The role of consumers in the uptake of decentralised energy storage technologies

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Abstract

There is increasing interest in the role that distributed energy (electricity and heat) storage (DES) might play in helping meet the challenges facing city energy systems. In this paper we will consider the role of consumers in the potential uptake of household and community-scale battery storage. The research uses a mixed methods approach combining literature reviews, focus groups, a survey and semi-structured interviews. The results show how the likely adoption of battery storage is dependent upon a complex interplay between the perceptions of consumers, the institutions involved in DES deployment, the business models that are available and the broader regulatory environment.

1. Introduction

Various forms of decentralised electricity and heat storage (decentralised energy storage, DES) could play an important role in addressing the challenges of meeting increased energy demand and integrating new forms of low carbon energy supply into city energy systems (Taylor *et al*., 2011). In addition, there are also broader policy priorities that act as drivers for the development and deployment of DES including improving air quality within city/regional boundaries, reducing energy poverty, improving housing provision, meeting industrial energy demands for economic growth, and developing new clean-technology industries. Services that can be delivered by energy storage include matching supply and demand over periods from seconds to days, maximising the utilisation of existing and new infrastructure, providing links between heat and electricity systems so allowing trade-offs between the two and ensuring secure energy supplies.

However, while the development of these small-scale storage systems has received a lot of attention and new technologies, for example, the Tesla Powerwall and, aggregation platforms such as Moixa's GridShare are now available, we currently have a limited understanding of the role that households and communities could play in owning or using these technologies, and the benefits that would fall to consumers rather than the energy system as a whole.

In this paper we will address this gap by considering the role of consumers in the potential uptake of community- and household-scale storage. We cover three distinct but interlinked aspects; 1) public acceptance of decentralised energy storage, 2) the likely non-traditional business models that will be appropriate for household ownership or use of storage, and 3) the policy and regulatory barriers that these business models may face.

2. Methodology

The research undertaken used a range of methods including focus groups with the public and a nationwide survey of over 900 households, reviews of business model case studies and international energy storage policy, and semi-structured interviews with storage technology developers.

To understand public perceptions of DES, we applied an approach based on the Energy Cultures Framework (ECF) (Stephenson *et al*, 2010), which was originally developed for understanding energy

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behaviours. Applying this wider system perspective, we connect what people *have*, *think* and *do* (described as *material culture*, *norms* and *practices* in the ECF) in relation to energy contexts that might influence the perception of DES technologies and therefore the wider renewable landscape (Figure 1).

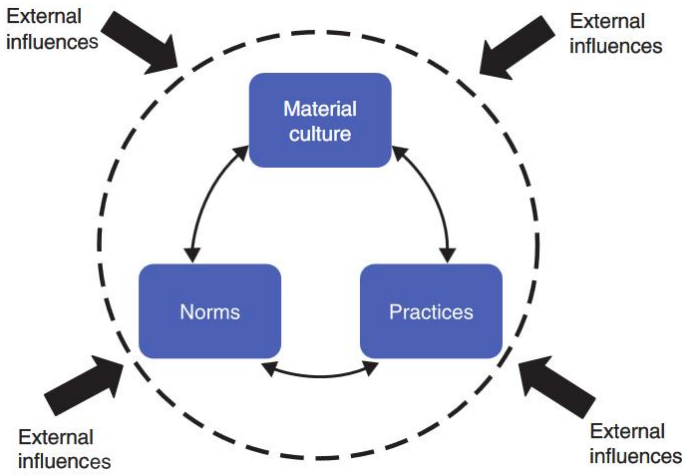

Figure 1: The energy cultures framework (from Stephenson *et al*. (2010))

Four focus groups were carried out in the city of Leeds in February and March 2017 across the lay public and people with solar panels installed. Two of the focus groups consisted of lay public who either rented their homes or were home-owners (without PV installed). The other two focus groups consisted of people who lived in council-owned properties that already had PV installed. The council tenants did not have to pay for the capital or maintenance costs of the PV panels. The inclusion of this group was prompted by interest from the council in installing small-scale battery storage in these households, and in this case tenants would not be expected to invest themselves in the technology. The tenants did not receive the feed-in-tariff payments from the PV (which instead provides revenue for the council), although they did benefit from free consumption of the generated electricity. Selection for the groups was purposive, and the prosumer group provided contrast in terms of having relevant technological experience. Further details can be found in Ambrosio-Albala *et al.* (submitted).

