Neighbourhood batteries in Australia: Anticipating questions of value conflict and (in)justice

Hedda Ransan-Cooper [1,*], Marnie Shaw[1], Björn C. P. Sturmberg[1,], Lachlan Blackhall[1]

[1] Battery Storage and Grid Integration Program; School of Engineering; College of Engineering and Computer Science; The Australian National University

[*] Corresponding Authors: hedda.ransan-cooper@anu.edu.au,

Abstract

Neighbourhood batteries are a new scale of energy storage that has the potential to transform the energy system in Australia, and elsewhere. This paper reports on a research project that aimed to uncover the potential benefits and harms or risks that this technology could engender. In recent years, energy researchers have grappled with incorporating practices of responsible research from different conceptual standpoints including value-sensitive design (VSD), responsible research and innovation (RRI) and energy justice. Jenkins et al (2021) synthesised these three approaches and suggested opportunities for future integration. Our research project, involving qualitative research with energy professionals and citizens, considers elements of all three approaches, presenting an ideal opportunity to reflect on integration and the gaps that remain. We argue for collective efforts to ensure this scale of storage not only does not exacerbate energy injustice, but also enables an energy system that better reflects Australians' desires for a clean and fair energy system. Our research revealed that a priority for decision-makers is a consideration of how benefits will be decided and distributed and risks mitigated.

Keywords: energy justice, community energy storage, neighbourhood batteries, stakeholders, responsible research, value sensitive design

1. Introduction

Neighbourhood batteries are an emerging class of batteries that have the potential to transform energy systems. In Australia, this scale of battery is already being rolled out in streetscapes, beginning in Western Australia, a State where the electricity system has not been privatised and disaggregated. It remains to be seen whether these batteries will become a standard feature of the future grid as they face a range of complex technical, economic and socio-political challenges. Nonetheless, they are already attracting the attention of distribution network companies (DNSPs), community energy groups and state and federal governments, as evidenced by on-the-ground projects, funding programs and pledges and increasing media attention. In 2019, our project team received funding from a federal government agency to explore the range of techno-economic, social and regulatory dimensions to this scale of technology as a basis for the energy sector to create policies and responses to a nascent technology type. This paper details the social research findings of this project.

Existing research on neighbourhood batteries can be broadly categorized into two approaches. The first has focused on the range of technical and economic value streams afforded by neighbourhood batteries, for instance voltage management[1]. This body of work often applies optimisation techniques to minimise financial costs, sometimes also considering particular network constraints. It explores the viability of this technology from a techno-economic perspective which tends to find neighbourhood batteries are a more efficient solution than other scales of storage such as household batteries[2,3]. The second approach, sits in the social sciences, broadly speaking, and explores the potential for neighbourhood batteries to become a more common feature of the energy system largely through the theoretical framing of transition studies. Only two studies[4,5] have so far emphasised the need to take a responsible research and innovation (RRI) approach.

In this paper, we argue that neighbourhood batteries can benefit from a deeper examination of potential impacts. We suggest researchers and policymakers adopt an orientation that remains open to the question of whether this technology is in the public interest. This overarching question is embedded in approaches such as RRI, value-sensitive design and energy justice[6]. We draw on data from interviews and focus groups with energy sector professionals and citizens to explore three, inter-related questions informed by the different research traditions:

1. What are the range of values that may need to be incorporated into the design of the battery algorithm (informed by value-sensitive design)?
2. What concerns are associated with the technology ahead of it being rolled out at scale?
3. What are the ways that neighbourhood batteries may exacerbate existing energy injustice, or create new types of injustice?

By asking questions from these different approaches, we hope to overcome their limitations when considered individually and test the feasibility of integration between them.

Regarding terminology, we have opted for the term *neighbourhood batteries*. Another term used in the literature is community energy storage (CES). However, we opt for a term that describes the location of the battery, because it is by no means given that the battery will have the features of a community energy project. There is an established literature on community energy which, while broad, considers community energy to involve some level of community ownership and/or decision-making power[7]. While it is possible that the community may be involved in neighbourhood scale storage, and thus that they may select to employ the term *community battery*, it is also currently feasible for models which may not meet the definition of community energy, for instance where the battery is owned by a distribution network with minimal involvement from the community. We define

neighbourhood batteries as a <5MW battery located in front of the meter in the distribution network, which may provide a range of functions, be owned by variety of actors to provide a wide range of potential services and values. We agree with Koirala et al.[4] that it is a socio-technical artefact and therefore a broader definition may thus better suit the diversity of forms in which it may come in.

The paper begins with a more detailed overview of previous research and outlines the research questions guiding the analysis. It then describes the methods, discusses results and concludes with implications for future research.

2. Framing neighbourhood batteries

The majority of social science research on neighbourhood batteries has been preoccupied with their potential to become a common feature of the energy system through understanding stakeholder views. This question emerges from within transition studies and typical methods draw on expert views as well as examining the viability of different business models vis-à-vis contemporary energy systems. For instance, Gaede and Rowlands[8] explored the views of energy professionals to gauge the transformative potential of storage (including grid and distribution scales). The authors concluded that the extent to which storage would be transformative was determined by a combination of policies, unanticipated consequences of these in different sub-sectors and the struggles between actors to exert control over outcomes. Technology uptake is fundamentally political and understanding the views of key stakeholders as well as the dynamics of existing regimes is key to understanding the potential of an emerging technology.

Grünewald et al[9] and Müller and Welpe[10] similarly draw on expert interviews to argue that neighbourhood-scale storage is mis-aligned to the electricity systems of the UK, and Western Australia/Germany respectively[11]. Grünewald et al. explore this question in the context of debates between those that favour letting the market 'choose' the required technologies versus the need for government support. These studies provide in-depth understanding of the challenges associated with introducing a new scale of storage from the perspective of decision-makers. Nonetheless, in line with common criticisms of transitions theory, we see that studies using this framework have been less adept at foreseeing future changes[i] and also less focused on energy justice considerations[12,13].

Less commonly, another type of social science study is deliberately situated within a responsible research and innovation (RRI) framework. The goal is to facilitate a new discourse in the design and implementation of neighbourhood batteries, that supports the transition to a sustainable, reliable, inclusive and affordable future energy system [14]. RRI does not set out to necessarily challenge systems of power, and thus, arguably in general terms, has received much more attention and application by decision-makers[15]. Two key features of RRI relate well to our project. Firstly, we aimed to anticipate the impacts of this technology early in its development in order to pre-empt some of the unanticipated effects of the technology (a well-known issue in technology development). At the inception of our project, there were only a handful of neighbourhood batteries operating in the state of Western Australia. In this sense, our research team was in a strong position to explore some of the potential impacts ahead of wider roll-out. While battery technology is not 'new' per se, several features make it clear that it sits squarely within the category of an emerging technology. Firstly, neighbourhood batteries will generally be located on public land not within people's homes thus raises planning questions around visual amenity, noise, and associated impacts. Secondly, it represents a new bundle of 'services' associated with its location in the distribution network, including network support, energy arbitrage (in contexts where there are such energy markets), 'soaking up' solar locally, and the potential to lower carbon emissions through enabling a greater penetration of renewables. None of these individually are new, but the bundling of these services together raises questions about

which services will be prioritised, and with what flow on effects. For our approach in this project, we have been drawn to notions of responsibility as ongoing 'care'[16,17]. We are committed to contributing to dialogue with decision makers and other actors to ensure that potential impacts are highlighted and considered as an ongoing process – rather than as a one-off box-ticking exercise. We draw on RRI to identify *what are the range of concerns associated with the technology, and what is our responsibility for contributing to discussions in the policy and research community?*

