my data?
Autonomy	Can we change how the battery is behaving later? How is power distributed to different households? Who gets what?	What if I don't like what the battery is doing?	What is the battery doing on its own?

Agency	Can I opt-out of the CB if I change my mind? Do I have to install solar panels?	Will the whole community be involved? Who's in and who's out? Can the community make decisions about the battery? Who decides what the battery does or whether it can be changed?	Who is controlling the battery?
Assurance	Is the battery environmentally sustainable? Where will the battery go when it is old? Can the battery be recycled? Can I still have gas in my property as well? What happens to old solar panels? What are solar panels made from? What if my neighbour's tree blocks my panels? Who is looking after the system?	Will the CB solve reliability issues? Who will we speak to if something goes wrong? Can renters access the CB too?	Does the CB emit anything? Is the CB noisy? Is the CB safe if children are playing near it? What if a fire burns through the area? Can the CB explode? What if someone hits the CB with their car? How is the system protected from hacking?

Appendix 7 - Systems Map



Financial flows   Communication flows   Battery energy flows   Main grid energy flows

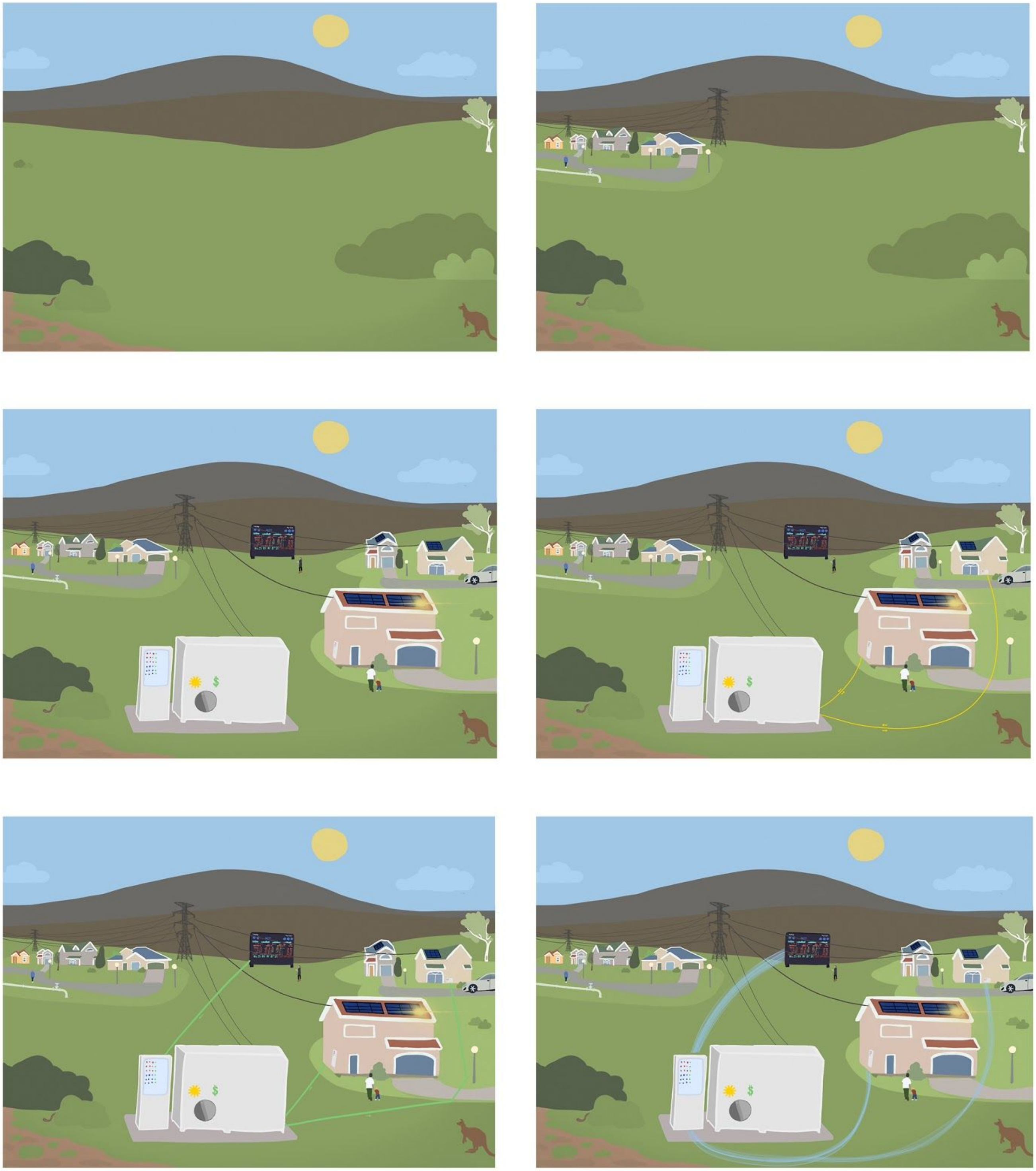
This system map represents the basic components of the community battery system at Jacka. In recognising the need for a community engagement tool, this map is designed to be an interactive narrative tool to help community members understand and visualise how the system works and may affect them. As shown below, the map is designed to have six main layers:

1. Country (which underpins everything)
2. The neighbouring gas-dependant suburb of Taylor, connected to the grid (Jacka 2 is the greenfields site next door)
3. Jacka 2 (once constructed with the community battery in situ, houses also connected to the grid. The energy market is represented by the black stock exchange scoreboard)
4. Battery energy flows (to and from each house)
5. Financial energy flows (to the houses through reduced bills and to the market)
6. Communication flows

This is an innovative system map which aims to demonstrate how a systems map *could* look. This is designed to be physically printed as an engagement resource. Country is printed on paper, and the next five layers are to be printed on transparency paper to be layered on top of the Country layer as the system is verbally explained through storytelling.