Following the focus groups, a survey was designed and conducted in February 2018 to assess public acceptance of distributed energy storage technologies (batteries) at both household and community level amongst a larger sample of the public. The survey had 949 participants who were recruited by a market research company and the sample was gender and age balanced to be nationally-representative for the UK.

The survey was organised into different sets of questions. At the start, it requested various socio-demographic information from the participants (e.g. gender, age, place of residence). The first set of questions then captured the uninformed evaluation by the participants of batteries. After this, respondents received some information about batteries, their benefits and the potential risk they might entail. The second section included questions to test the (more) informed evaluation of these technologies. Following this, the sample was split into two groups: half of the sample answered questions about batteries at a household level while the other half answered questions about community energy storage. Finally, the survey included a set of general questions about values, trust, environmental self-identity and lifestyles that was completed by the whole sample.

The review of literature on non-traditional business models for energy storage was complemented by case studies focusing on three of the most innovative city-scale business models identified in the UK and interviews with two storage technology developers. The business models examined were those employed by the ERIC project (Oxford), the North Star Solar project (Stanley, County Durham) and the Western power distribution SoLa BRISTOL project (Bristol, England). Interviews were conducted with representatives from Moixa Technology (Chris Wright, co-founder and CTO) and North Star Solar (Peter Sermol co-founder and Managing Director), who have been involved in some of the case study projects. Based on these interviews we attempt to assess to what extent the theoretical opportunities and challenges identified in the existing literature are applicable to our case studies, and to draw lessons from the experience of the companies which have established themselves in this emerging market using innovative business models.

3. Results and discussion

Public perceptions

Topics that reoccurred frequently in people's discussions about DES during the focus groups included their expectations about who should be responsible for helping them adopt the technology and what benefits it would need to deliver for them to be interested.

> *Male 2: I suppose at the end of the day it comes down to the fact what are the benefits for me and how long is it going to take me to get those benefits and to get back what I'm putting in. Ultimately I think that's the way that most people are going to look at it.*

> *Male 5: It would be about trust so I'd want somebody I could trust and I would like to think I could trust the information the government provided me rather than 1 of 50 companies that would be telling me I needed this when this company said I needed this.*

Both national and local government are seen as key actors in delivering information and support in this regard, but with different roles. Yet, at the same time, a lack of trust in public institutions, often based on previous experience, can be a significant barrier.

> *Female 1: (…) basically, both the council and the energy suppliers are going to be out for themselves, so somebody independent to both, who's just there to tell you exactly what it is that you're using, what you're burning, what you're saving..*

As a whole, people expect that the national government will provide credible information on DES, guarantee their rights and deliver sufficient direct funding or other financial support to make DES, such as batteries, attractive to households. Specifically in situations where energy supply could be compromised, the government should be ready to cope with this without it affecting households. People also consider that the government has an important role in encouraging of behaviour change in respective to practices, such as battery adoption, that could have beneficial impact on energy supply and use. Despite this, people are sceptical about whether the Government is willing to provide the support that they would want.

> *Female 1: If the government is saying that they've got these shortages of energy, why don't they just make every single household in the whole of the country have solar panels?*

> *Male 4: I'd like that from the government but I wouldn't expect. It would be nice to think that the government is with everybody else, (…) And it would be nice to think that the government would want to get involved and would want to really push this but are they really going to do it? Is it going to benefit them and their friends?*

In general, people see the local council as having an important role in the practical aspects of adopting a battery. Nevertheless, previous poor experiences with previous schemes of different types can negatively impact people's willingness to be involved. In cases where people would be willing to adopt a battery, then they believe that "ideally" the council should be involved. In this regard, participants hoped that the process will be fair (as perceived by them) in as much as it should take into account their individual views and needs.