Similar to Koirala's exploration of neighbourhood batteries in the context of RRI, we are concerned with anticipating any potential future effects of this technology in order to pre-empt risks and align its development with societal values. However, our study differs from Koirala et al.'s early and important contribution on this topic in several respects. Firstly, our study is grounded in empirical research of a range of actors' views rather than being a consideration of hypothetical concerns and issues. Secondly, it responds to some of the limitations of RRI. Namely, 1) that RRI fails to properly challenge the 'innovation imperative' often quite uncritically following the incumbent innovation trajectory; 2) that RRI is conceptually naive in not providing a yardstick by which to consider the range and potentially contradictory values among relevant stakeholders; and 3) that RRI fails to elicit participation from diverse participants but in a way that is on their own terms rather that predefining the scope of their participation [6]. It is difficult to respond to the first concern in the sense that considering the technology alone can be seen as a tendency towards uncritical trajectory-following. We respond to this concern by highlighting the potential negative effects of this scale of storage and in emphasising occasions where research participants suggested alternatives (for instance reducing energy demand). We respond to the latter two concerns by grounding our analysis in the views of diverse perspectives, including voices not typically reflected in energy policy decision-making and technology design and using the energy justice framework for normative guidance.

While we recognise that there are calls for energy justice approaches more generally to deepen engagement with other (non-Western) philosophical approaches, we do not attempt to do so within this paper, but acknowledge this remains an important research agenda.

2.1 Designing neighbourhood batteries responsibly requires consideration of values and justice

We now turn to Value Sensitive Design (VSD) and energy justice to help complement the RRI framing. From the outset of our project, we sought to explore a wide range of potential impacts of neighbourhood batteries. We brought our own values to bear in designing the research questions and methodologies. Namely, the team of chief investigators were concerned with 1) ensuring this scale of storage would increase access to affordable energy and 2) that it would enable a greater penetration of renewables, in keeping with our overarching concern with decarbonisation. The expertise within the project team varied and included experts in data science, power systems engineering, physics of renewable energy, and environmental sociology. It is important to note that the early stages of discussion and research design could not be described as reflecting a thorough consideration of the three research themes we now outline. Nonetheless, the research questions we explored, and the methods we used did reflect key concerns and issues raised by value-sensitive design (VSD), responsible research and innovation (RRI) and energy justice. As such, we use this as an opportunity to take up the call to integrate these approaches recently synthesised by Jenkins et al[6]. In particular, we are interested to test what integration makes possible in terms of insights and potential impact in the realm of research and decision-making.

2.1.1. Value-sensitive design (VSD)

VSD emerges out of computing studies and was developed as a way to provide a systematic and principled method for incorporating human values in the design of information technology[18] (for further detail see a recent review[19]). For neighbourhood batteries, the key potential application is around designing the algorithm that controls battery behaviour. Unlike traditional generators whose actions are constrained by physical consideration of kinetics and thermodynamics, the actions of batteries are more directly governed by the algorithms that have been constructed by human engineers. They therefore focus attention to human values (defined broadly by what people find important) involved in the design process. Because these algorithms can be designed to deliver multiple benefits, VSD can provide a method for exposing these values and supporting decisions about trade-offs and priorities. At the same time, VSD rarely considers the up-and down- stream impacts of technologies and their systemic impacts. It has also been criticized for having no ethical yardstick by which to measure what values could and should be included in design, weaknesses that are at least partly addressed by RRI and energy justice[6]. Yet VSD is helpful for providing design guidelines around what people value in a new technology, so it framed the question: *What are the range of values that may need to be incorporated into battery algorithm design as well as potential trade-offs?*

2.1.2 Energy justice

We turn to energy justice to guide us in asking distributional questions around the impacts of neighbourhood batteries, and to guide questions within our modelling work, around how non-users might be impacted by this technology as well as noting who should be included in design decisions and they should be involved[20] . Energy justice suited our concerns as it has been positioned as 'a mechanism that can: (1) expose exclusionary and/or inclusionary technological and social niches before they develop, leading to potentially new and socially just innovation' [6]. Energy justice has a normative dimension providing a lens of what things 'ought to be'. It provides a framework for us to 1) identify the concerns associated with neighbourhood batteries (ie where are the benefits and harms distributed?) 2) identify who this technology affects; and 3) identify strategies for remediation[21]. In the case of a technology that has yet to be rolled out at scale, our primary concern was to identify the range of perspectives and concerns of people potentially affected by neighbourhood batteries so that we could begin modelling how the neighbourhood battery could impact those concerns. In this way, an energy justice approach informed a key goal underpinning the project, namely to explore: *What are the ways that neighbourhood batteries may exacerbate existing energy injustice, or create new types of injustice?*

Finally, our work contributes to an existing literature on householder perceptions, imaginaries and relationships with this scale of storage – albeit in our case without a relationship to a concrete project. Several studies have explored citizens' view of neighbourhood batteries. One used the Energy Cultures Framework to interpret and explain citizens' views from focus group discussions[22]. The other used a mixed method approach to gauge views of shared storage[23]. The former found that many peoples' understandings and expectations of shared storage were highly influenced both by their own household context, but also expectations or experiences of government and understandings of the technology itself. Hoffman and Mohaupt[23] spoke with solar owners and found people were concerned about fairness and transparency in models where there was a billing relationship. Koirala et al's[24] has also produced one of the few studies that analysed a specific instantiation of neighbourhood batteries. This focus, in line with a theme of interest to transition studies, has been to explore the role of different actors in creating new forms of social innovation that are co-produced alongside local communities shaping and enacting neighbourhood scale storage.

3. Methods

This research project involved a collaboration between researchers located in a transdisciplinary research program. Because neighbourhood batteries are new, there was no 'dominant design' to analyse. As such, we had to design a flexible research approach that would enable an exploration of the relationships between potential models under consideration already but also provide scope for participants to open up new models not previously considered. The funded period of the project was 18 months but further research activity followed and we report on research activity that took place between March 2019 and April 2021.

The research activity comprised several elements, not all of which will be reported in detail here, including modelling a local energy use tariff[25], modelling the cost-benefit analysis of different ownership models[26] and exploring stakeholder views of neighbourhood batteries. The paper draws on the stakeholder analysis but references will be made to the other research elements where relevant. Stakeholder analysis was compromised of a qualitative research design involving nine 'grounding' expert interviews[27], followed by two focus groups[28] with energy professionals (21 participants in total) and eight focus groups with Australian citizens located in six (out of the eight) states and territories in rural and urban localities (57 participants in total). We also undertook informal dialogues with energy professionals via email, webinar dialogue and participant observation in a working group set up by a consumer advocacy group to enable sharing of experiences about this emerging technology among interested parties.