The map represents human and non-human actors (including the endangered striped legless lizard in the bottom left hand corner). We aimed to achieve a balance of simplicity and complexity to highlight the most important aspects of the system. This involved deliberate omissions of what we considered to be unnecessary technical details and jargon as per Recommendation 2. It was designed to be understood even with a low level of literacy.

As the final operational model for the community battery is yet to be decided, we deliberately left out any information pertaining to a specific model, inserting sufficient detail (visual cues) to verbally explain these models. The layering technique paces the information flows to the viewer, allowing them to build understanding of the complex system gradually in a supported way. The optimisation of the battery's machine learning algorithm is also represented by a switch on the battery itself. CPS can feature extremely complex and overwhelming interdependencies of components and stakeholders. This map demonstrates how even the most complex system can be explained as long as the viewer can identify and picture themselves within the system.



The six layers of the system map, to be layered as transparencies when printed.

Appendix 8 - Emergent Properties

Complex systems contain many components and layers of subsystems with multiple, non-linear interconnections that are often difficult to recognise, manage and predict (Marashi & Davis 2006, p. 1536). Although variations in the definition for a complex system exist, a common phenomenon arising from these systems is that of 'emergence'. Emergent properties arise from complex systems as a result of the interaction of components that can not be explained by looking at the properties of the individual components in isolation (Leveson 2011, p.64). They are considered to be a significant underlying cause of 'unintended consequences', especially because increasingly complex systems make it very difficult to anticipate all the ways that components will interact and all the results of those interactions. Identifying emergent properties at the design stage can help to plan for unintended consequences, even where the specific consequences themselves cannot all be identified.

The following table identifies some emergent properties that might arise as the community battery system is implemented. It also takes into account the importance of considering different levels of scale in order to identify the different levels of change that may result. In our assessment of emergent properties, we thought about two types of scale and levels of change, namely time and geographic reach. The table below therefore sorts possible emergent properties into categories based on the time scale in which they might emerge (5 years or 10 years) and the geographic scale that they might emerge on (Jacka, ACT, Australia).[8] Identification of these emergent properties made it possible for us to consider how the current battery project design might give rise to them and design our recommendations cognisant of how they might be either amplified or diminished.

Table 4 - Emergent Properties

Scales	**Time (5 years, 10 years) : Geographic (Jacka, ACT, Australia)**		
Intended Effect	**Emergent Behaviours**		
	Positive	**Depends on perspective[9]**	**Negative**
A community battery system that drives sustainable energy outcomes	Scale: within 5 years in Jacka ● A sense of community spirit and ownership, including ideas around Jacka being a unique place to live ● Community resilience built as a result of community engagement in the battery and the ability to make decisions that impact how the battery is operated Scale: within 10 years throughout Australia ● Increased awareness around solar energy drives demand for further innovations in the solar energy field	Scale: within 10 years in Jacka ● House prices in Jacka increase because of a combination of its strong sustainable energy credentials and the community spirit Scale: within 10 years in the ACT ● Reduction in economies of scale for gas, leading to higher bills for suburbs that rely more on gas Scale: within 10 years throughout Australia ● Roll-out of community batteries drives technical battery innovation, leading to cheaper storage and	Scale: within 5 years in Jacka ● Poor implementation (including because of poor communication to residents) leads to significant conflict in the community over the community battery ● Poor design/implementation leads to dislike of the system and an increased distrust in the energy sector emerges ● Capacity to generate solar power becomes the determining factor for influence within the community. Decision making in relation to the

[8] While notions of time scale and geographic scale extend far beyond 10 years and Australia, we have limited our analysis to these scales as they are the most relevant to implementation of the project at hand. This analysis would be improved through consideration of how community batteries might contribute to broad environmental outcomes, but we lack the expertise to do so and have therefore not attempted it.
[9] While some behaviours may be easier to classify as positive or negative, others may be dependent on the perspective they are viewed from.

	• Change in perception of energy as an individual resource to energy as a shared resource	ultimately making community batteries unnecessary as individual storage becomes affordable for all	community battery may be skewed towards households with larger plots and more solar panels Within 10 years in Jacka • Poor implementation contributes to house prices in Jacka decreasing because it is perceived as a suburb with poor community and expensive assets that aren't used and cause friction • Reduced costs of individual batteries make the community battery system unviable Within 10 years in Jacka, ACT and Australia • Ill-feeling generated in Jacka results in lack of trust in community batteries generally and a failure to consider them as a viable sustainable energy tool in future