The right kind of information provision is essential both in terms of quantity and quality for assuring this. People have difficulties in identifying the benefits of DES; therefore any information should help to clarify these benefits. In quality terms, information should be precise and credible. It also needs to be provided in a way that the recipient finds useful.

> *Female 4: Yeah, for your needs, the needs of your house, you know; this is how much electricity your solar panels have created; this is how much you've used. (…) to kind of assess how you live for a week, to see the peaks and troughs, when you use your electricity, to be able to work out that way what would benefit you better, using the electricity.*

This means providing the content tailored to the user's personal needs and recognising the limitations of their technical knowledge – perhaps through a home visit during which the householder can ask questions. Hence, those involved in the DES sector need to recognise potential user's lack of knowledge and concerns when they are producing information about the technologies.

The preliminary results from analysing the survey largely support the findings from the focus groups, but also provide additional information on some issues. Level of awareness and familiarity with batteries for energy storage at the home level were low. While 62% of people had heard of energy storage, only 19% said they were "familiar" or "very familiar" with the technology. When provided with information about the benefits and risks of the technology, 78% thought it sounded like a good solution to helping meet environmental challenges. Costs seem to be a very limiting barrier for installing batteries at the household level. Only 14% of respondents indicated that they would be happy to have a battery system in their home if they had to pay the total costs. Half of the participants thought that public funding should be used to subsidise the purchase price of battery systems.

Levels of awareness about community energy storage were even lower than for household systems, with 87% of people saying they had not heard of it at all. Once the concept was explained, more participants would be more supportive of having a battery bank at the end of the street if the whole community could benefit from it.

Business models

Drawing on a review of the literature, a framework consisting of three layers was developed to categorise the different types of business model that are relevant to city-scale energy (Figure 2). The first layer consists of traditional business models for the purchase and storage of electricity, which are largely dictated by the degree to which a consumer is connected to the grid (i.e. on-grid, off-grid or private wire). The second layer outlines the 'core' business models which provide innovative city-level solutions to local customers (e.g. those that support prosumers, third party aggregators, community groups, and municipal suppliers). The third layer contains the business models that

augment the core layer by delivering specialised ancillary services, such as those that help enable industry code compliance. These business models can help enable actors, such as households, companies and local authorities, to create a profitable case for energy storage.

Theoretical modelling work was undertaken to explore the potential number of prosumers in a hypothetical energy system. The results suggest that if prosumers with storage (and without aggregation) are able to optimise self-consumption (relative to buying and selling electricity from and to the grid), then this is the most beneficial outcome and increases the expected number of prosumers. This in turn leads to fewer power exchanges with the grid, thus decreasing the grid's total variable costs. Under these circumstances, traditional consumers contribute more to grid financing through their electricity bill than prosumers because the fixed cost of the grid is recovered through the price of each unit of electricity sold (and traditional consumers buy more grid electricity than the equivalent prosumer). In contrast, the picture becomes more complex when aggregation is allowed in the model, so that prosumers can provide capacity services to the grid. Not surprisingly, the expected level of prosumers increases with the price paid for ancillary services, however this level can only be reached if network costs exceed the cost of importing from the grid. The additional network costs are covered by prosumers as payment for accessing aggregated ancillary services. Therefore, the distributional effects on traditional consumers may be alleviated due to prosumers providing ancillary services.

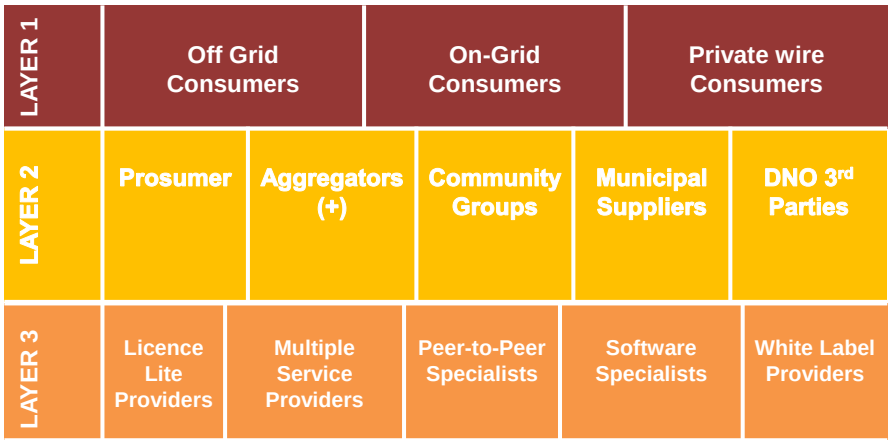

Figure 2: Non-traditional business models for distributed energy storage (adapted from Burlinson *et al*. (2018))