Drawing from research in community energy[7], we suspected that there would be a wide range of different values motivating different place-based communities in relation to their views on neighbourhood batteries. As such, we wanted to identify a wide range of values, experiences and understandings of stakeholders affected by this technology as a first step to a placed-based, iterative process for future projects. VSD requires structured conversation about trade-offs which was not within scope of this first tranche of research activity and as such, our analysis does not include a structured discussion about trade-offs although these will be reported on when they emerged spontaneously. The interview questions and focus group questions were quite open ended and designed to elicit 1) general first impressions of the technology, 2) ways in which citizens could be involved e.g. through a billing, such as a subscription service (in line with prevailing views of business models in the Australian context), as an investor, or through some form of community ownership 3) perceived benefits of the technology; 4) perceived risks or practical concerns raised by the battery. We also began the citizen focus groups with an icebreaker question around what energy means to participants, a useful way to understand part of what frames participants understandings of energy technology[29].

The interview and focus group questions were designed to be open ended to open up new possibilities of what the technology could be[30], and to understand initial impressions, while still providing some basic information about what the battery could do and some initial issues[27]. Our interview prompts for example, raised the question of how solar-and non-solar owners may differentially benefit in models that only offered a subscription tariff to solar owners.

While the questions on perceived benefits and risks related specifically to the artefact, other open ended questions raised the possibility of system wide effects (e.g. exacerbating inequality) and up- and downstream effects, in line with the framing of our study within RRI. RRI and energy justice also informed our selection of participants, including a focus group with First Nations Australians, whom remain socially and politically marginalised through ongoing colonization[31], as well as rural Australians who have often experienced political disenchantment in energy projects[32].

In total, we spoke with 57 householders in eight locations. We aimed for breadth of experience and diversity across the Australian community selecting: rural (4) and urban (4) locations; a range of socio-economic characteristics and voting patterns, profiled using Australian Bureau of Statistics and Australian Electoral Commission data; and households with and without rooftop solar and battery systems, encouraging broad participation by providing vouchers for participation. We aimed to reach citizens across different political orientations with varying levels of education and income but could only control this to the extent that we targeted particular localities and used various recruitment channels, including online (community Facebook groups and local council emails), poster-fliers located in community spaces, and word of mouth. One focus group was held in one of the most culturally diverse suburbs in Melbourne. Five participants in Broome (Western Australia) were Aboriginal First Nations people from different parts of the Kimberley region in Western Australia and were recruited via a local Institute through their longstanding engagement with Aboriginal people living in the region. The focus group in Adelaide was made up of only solar and home battery owners as we were interested to understand whether residential battery owners would see neighbourhood scale in a different light.

The citizens were evenly split along gender lines (28 Female, 29 Male) but overall participants tended to be older (11% were in the 18-34 age bracket, 14.8% in the 35-44 age bracket, 31.5% in the 45-59% age bracket, 37% in the 60-74 age range and 5.6% in the 75+ age bracket). 31% had Secondary and Vocational school education, two participants held a diploma while the remainder had a university qualification. 60% of participants owned renewable generation technology and 70% of participants were owner-occupiers. 16% lived in apartments or townhouses. As such, even while we did have representation from different backgrounds, our cohort tended to underrepresent apartment dwellers, young people and renters, which presents a limitation to the scope of work and analysis. For future research, modes of recruitment should pay particular attention to these groups.

The 21 energy professionals represented the following sectors:

- Local, State and Federal government (four)
- Networks (DNSPs) (eight)
- Retail sector (including a community owned retailer)/consultancy (four)
- Non-government, mostly in the consumer advocacy area (five)

Five of the energy sector participants had worked directly on implementing energy projects with local communities. The nine grounding interviews used to orient ourselves in the area of neighbourhood batteries were conducted with the project partners (which included two community energy groups, one community energy retailer, two networks, one peak body for DNSPs, one privatised arm of a DNSP and an energy consultant). The gender breakdown of energy sector professionals was six women and 15 men.

The key concern emerging from using an energy justice framing, was identifying what mattered to people *generally* in terms of energy futures – beyond the neighbourhood battery. But the energy justice lens also informed the modelling work we undertook that explored the effects on different value streams (including participating householders) under different ownership models of neighbourhood batteries[5].

All interviews and focus groups were recorded, transcribed and analysed in QSR NVivo. The data analysis was informed by Derek Layder's adaptive theory methodology[33] in which both inductive and deductive approaches can be used depending on the circumstances to modify or generate new theory. In this specific case, the coding process began with some orienting concepts from the research questions outlined above, as well as previous research on Australian householder's views and

experiences of energy technologies[34–36]. However, in practice, an inductive approach was taken to generate the codebook.

4. Results and discussion

Our results and discussion firstly cover the benefits and risks raised by participants (Figure 1.). We subsequently translate those specific risks and benefits into a typology of public values originally developed by Demski et al[37], which enables us to explore our first two research questions relating to anticipating concerns and understanding values trade-offs (Table 2). Next, we consider the risks and issues raised through the lens of energy justice, namely, aspects of governance and accountability that may threaten just outcomes and hinder a transparent approach to navigating the trade-offs that we have uncovered.

4.1 Values and experiences of energy

On the whole, both energy sector professionals and citizens were positive about neighbourhood batteries' potential, citing their multiple benefits. Potential negative impacts were raised as well, some of which could be resolved through negotiations within the design phase, but others may be more difficult to resolve (discussed below). As discussed by Demski et al[37] people reveal values both explicitly and implicitly. In our analysis participants often stated their values explicitly, for example, when talking about positive or negative attitudes towards a technology or energy change in Australia more generally. Implicit values were also derived through a more detailed data analysis, whereby underlying values were inferred from the expression of concerns about key issues, for example the human rights abuses and environmental impacts associated with the batteries. The perceived benefits and risks associated with energy sector professionals and citizens are outlined in Figure 1, and linked to public values in Table 1. Some of which related to algorithm design of the battery (bold), but some which relate more generally to questions of policy design and governance. The battery optimisation algorithm is what makes the battery discharge and charge at particular times. 'Knowledge barrier' is included in consideration of algorithm design because optimisation is complex and it may be difficult (or even impossible) to fully understand the battery's behaviour, depending on the design of the algorithm. Safety management and maintenance on the other hand are issues that need to be resolved independent of the specifics of the optimisation design. While there was overlap between energy professionals and citizens, there were also some points of divergence (see, Figure 1).

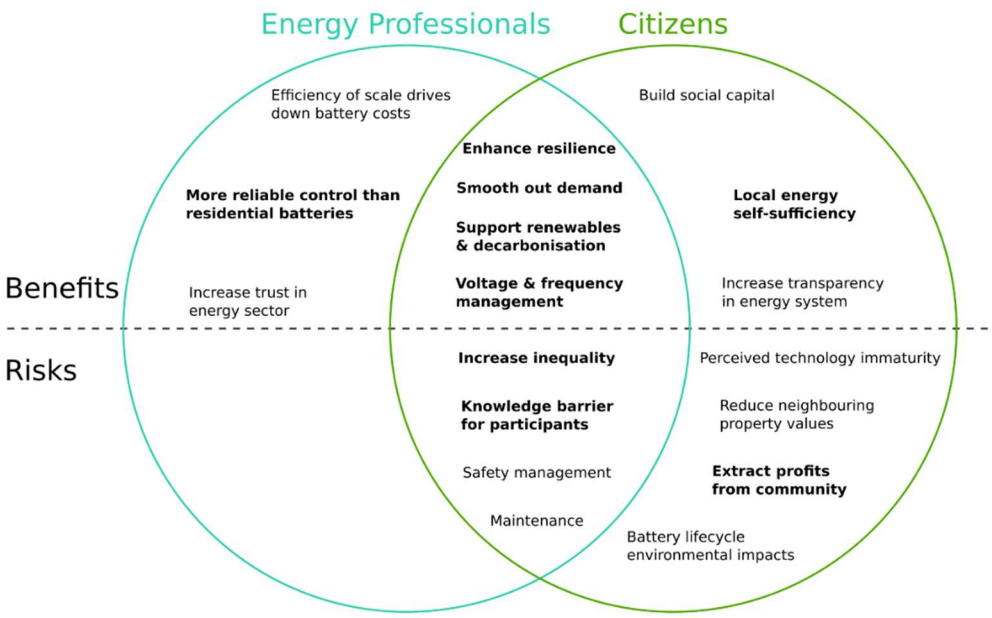

Figure 1. Benefits and risks reflecting public values about energy systems. The bolded issues relate specifically to battery optimisation design, whereas others relate to questions of policy design and governance.

Public values	Benefits Risks	Quotes
Efficient and not wasteful **(Avoiding waste, efficiency, Capturing opportunities)**	Efficiency of scale drives down battery costs Question whether it is the most 'efficient' option	*It could be that community batteries are very efficient for the network stability issues you were talking about, but I don't know. I'm not worried about spending money to stop using fossil fuels, I'm worried about spending money on the wrong option.* - Karl, Canberra
Environment and nature **(Environmental stewardship, climate change mitigation)**	Support renewables and decarbonisation	*My gut feeling, my instinct with energy is always right now that the awareness that we have about the environment is to move in every way we possibly can towards renewable, sustainable energy.* – Anne, Sydney
	Battery lifecycle environmental (and social) impacts	*I think long-term though, you said batteries only last 10 years…. After that, what? What do you do with the batteries? Yeah, because it might be sustainable now but long-term, is it sustainable? I think that would be my only concern with this* - Sky, Melbourne
Security and stability **(Safety, Reliability, Availability and affordability)**	More reliable control than residential batteries Voltage and frequency management Enhance resilience Smooth out demand	*They'll reach a point where they're producing more than they're consuming. So it'd be really awesome if then what they produce gets stored [in a neighbourhood battery] so then it can be used later when the sun goes down.*

		- Terry, Noosa
	Safety management Maintenance	*Yeah. You can't have any Joe Blow just going there and trying to maintain it or look after it, when you haven't got the expertise behind it; and to me that is like another hazard.* - Angel, Cootamundra
Social justice and fairness **(Social justice, Fairness, honesty and transparency)**	Increase trust in energy sector Increase transparency in energy system	*So, I think it would introduce a whole bunch of positive human behaviour aspects into it as well. As opposed to if it's a private company, then they'd probably want to hold all that data. But I think if it's a local government thing then you would get data sharing and greater collaboration between communities. To be able to balance out the load. To be able to do more active trading between communities and households.* - Yiannis, Adelaide *I think that is a risk in this whole thing [around neighbourhood batteries] that the benefits could be distracted off. As I said we've got enough issues with solar PV which I'm incredibly obviously supportive of because we spent so much effort on them, but I still think that nobody still really understands who benefits and who doesn't benefit from this rollout so far.* - Gary, local government
	Increase inequality Reduce property values Noise Extracts profits from community	*I trust energy retailers as far as I can throw them because they are a complete waste of time. I don't get a choice of what energy wholesaler I have, and it doesn't matter just about wherever I live in Australia there's only one*.

		- Thomas, Canberra
		Because, like I know what it's like with these energy companies, all they can think is dollar signs, and they really don't care about the customer. - Angel, Cootamundra
Autonomy and power **(Autonomy and freedom, Choice and control)**	Local energy self-sufficiency Knowledge/complexity barriers for participants directly involved via a subscription option	*I imagine myself if there was some sort of community battery scenario I'd feel I had a lot more power over my usage and that would be really attractive. So I'm technically illiterate but it would be a big selling point for me.* – Julie, Canberra
		Well, right now for example, the house I'm living in, it just got sold and we've only lived in it for two years now. It's a townhouse. So, if you tell me, "Would you like the subscription and further down the line, your power bill is going to reduce," for me, that's not going to make much of a difference because I don't know how long I'm going to live here. – Aram, Melbourne
Process and change **(Long-term trajectories, Interconnected, Improvement and quality)**	Build social capital Perceived technology immaturity	*There are lots of streets around ours where once a year they have the [fire preparedness] training and they all wear the hoses and the fire brigade comes down and helps out and they have a cup of tea and bring cakes and say hi to one another. So it could be a good community bonding exercise maybe* - Maria, Sydney.
	Lack of long-term planning	*Why not simply make some strategic whole of government*

decisions rather than leaving it to lots of little players who could leave us with lots of complex, not particularly efficient, not particularly effective outcome.

- Gary, city council

Table 1. Public values associated with the perceived risks and benefits raised by energy professionals and citizens.

We now discuss some of the key benefits raised by participants in more detail.

Supporting renewables and decarbonisation

Both citizens and state and municipal government officials emphasised a key benefit of storage was that it could support greater renewable penetration and thus support decarbonisation goals. All but one citizen participant expressed concern about climate change and a desire to transition away from a dependence on coal to a renewable energy system. A general understanding of the intermittency of renewables, and of grid congestion, was a key factor justifying the view that batteries were an important element of a renewable energy transition. While this stood as a general point, several participants felt less clear that neighbourhood batteries were the right technology to achieve this balancing purpose, and several participants articulated the need for a clear justification that this scale of storage was the best option available (as a comparison, for instance with electric cars). Yet, a common response in general, was that the potential of this technology was seen through the prism of what it could deliver in terms of speeding up the transition to renewables.

Local energy

Next, a theme around local energy production also emerged among both sub-national government officials, networks and citizens, albeit with different emphases and for different reasons. Valuing 'local' could be seen equally through a positive lens about idealised futures, but also as a reaction against energy privatisation and associated sense of loss of control (discussed in more detail below). For sub-national government participants, local generation especially in regional areas was seen as politically expedient. Some network participants, while not necessarily understanding the reasoning were also "surprised" about how often communities in different networks articulate interest linking local energy generation with consumption. Citizens raised this notion in a number of different ways. Some articulated that having power stored locally would somehow create a greater sense of agency and engagement in energy consumption. Other participants, including with particular emphasis, Aboriginal participants, wanted jobs associated with the battery to be local and for the financial benefits of the battery to flow locally. The desire for benefits to stay locally could be mediated through the design of the battery algorithm, but concerns around ownership and its linkages with benefits, belie the need to take a broader view beyond algorithm design to the broader funding, ownership and governance of the technology. As Yiannis from Adelaide said: 'I think there's a whole bunch of benefits – [but] I think it would be very, very hard for private interests to be able to pull this off.'

Other citizens reflected on the efficiencies that local production and consumption would provide, pointing out that neighbourhood batteries might reduce the need for expensive infrastructure that transports energy from elsewhere. All these justifications provide insight into a shift in Australian's

relationship with the energy system, one which imagines a closer relationship between production and consumption, and with that, a greater sense of connection and local control over energy systems.