A review of the practical experience with energy storage highlighted a number of important lessons. For example, community storage has been successfully deployed in the British Isles and Germany to help support local renewable generation and create self-sustainable micro-grids. On the other hand, batteries trialled by prosumers in the UK have exhibited limited potential savings, specifically when used for back-up power and increased self-consumption of solar-PV. Moreover, there is limited empirical evidence to suggest whether more innovative business models that stack additional revenue (such as aggregation, peer-to-peer trading etc.) improve the overall business proposition and profitability of DES in the UK.

Regulatory environment

There is currently limited financial benefit to householders from installing DES. The value of DES comes from engaging in arbitrage (i.e. storing electricity when it is cheap and using it when electricity is expensive) and from selling services to the ancillary services market (which supports the operation of the transmission and distribution system). At the moment the vast majority of domestic consumers pay a flat tariff for their electricity and, even when a household has PV installed, the

revenues from arbitrage are likely to be small.[2] The value of providing ancillary services may be greater but, at the moment, few consumers have direct access to this market.

However, the overall value of DES to the energy system is likely to increase as renewable technology deployment continues, and there may be wider societal benefits (i.e. positive externalities) that are not easily captured through the market. Policy and regulatory frameworks therefore need to evolve to prepare markets for these future developments and remove unnecessary barriers so that the economic value of DES can be realised in the future.

The UK has recently made some moves in this direction, with a number of policy interventions targeted specifically at promoting energy storage. In the 2017 Smart Systems and Flexibility Plan the UK Government (and OFGEM) committed to a number of changes around licensing, planning, connections and charging for storage, to remove regulatory and policy barriers to allow energy storage technologies to 'compete on a level playing field' (OFGEM, 2017). These included the following: a revision to the charges placed on storage facilities so that they are no longer double charged as both consumers and generators of electricity and only pay generation charges; a regulatory definition of energy storage as a subset of the generation asset class, clarifying its status as part of the electricity system; and, a clarification of the rules around co-locating energy storage with renewable energy.

These recent policy interventions by the Government are helpful to energy storage, but do not go as far as developments in other countries. A review of international experience with energy storage, covering the United States (specifically California, New York and Hawaii), Germany and Japan, identified a number of lessons for the UK. Apart from Hawaii (which has unusually high energy prices) all the countries/states reviewed have subsidies to promote energy storage. If the UK wants to increase the rate of energy storage deployment then some form of subsidised intervention should be considered; e.g. a direct energy storage subsidy, or competitive auctions. The value of rooftop PV can be enhanced with the introduction of energy storage and so promoting batteries alongside solar PV can provide a route to market, as has happened in Germany. California and New York have used load shifting programmes to promote electrical and thermal energy storage. A load shifting programme in the UK could promote battery storage, helping to reduce congestion on the network at times of peak demand.

4. Conclusions

The general public is not currently well informed about either household or community-level DES. Both local and central government are seen as playing an important role in delivering credible information and practical support to help householders adopt the technology or in delivering community-level schemes. Yet, at the same time, a lack of trust in both public and private institutions may present a significant barrier and consumers' experience (good or bad) with previous schemes, such as the installation of PV, can also be an important factor. Under current market arrangements and with traditional business models, there is little financial benefit to householders from installing DES, even if they have PV installed and this presents a major barrier. Changes to the regulatory system, combined with a range of innovative business models that allow householders to access new sources of revenue, would provide greater incentives for the uptake of DES. These developments could also result in an increased number of prosumers.

[2] Households with PV can use a battery to store the "free" electricity generated by the PV system during the day for use to meet peak demand in the evening, thus reducing their overall purchase of electricity from the grid.

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Keywords

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