Stability and reliability

Both citizens and the full range of energy sector professionals understood the intermittency of renewables and the technical challenges of matching generation and load in diurnal terms and between seasons as well as specific power system issues with voltage and frequency balancing. Some citizen participants, for example, had knowledge of locations in the grid with high household solar penetration. DNSP professionals were focused on the battery increasing hosting capacity of the network and to provide network services (to balance load) and therefore defer other types of network investment. Linked to this, Networks and some citizens also raised the possibility of the battery providing energy in system outages. Most citizen participants were not overly concerned about power outages and did not spend significant time discussing the potential for a battery to improve the resilience of their local grid (at least two focus group locations experiencing higher than average network outages). One of the two focus groups, however, did emphasise that this would be an important feature of neighbourhood batteries for them.

Building social capital

Finally, both citizens and energy sector professionals (in particular sub-national and consumer advocates) raised a less obviously tangible benefit – the potential for neighbourhood batteries to strengthen social relationships. For the professionals, the focus was on the potential to build trust in the energy sector (in Australia, dissatisfaction with the energy market is high, with retailers among the least trusted organisation types[38,39]). On the flipside, one energy professional articulated the view that, because individual households will increasingly have greater opportunities to gain value from their residential storage systems, that distrust in established retailers may mean householders would rather opt to have storage in their homes, rather than being involved in a shared community batteries model, if only (distrusted) incumbents were involved. Citizens on the other hand, did not articulate any desire for a closer relationship with any of the known incumbents. Several participants, however, expressed the potential for the battery to create new, or strengthen existing, social connections between neighbours (see Maria's quote in Table 1). People were uncertain about the specific mechanisms to achieve this, but some turned to existing examples as a point of reference. For example, similarly to regular fire preparedness exercises, community members may get together to discuss the performance of the battery.

In the benefits and risks described above (and below), we see reflected a number of values that closely align with the public values for energy systems discussed by Demski et al in the UK context[37]. Namely that neighbourhood battery design and roll out should reflect values of efficiency and not be wasteful, maintain integrity of the environment, should lead to a secure and stable system, be fair and inclusive, not threaten autonomy and power (ie not significantly infringe on people's daily lives through adding bill complexity)[37], and be developed with a long term plan in mind. Our early research indicates VSD and similar methodologies could be helpful in facilitating discussion about how these values are more specifically defined and prioritised in individual battery scenarios. A separate analysis we have conducted has shown – via modelling – that these values cannot all be 'stacked' and that some trade-offs will need to occur[5]. At the same time, broader concerns about ownership, control and transparency around benefit distribution discussed below, reveals that VSD should be complemented by other considerations that fall beyond the specific design of the battery optimisation (and that also will have their own trade-offs to consider).

4.2 Potential for energy injustice: Accountability and neighbourhood batteries

The challenge of 'value stacking' and ownership

Questions of ownership and benefit distribution were front of centre of discussions among both energy sector professionals and citizens. Here, we see how inextricable ownership is from the risks raised by participants, including 1) safety and maintenance, 2) increasing inequality, 3) flight of value to corporate interests 4) increasing complexity and opacity of the energy system.

While financial streams such as network support, energy arbitrage, and customer billing could hypothetically be 'stacked' to create a compelling business case, disaggregation has complicated this picture. As part of disaggregation and privatisation, DNSPs are not entitled to trade in electricity markets. Retailers who can gain profit from energy arbitrage and other energy markets, cannot recoup financial returns on (as yet) unpriced network services and have no direct interest in increasing the hosting capacity of distribution networks. Networks, could lease out their battery to a retailer or other third party but they are reluctant because of a lack of guaranteed attractive returns, and their organisational culture of risk aversion. Indeed, our participants believed that regulatory barriers to neighbourhood batteries have been overstated and that a number of models are feasible within current regulations, not only within embedded networks[10].

The question of ownership is not just central to making a business case stack up within the prevailing regulatory framework, it was also linked to questions of trustworthiness and public benefit. These questions were raised by government participants, community energy and consumer advocacy participants and citizens themselves. There were concerns, for example, that network ownership would lead to increases in network costs, with one consumer advocate arguing there is no mechanism to reduce underutilised network assets, meaning consumers pay for network assets they may not be benefiting from. Moreover, given the increasing volume of residential batteries (which retailers can potentially access through aggregators), there is a risk from an efficiency perspective that the network will not optimise community batteries with respect to other customer owned assets, leading to inefficiencies in meeting network constraints. Overall, there was a concern that DNSPs may prioritise their own interests over both the interests of the system as a whole and individual customers. Citizens also articulated scepticism that savings would indeed be passed on to customers. Retailers were also seen as problematic. While they may be able to aggregate the neighbourhood battery with other customer owned batteries and optimise these assets collectively to meet the network needs, network participants raised the point that networks may see such network services as too uncertain to rely on for their upgrade planning requirements. Together, networks, consumer advocates and citizens, all expressed significant concern around retailers owning and operating the battery.

Nonetheless, direct ownership by local communities was not endorsed by citizen participants. They reflected that being involved directly in managing a battery could become very complex in terms of decision-making and the expertise required to maintain and operate the battery safely. Citizens were also concerned this model of ownership may engender new forms of inequality between communities. Because many citizens were sceptical about direct citizen management of neighbourhood batteries, they suggested owners could be local government, schools, nursing homes and even research institutes, all seen as much more trustworthy than incumbents. Likewise, several energy sector professionals including consumer advocates and network professionals believed it was likely local governments who would be the 'first movers', because they place a high value on the role of energy storage in decarbonisation targets. In this sense, the re-localisation of energy supply via local government management of neighbourhood batteries, was imagined as a new form of energy governance, which some referred to as 'federated microgrids' as an alternative to the current national electricity market.

Several systemic concerns emerged in citizen focus groups. The most common caveat surrounding positive impression of neighbourhood batteries was concern about the cradle-to-grave impacts of batteries including both human-rights abuses and environmental harm in supply chains. Other

systemic concerns related to the trade-offs in investment, in case this was not the most efficient technology option compared to e.g. demand management (ie 'just using less energy'). These issues cannot be resolved merely by re-design of the battery algorithm and require consideration of battery material supply chains and post-life recycling and disposal.

The discussion taken together about business model design, ownership and systemic risks raises key challenges about defining responsibility and accountability, neighbourhood battery impact and scalability. Institutions that are tightly linked to local context through multiple types of social and epistemic relationships (such as an urban gardening project) may be difficult to scale up[40,41]. Scalability through dominant business models of neighbourhood batteries need not radically challenge the energy regime. However, this may come at the expense of building new types of relationships between citizens and the energy system with associated co-benefits, for example through participation in design decisions particular to communities own motivations and goals. Our focus on responsibility and justice reorients the problem from regulation and 'fit' with the energy system to one which reveals all the existing problems with the energy system and suggests the need for re-design rather than accommodation. Our analysis also reveals that trustworthiness and the presence (or lack) of systems of accountability are equally as important to consider as business case modelling, and indeed are inextricably intertwined with the range of (financial and non-financial) values that can be accessed[42].

4.3 How can potential distributional injustice be avoided or remediated?

While rooftop solar and neighbourhood batteries together enable the possibility of re-localisation of energy, their configuration also raise the possibility of new forms of inequality and distributive injustice. Early field trials of neighbourhood trials in Western Australia have, for instance, exclusively engaged solar customers and found that even within this homogeneous cohort not all customers were better off under a subscription model. Energy sector professionals and householders were concerned about what would happen if the benefits of neighbourhood batteries were geographically bounded to specific localities. This concern is informed by existing inequalities where solar rollout in Australia has significantly reduced millions of householders' bills, but as also created new forms of inequality in accessing cheaper electricity[43]. One city councillor was concerned that neighbourhood batteries could similarly lead to perverse public outcomes.

As this risk emerged in conversations within the project team, we realised we had a responsibility to highlight this risk in our modelling work. Consequently, alongside modelling scenarios with a subscription option, we also investigated models that did not require subscription, and models that allow households both with and without rooftop solar to participate and benefit.

More recent work has also highlighted the importance of understanding how benefits accrue not only to customers who directly participate in neighbourhood battery schemes (i.e. through a subscription model) but also to those citizens who may benefit as a consequence of changes made to accommodate the deployment and operation of neighbourhood batteries. An example of this is the proposed introduction of new local tariffs[25] that will underpin the operation of neighbourhood batteries but which will also potentially result in reduced electricity bills for citizens in the vicinity of neighbourhood batteries, even when not directly participating in the neighbourhood battery scheme[44] .

4.3.1. Value conflicts and differences

Exploring differences in values articulated in the data provides an important insight into potential points of tension between different actors in the energy transition – and distributional injustice – as models get developed and rolled out, with implications for recognition and procedural forms of justice.

There was surprising level of consensus among energy professionals, with the finding that, rather than overt tension or disagreement, differences in emphases were more common. The most overt area of tension appeared to be around who is best placed to own the battery (discussed below). Similarly to findings from Grünewald et al[9], there were discussions among both energy sector professionals and citizens about the role of the market, the government and how to navigate investment decisions in the context of the prevailing policy uncertainty in the Australian context. One council professional stated the investment signals needed to be driven by long term planning.

While one network professional initially stated the decision to roll out a battery should just be a 'competition between solutions', he ultimately agreed this perfect market was unlikely to exist in Australia with both state and federal governments increasingly 'intervening' in the market to underwrite new generation investments. Pragmatically, all but the market regulator would agree that *ad hoc* approaches involving different alliances are more likely to drive investment, rather than a perfect market design.

Citizen participants also discussed the tension between an approach that favoured levelling the playing field in the market rules to enable investment in batteries, versus those that wanted a fundamental redesign of the system. While several favoured an incremental approach, a large number of participants in six out of the eight focus groups expressed a desire for an alternative governance approach. For some participants this was out of a strong framing of energy as an essential service, and thus an "ideological" position that energy should not be a for-profit commodity. For others, it came out of a direct experience of terrible customer service with their retailer. For other participants this view was linked to the perception that energy incumbents had not been proactive enough in transitioning to renewables. Finally, some participants referred to a need more generally to manage resources collectively, rather than as individuals in a financial relationship with energy companies:

> I think at the moment energy is seen as very much an individual thing. It's a consumer good if you like, we consume it individually on our properties or in our homes… So it does need to be as Sacha was saying, it's a societal shift in the thinking around how we use our natural resources …. You can have a big five bedroom house, five bathrooms, have all the lights on all the time if you like if you want to and can manage paying the big electricity bills, so that's a choice at the moment. So in order for this [neighbourhood batteries] to occur as a natural part of Australian communities I think we do need to have a conversation or a real debate about whether we do want to see electricity as a social good, not necessarily just an individual good.
> - Margaret, Noosa

Our analysis reveals that the privatisation of the electricity market in terms of paving the way for a diversity of tariffs (e.g. subscription models), as well as privatisation of the energy system in terms of solar ownership together create the possibilities of new types of inequalities between householders.

Below we outline several nuanced differences among our participants, which represents only the start of exploring these differences and commonalities in more detail. Further research is warranted as these differences are difficult to parse out and analyse in the context of open-ended focus group discussions.

Rural versus urban

Rural people were unconcerned about land availability for the physical location of the storage itself. Rural people were also likely to be more comfortable with the idea of rural councils delivering energy via community batteries since they already had other services such as water being delivered by council. Melbourne participants raised issues of land value – citing petrol stations as already reducing

the house/land value of adjacent properties. Urban participants were also more concerned about the possibility of the storage site being vandalised.

Solar versus non-solar owners
Solar owners liked the idea of their energy going to a specified battery that was serving their local community. Battery owners were also very positive about neighbourhood batteries, not seeing this to be in competition with their own residential batteries. In relation to questions of equity, solar owners rarely saw themselves as implicated in driving inequity in the system (bar one participant). They tended to focus on their positive role in the energy system.

Renters versus home owners
Participants that were renters did explicitly point out that they are currently excluded from accessing solar, and saw neighbourhood batteries as a great option to be able to increase their access. Yet many questions emerged. For instance, renters also wondered whether they would be able to participate in this scheme without the explicit consent of their landlords. Clarity around accessibility to renters appeared very important. Unlike home owners who could see the return on their infrastructure investment over time, renters who may need to move in a short space of time were keen on any bill savings from the storage scheme to be seen immediately.

Apartment dwellers
One participant mentioned that notwithstanding some challenges around making decisions in body corporate contexts, people that buy into townhouses are used to the concept of having shared resources. Particularly in the case of new builds then, a shared battery for townhouse complexes could be a good model, as it is not too different from what people are used to already.

Younger participants
While the overall sample within the citizen focus groups was on the older end, a couple of younger participants provided a hint that younger generations may have slightly different nuances in terms of their view of shared storage. In our sample, it appeared younger people were even more in favour of collective solutions compared to older generations. Further research into younger generations' perspectives would reveal more.

First Nations participants from the Kimberley region
First Nations citizens in the Broome focus group were also highly supportive of renewable energy as a direct result of personal experiences. Many remote communities have experienced improvements in energy access and affordability since the Bushlight program[ii]. In remote Aboriginal communities, solar systems have meant people can live more safely, securely, and flexibly compared with the earlier times when they relied exclusively on diesel generators. Due to their extensive experience directly managing solar and battery technologies, participants were highly aware of the need for ongoing maintenance of these technologies. They have also experienced different third parties who were contracted to maintain these systems and had a clear preference for regular and responsive maintenance. Like participants from other focus groups, participants wanted any model to be very simple and easy to understand and not to contribute to bill and payment complexity (something that remains a significant issue[45]).

5. Conclusion

This paper aimed to start a conversation among researchers and practitioners about what neighbourhood batteries could be, and as equally important, whether they even should be and what they definitely should not be. Rather, than present an exhaustive account of applying VSD, RRI or energy justice to the prospect of neighbourhood batteries, we aimed to answer Jenkins et al's[6] call for synthesis between what can be seen as complementary research traditions. Reflecting on

integration, we can see how the different traditions have enabled the project team to have a broad ranging dialogue around anticipating the various potential – positive and negative – impacts and changes of neighbourhood technologies, embedded in a normative framework. A focus on values, defined early simply as 'what do people want' - provided a bridge between researchers with science backgrounds to engage in broader questions about energy justice and conversations about the role of our research and how we communicate our findings to the energy sector and broader community. The openness of the researchers with non-social-science backgrounds to concerns about potential harms directly related to an attitude and outlook associated with responsibility-as-care, a theme we discussed extensively throughout the project's evolution.

Our research revealed that the values and expectations for neighbourhood batteries covered a wide range of dimensions. Some citizens and energy professionals are concerned that the prevailing energy regime under privatisation may not sufficiently accommodate these values and expectations. Our focus on responsibility and justice reorients the problem from regulation and 'fit' with the energy system to one which reveals all the existing problems with the energy system. This suggests the need for re-design rather than accommodation. For instance, business models that reduce a subset of householders' bills may face challenges in terms of responding to concerns of energy injustice. We also found significant gaps in responsibility and accountability in relation to e.g. battery lifecycle impact, algorithm transparency and accountability, and the distribution of benefits associated with particular business models. Trustworthiness and the presence (or lack) of systems of accountability are equally as important to consider as the business case, and indeed are inextricably intertwined with the range of values that are available.

Questions about the appropriateness of neighbourhood batteries were also inextricably linked with how they might fit into the energy transition more broadly, raising important flags for policymakers to ensure they consider this technology in terms of systemic energy transition trajectories. Finally, in line with previous research[46], citizens' engagement with prospective neighbourhood technology will likely differ along several different lines including previous experience with renewable energy technologies, their location (rural vs urban) and their age, among other characteristics.

This research represents a first attempt at synthesising a range of approaches in considering how neighbourhood batteries can reflect values responsibly and in line with principles of energy justice. Future research is required to further apply these frameworks, both individually, and where necessary in an integrated way, to further inform future decisions about whether this technology can meet normative ideals of energy justice.

6. References

[1] C.P. Mediwaththe, L. Blackhall, Network-Aware Demand-side Management Framework with A Community Energy Storage System Considering Voltage Constraints, IEEE Trans. Power Syst. (2020) 1–1. https://doi.org/10.1109/TPWRS.2020.3015218.

[2] E. Barbour, D. Parra, Z. Awwad, M.C. González, Community energy storage: A smart choice for the smart grid?, Appl. Energy. 212 (2018) 489–497. https://doi.org/10.1016/j.apenergy.2017.12.056.

[3] D. Parra, M. Swierczynski, D.I. Stroe, S.A. Norman, A. Abdon, J. Worlitschek, T. O'Doherty, L. Rodrigues, M. Gillott, X. Zhang, C. Bauer, M.K. Patel, An interdisciplinary review of energy storage for communities: Challenges and perspectives, Renew. Sustain. Energy Rev. 79 (2017) 730–749. https://doi.org/10.1016/j.rser.2017.05.003.

[4] B.P. Koirala, E. van Oost, H. van der Windt, Community energy storage: A responsible innovation towards a sustainable energy system?, Appl. Energy. 231 (2018) 570–585. https://doi.org/10.1016/j.apenergy.2018.09.163.
[5] H. Ransan-Cooper, B.C.P. Sturmberg, M.E. Shaw, L. Blackhall, Applying responsible algorithm design to neighbourhood-scale batteries in Australia, Nat. Energy. 6 (2021) 815–823. https://doi.org/10.1038/s41560-021-00868-9.
[6] K.E.H. Jenkins, S. Spruit, C. Milchram, J. Höffken, B. Taebi, Synthesizing value sensitive design, responsible research and innovation, and energy justice: A conceptual review, Energy Res. Soc. Sci. 69 (2020) 101727. https://doi.org/10.1016/j.erss.2020.101727.
[7] J. Hicks, N. Ison, An exploration of the boundaries of 'community' in community renewable energy projects: Navigating between motivations and context, Energy Policy. 113 (2018) 523–534. https://doi.org/10.1016/j.enpol.2017.10.031.
[8] J. Gaede, I.H. Rowlands, The value of multiple perspectives, Energy Res. Soc. Sci. 48 (2019) 262–268. https://doi.org/10.1016/j.erss.2018.12.007.
[9] P.H. Grünewald, T.T. Cockerill, M. Contestabile, P.J.G. Pearson, The socio-technical transition of distributed electricity storage into future networks—System value and stakeholder views, Energy Policy. 50 (2012) 449–457. https://doi.org/10.1016/j.enpol.2012.07.041.
[10] S.C. Müller, I.M. Welpe, Sharing electricity storage at the community level: An empirical analysis of potential business models and barriers, Energy Policy. 118 (2018) 492–503. https://doi.org/10.1016/j.enpol.2018.03.064.
[11] S. Gährs, J. Knoefel, Stakeholder demands and regulatory framework for community energy storage with a focus on Germany, Energy Policy. 144 (2020) 111678. https://doi.org/10.1016/j.enpol.2020.111678.
[12] J. Köhler, F.W. Geels, F. Kern, J. Markard, E. Onsongo, A. Wieczorek, F. Alkemade, F. Avelino, A. Bergek, F. Boons, L. Fünfschilling, D. Hess, G. Holtz, S. Hyysalo, K. Jenkins, P. Kivimaa, M. Martiskainen, A. McMeekin, M.S. Mühlemeier, B. Nykvist, B. Pel, R. Raven, H. Rohracher, B. Sandén, J. Schot, B. Sovacool, B. Turnheim, D. Welch, P. Wells, An agenda for sustainability transitions research: state of the art and future directions, Environ. Innov. Soc. Transit. 31 (2019) 1–32. https://doi.org/10.1016/j.eist.2019.01.004.
[13] B.K. Sovacool, D.J. Hess, Ordering theories: Typologies and conceptual frameworks for sociotechnical change, Soc. Stud. Sci. 47 (2017) 703–750. https://doi.org/10.1177/0306312717709363.
[14] B.P. Koirala, E. van Oost, H. van der Windt, Community energy storage: A responsible innovation towards a sustainable energy system?, Appl. Energy. 231 (2018) 570–585. https://doi.org/10.1016/j.apenergy.2018.09.163.
[15] A. Genus, M. Iskandarova, Responsible innovation: its institutionalisation and a critique, Technol. Forecast. Soc. Change. 128 (2018) 1–9. https://doi.org/10.1016/j.techfore.2017.09.029.
[16] B. Adam, C. Groves, Futures Tended: Care and Future-Oriented Responsibility, Bull. Sci. Technol. Soc. 31 (2011) 17–27. https://doi.org/10.1177/0270467610391237.
[17] A. Grinbaum, C. Groves, What Is "Responsible" about Responsible Innovation? Understanding the Ethical Issues, in: Responsible Innov., John Wiley & Sons, Ltd, 2013: pp. 119–142. https://doi.org/10.1002/9781118551424.ch7.
[18] A. Borning, M. Muller, Next steps for value sensitive design, in: Proc. SIGCHI Conf. Hum. Factors Comput. Syst., Association for Computing Machinery, New York, NY, USA, 2012: pp. 1125–1134. https://doi.org/10.1145/2207676.2208560.
[19] T. Winkler, S. Spiekermann, Twenty years of value sensitive design: a review of methodological practices in VSD projects, Ethics Inf. Technol. 23 (2021) 17–21. https://doi.org/10.1007/s10676-018-9476-2.

[20] K.E.H. Jenkins, Energy justice, energy democracy, and sustainability: normative approaches to the consumer ownership of renewables, in: Jens Lowitzsch (Ed.), Energy Transit., Palgrave Macmillan, Cham, 2019: pp. 79–97.
[21] D. McCauley, R.J. Heffron, H. Stephan, K. Jenkins, Advancing energy justice: the triumvirate of tenets and systems thinking, Int Energy Law Rev. 32 (2013) 107–110.
[22] P. Ambrosio-Albalá, P. Upham, C.S.E. Bale, Purely ornamental? Public perceptions of distributed energy storage in the United Kingdom, Energy Res. Soc. Sci. (2019). https://doi.org/10.1016/j.erss.2018.09.014.
[23] E. Hoffmann, F. Mohaupt, Joint Storage: A Mixed-Method Analysis of Consumer Perspectives on Community Energy Storage in Germany, Energies. 13 (2020) 3025. https://doi.org/10.3390/en13113025.
[24] B.P. Koirala, E. van Oost, H. van der Windt, Innovation Dynamics of Socio-Technical Alignment in Community Energy Storage: The Cases of DrTen and Ecovat, Energies. 13 (2020) 2955. https://doi.org/10.3390/en13112955.
[25] Authorship withheld for blind review, The symbiosis of local network tariffs and community-scale energy storage, Appl. Energy. (Under review).
[26] Authorship withheld for blind review, Community batteries: a cost/benefit analysis, 2020. arena.gov.au/knowledge-bank/community-batteries-a-cost-benefitanalysis.
[27] Alexander Bogner, Beate Littig, Wolfgang Menz, Generating Qualitative Data with Experts and Elites, in: U. Flick (Ed.), SAGE Handb. Qual. Data Collect., 2018.
[28] J. Cameron, Focusing on the focus group, in: I. Hay (Ed.), Qual. Res. Methods Hum. Geogr., Second edition, Oxford University Press, 2005.
[29] A. Parker, J. Tritter, Focus group method and methodology: current practice and recent debate, Int. J. Res. Method Educ. 29 (2006) 23–37. https://doi.org/10.1080/01406720500537304.
[30] A. Stirling, Keep it complex, Nature. 468 (2010) 1029–1031. https://doi.org/10.1038/4681029a.
[31] M. Langton, The “wild”, the market and the native: Indigenous people face new forms of global colonization, in: W.M. Adams, M. Mulligan (Eds.), Decolonizing Nat. Strateg. Conserv. Post-Colon. Era, Earthscan, 2003.
[32] H. Ransan-Cooper, S.A. Ercan, S. Duus, When anger meets joy: how emotions mobilise and sustain the anti-coal seam gas movement in regional Australia, Soc. Mov. Stud. 17 (2018) 635–657. https://doi.org/10.1080/14742837.2018.1515624.
[33] D. Layder, Sociological Practice, SAGE Publications Ltd, 6 Bonhill Street, London England EC2A 4PU United Kingdom, 1998. https://doi.org/10.4135/9781849209946.
[34] H. Ransan-Cooper, H. Lovell, P. Watson, A. Harwood, V. Hann, Frustration, confusion and excitement: Mixed emotional responses to new household solar-battery systems in Australia, Energy Res. Soc. Sci. 70 (2020) 101656. https://doi.org/10.1016/j.erss.2020.101656.
[35] Y. Strengers, L. Nicholls, Convenience and energy consumption in the smart home of the future: Industry visions from Australia and beyond, Energy Res. Soc. Sci. 32 (2017) 86–93. https://doi.org/10.1016/j.erss.2017.02.008.
[36] Y. Strengers, L. Nicholls, A. Glover, P. Arcari, R. Martin, Engaging households towards the Future Grid: an engagement strategy for the energy sector, Emerging Technologies Research Lab (Monash University) and Centre for Urban Research (RMIT University), Melbourne, Australia, 2019. https://www.monash.edu/__data/assets/pdf_file/0004/1862833/Engaging-households-towards-the-Future-Grid-FINAL-181219.pdf (accessed October 8, 2020).
[37] C. Demski, C. Butler, K.A. Parkhill, A. Spence, N.F. Pidgeon, Public values for energy system change, Glob. Environ. Change. 34 (2015) 59–69. https://doi.org/10.1016/j.gloenvcha.2015.06.014.
[38] Energy Consumers Australia, Energy consumer sentiment survey: December 2018, Sydney, 2018. https://energyconsumersaustralia.com.au/wp-content/uploads/Energy-Consumer-Sentiment-Survey-Report-December-2018.pdf.

[39] Nicholls L, Arcari P, Glover A, Martin R, Strengers Y, Engaging households towards the Future Grid: Experiences, expectations and emerging trends Interim Report, Centre for Urban Research, RMIT University, Melbourne, 2019.
[40] S. Sareen, K. Rommetveit, Smart gridlock? Challenging hegemonic framings of mitigation solutions and scalability, Environ. Res. Lett. 14 (2019) 075004. https://doi.org/10.1088/1748-9326/ab21e6.
[41] F.W. Geels, T. Schwanen, S. Sorrell, K. Jenkins, B.K. Sovacool, Reducing energy demand through low carbon innovation: A sociotechnical transitions perspective and thirteen research debates, Energy Res. Soc. Sci. 40 (2018) 23–35. https://doi.org/10.1016/j.erss.2017.11.003.
[42] M.R. Greenberg, Energy policy and research: The underappreciation of trust, Energy Res. Soc. Sci. 1 (2014) 152–160. https://doi.org/10.1016/j.erss.2014.02.004.
[43] A.J. Chapman, B. McLellan, T. Tezuka, Proposing an evaluation framework for energy policy making incorporating equity: Applications in Australia, Energy Res. Soc. Sci. 21 (2016) 54–69. https://doi.org/10.1016/j.erss.2016.06.021.
[44] A mutually beneficial approach to electricity network pricing in the presence of large amounts of solar power and community-scale energy storage - ScienceDirect, (n.d.). https://www-sciencedirect-com.virtual.anu.edu.au/science/article/pii/S0301421521004651?casa_token=fvigf5joplsAAAAA:J6me39JXhxtqFPzfOtn3CqaS3AaZBhnS6zZIazoE-vMcYIRgk6_qRRuMRruIlsklDZBi3HDwVl4q (accessed October 15, 2021).
[45] A. Dwyer, T. Vernes, Power usage in the Bidyadanga community and its relationship to community health and well-being., Nulungu Institute, The University of Notre Dame, 2016.
[46] H.S. Boudet, Public perceptions of and responses to new energy technologies, Nat. Energy. 4 (2019) 446–455. https://doi.org/10.1038/s41560-019-0399-x.

---

[i] We have witnessed neighbourhood battery roll-out in the very jurisdiction it was considered challenging (Western Australia). These have been rolled out through a coalition between a retailer and distribution network, having being pushed by the most senior political player for energy policy in Australia – the State's Energy Minister (pers comm, 2020).

[ii] Bushlight was a renewable energy program managed by the Centre for Appropriate Technology from 2002-2013, during which over 130 renewable energy systems were installed across remote Northern Territory, Western Australian and Queensland.